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The Relationship of Energy and Macro nutrient Intake on Fatigue Levels of Female Workers at The Bandarharjo Fish Smoking Center, Semarang City

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Abstract

Introduction: Inadequate intake of energy and macronutrients causes a decrease in an individual's ability to carry out his work activities and makes him feel tired or tired more easily. The purpose of this study was to analyze the relationship between energy adequacy level (EAL) and protein adequacy level (PAL) as well as the percentage of carbohydrate intake and the percentage of fat intake with the fatigue level of female workers.

Methods: This research is an analytic observational study with a cross-sectional design. The population in this study were 67 female workers at the Bandarharjo Fish Smoking Center, Semarang City. Research subjects were selected by purposive sampling of 40 subjects, based on inclusion criteria. EAL, PAL data were collected, as well as the percentage of carbohydrate and fat intake obtained through interviews using a 2x24 hour food recall form. Data analysis was performed by Pearson Product Moment correlation test on normally distributed data and Ranks Spearman correlation test on non-normally distributed data.

Results: The results showed that the average EAL was 86,6 (±26,3)% energy requirement/day, PAL was 64,5 (±23,5)% protein requirement/day, the percentage of carbohydrate intake was 51,5 (±7,6)% energy intake/day, and the percentage of fat intake was 34,7 (±8,6)% energy intake/day, and the level of work fatigue with an average reaction time of 429,7 (±121,9) milliseconds. There was no relationship between EAL (r=0,127 and p=0,435), PAL (r=0,159 and p=0,327), percentage of carbohydrate intake (r=0,036 and p=0,825), and percentage of fat intake (r=-0,088 and p = 0,590) with the level of work fatigue.

Conclusion: It can be concluded that there is no relationship between EAL, PAL, and the percentage of carbohydrate and fat intake with the level of work fatigue in female workers in the Bandarharjo Fish Smoking Center, Semarang City.

Keywords: Energy Adequacy, Protein Adequacy, Carbohydrate Percentage, Fat Percentage, Work Fatigue

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Introduction

Fatigue can significantly affect health and reduce work productivity, which can significantly increase the risk of work accidents for workers.[1] The dual role of female workers in carrying out work activities outside the home as well as within the household unknowingly increases the pressure both physically and mentally in its implementation. Therefore, the heavy workload due to multiple roles at work and in the household can cause work fatigue among female workers.[2]

Energy intake is an important aspect of nutrition for a worker, the mismatch of energy intake needs will accelerate the emergence of feelings of fatigue. This is due to the ability to carry out work activities which are influenced by labor energy intake from food and drink consumption. If this intake is not met, the ability of the workforce to carry out work activities will be reduced and it will be easier to get tired. The more the energy intake of the workforce does not match with its needs in carrying out work activities for 8 hours, the higher the fatigue feeling of the workforce.[3] The highest energy requirement is during the initial work shift and decreases until a steady state is reached.[2]

One other aspect of nutrition that is also a factor causing fatigue and feeling tired is the consumption of macronutrients, especially carbohydrates. The group of macronutrients with the largest source of energy and being important for human intake, among others, are carbohydrates, fats and proteins, especially carbohydrates.[2] Meanwhile, protein intake that is higher than the need can pose a low risk of moderate and severe fatigue.[3]

The Bandarharjo Fish Smoking Center in Semarang City is a smoked fish processing industrial area or commonly called fish smoking, most of which are home industries or those belonging to the informal sector.[4] This informal sector is different from the formal sector in which the implementation of occupational health and safety (K3) is well cared for and organized. Most of the workforce in the Bandarharjo Fish Smoking Center in Semarang City are female workers, which is around 75% - 80% of the total workforce. More than half of the female workers work in the smoking section, with more than ±10 years of service. In addition, the process of smoking fish at the Fish Smoking Center in Bandarharjo is still carried out traditionally or manually. The smoking process is carried out for 10-15 minutes. The workforce in each smoking area, especially in the smoking section, carries out work activities without definite or no rest periods from morning to evening with a long exposure of 8-10 hours per day. In general, in carrying out their work activities, female workers are not directly exposed to sunlight, but the smoking of fish and its removal are still done traditionally or manually, which causes a large need for manpower to carry out their work activities. Female workers also tend to spend a lot of their working time in a sitting position and repetitive movements, so that it can be a risk for symptoms of work fatigue. Based on research conducted by Rini (2021), it shows that 85,5% of the Bandarharjo Fish Smoking Center workforce experience work fatigue. There are several factors that influence it, including age, nutritional status, workload, and heat stress.[5] Meanwhile, based on the results of a preliminary study through observation and interviews with 10 female workers at the Bandarharjo Fish Smoking Center, it was found that all workers experienced symptoms of work fatigue, in the form of a feeling of dizziness in the head, stiffness in the palms of the hands, and aches or pain in the several parts of the body, such as the waist, back, and/or wrists or legs. This study aims to analyze the relationship between energy adequacy level (EAL) and protein adequacy level (PAL) as well as the percentage of carbohydrate intake and the percentage of fat intake with the level of fatigue of female workers in the Bandarharjo Fish Smoking Center, Semarang City.

Methods

This research is an analytic observational study with a cross-sectional approach. Located at the Fish Smoking Center, Jl. Lodan Raya, RT 01/RW 02, Bandarharjo, North Semarang, Semarang, Central Java and carried out in the period June - September 2022. The population in this study were 67 female workers. Sampling used a purposive sampling technique with 40 research subjects selected, based on inclusion criteria. The variables in this study were the level of energy adequacy (EAL) and the level of protein adequacy (PAL) as well as the percentage of carbohydrate intake and the percentage of fat intake as independent variables and the level of work fatigue as the dependent variable.

Variable level of work fatigue is categorized into four based on reaction time, namely normal with a value range of 150,0 – 240,0 milliseconds, light work fatigue (LWF) with a value range of 240,0 ≤ x < 410,0 milliseconds, moderate work fatigue (MWF) with a value range of 410,0 ≤ x < 580,0 milliseconds, and severe work fatigue (SWF) with a value range of ≥580,0 milliseconds. Measurements with the reaction timer were carried out 20 times, and the results number 1-5 and 16-20 were omitted because they were considered to be at the instrument adjustment level and the saturation level was starting to appear. Reaction time is the time span required from a stimulus is given to the emergence of an awareness or the implementation of a particular activity. The longer reaction time indicates the slowing down of processes that occur in the functioning of the nerves and muscles of the body.[5,6]

Data collection for independent variables was obtained through interviews using a 2x24 hour food recall form and measurements of the dependent variable were carried out using a reaction timer before and after work activities to measure reaction time to light stimuli. Data analysis in this study was in the form of Univariate and Bivariate. The statistical test uses the Pearson Product Moment Correlation Test if the data is normally distributed and/or the Ranks Spearman Correlation Test if the data is not normally distributed (with α = 5%). Based on the results of the Shapiro-Wilk Normality Test, data on age (sig. = 0,052), nutritional status with BMI (sig. = 0,556), percentage of carbohydrate intake (sig. = 0,266), percentage of fat intake (sig. = 0,412), and the level of work fatigue (sig. = 0,576) is normally distributed, while the data on energy adequacy level (sig. = 0,000) and protein adequacy level (sig. = 0,008) are not normally distributed.

Results

The Bandarharjo Fish Smoking Center consists of 26 fish smoking places. The businesses owned by most of them are home industries. These places can be divided into three production scales, namely large, medium and small. **Tabel 1** is a table of the characteristics of the respondent.

Tabel 1. Characteristics of Respondents

Variable	Min.	Max.	Mean (SD)	Category	f	%
Age (years)	27	65	50 (±10)	Elderly (≥40)	31	77,5
				Young (<40)	9	22,5
BMI (kg/m^2)	16,9	43,5	28,5 (±6,1)	Very Skinny (<17,0)	2	5
				Normal (18,5 – 25,0)	10	25
				Overweight (25,1 – 27,0)	5	12,5
				Obese (>27,0)	23	57,5
Energy Adequacy Level (%)	57,0	190,8	86,6 (±26,3)	Less (<90)	24	60
				Normal (90 -119)	12	30
				Over (>119)	4	10
Protein Adequacy Level (%)	34,7	130,4	64,5 (±23,5)	Less (<90)	35	87,5
				Normal (90 -119)	4	10
				Over (>119)	1	2,5

Table 1. (Continued)

Carbohydrate Intake Percentage (%)	35,5	69,8	51,5 (±7,6)	Less (<50)	16	40
				Normal (50-65)	21	52,5
				Over (>65)	3	7,5
Fat Intake Percentage (%)	12,1	50,2	34,7 (±8,6)	Less (<20)	2	5
				Normal (20 – 30)	9	22,5
				Over (>30)	29	72,5
Work Fatigue Level (milliseconds)	202,1	693,5	429,7 (±121,9)	Normal (150,0 – 239,9)	2	5
				Light Work Fatigue / LWF (240,0 – 409,9)	16	40
				Moderate Work Fatigue / MWF (410,0 – 579,9)	18	45
				Severe Work Fatigue / SWF (≥580,0)	4	10

In **Table 1**, all respondents have a light workload (75 – 100 bpm), which is 100% with a minimum value of 67 bpm and a maximum value of 100 bpm and an average working pulse of 85 (±8) bpm. This is because the workload variable has been homogenized with the inclusion criteria. Meanwhile, all respondents had heat stress that exceeded the threshold value (>28°C), which was 100% with a minimum value of 28,2°C and a maximum value of 28,5°C and an average working climate of 28,4 (±0,1)°C. This is because the work environment at the three measurement location points is indoors and is a smoking area so that it has a working climate that tends to be hot.

Table 1 illustrates the characteristics of respondents with older ages more than young ones. In addition, more than half of the respondents had nutritional status with an obese BMI. Then, more than half of the respondents had a percentage of EAL which was less than their energy requirement, in units of kcal/day. More than half of the respondents also had a percentage of PAL that was less than their protein requirement, in units of grams/day. Respondents with a normal percentage of carbohydrate intake based on their energy intake (kcal/day) were more than the other categories. Meanwhile, more than half of the respondents had a higher percentage of fat intake based on their energy intake (kcal/day). Respondents at the level of work fatigue with a moderate reaction time (milliseconds) compared to other categories.

Based on **Table 2**, it can be seen that the proportion of elderly respondents tends to experience work fatigue, namely the level of moderate to severe work fatigue as the highest category. Meanwhile, respondents with a nutritional status with a BMI that is overweight to obese tend to experience work fatigue, and it occurs most frequently in the category of moderate to severe levels of work fatigue.

Tabel 2. Cross Tabulation Results between Variables

Variabel	Category	Work Fatigue Level		Total
		MWF - SWF	Normal – LWF	

Table 2. (Continued)

		f	%	f	%	f	%
Age	Elderly	17	54,8	14	45,2	31	100
	Young	5	55,6	4	44,4	9	100
BMI	Overweight - Obese	16	57,1	12	42,9	28	100
	Very Skinny - Normal	6	50	6	50	12	100
Energy Adequacy Level (EAL)	Less	11	45,8	13	54,2	24	100
	Normal - Over	11	68,8	5	31,3	16	100
Protein Adequacy Level (PAL)	Less	19	54,3	16	45,7	35	100
	Normal - Over	3	60	2	40	5	100
Carbohydrate Intake Percentage	Less	8	50	8	50	16	100
	Normal - Over	14	58,3	10	41,7	24	100
	Over	16	55,2	13	44,8	29	100
Fat Intake Percentage	Less - Normal	6	54,5	5	45,5	11	100

Respondents energy adequacy levels (EAL) tended to have no differences in work fatigue and most occurred in less EAL with normal to light levels of work fatigue. Respondents whose level of protein adequacy (PAL) is less likely to experience work fatigue, namely those with moderate to severe levels of work fatigue as the largest category. The percentage of carbohydrate intake of respondents who are normal to more likely to experience work fatigue and most occur in the category of moderate to severe levels of work fatigue. Respondents with the percentage of fat intake are more likely to experience work fatigue, namely the level of moderate to severe work fatigue as the most category.

Table 3 shows the results of the Pearson Correlation Test between age, nutritional status (BMI), the percentage of carbohydrate intake, and the percentage of fat intake with the level of work fatigue has no relationship. In addition, the results of the Spearman Correlation Test between the level of energy adequacy (EAL) and the level of protein adequacy (PAL) with the level of work fatigue also have no relationship.

Table 3. Results of Relationship Analysis between Variables

Variable	*r-value*	*p-value*
Age	0,053	0,743
BMI	0,129	0,426
Energy Adequacy Level (EAL)	0,127	0,435

Table 3. (Continued)

Protein Adequacy Level (PAL)	0,159	0,327
Carbohydrate Intake Percentage	0,036	0,825
Fat Intake Percentage	-0,088	0,590

Discussion

Based on the results of the study, more than half of the respondents experienced work fatigue. Variable level of work fatigue is categorized into four based on reaction time, namely normal with a value range of 150,0 – 240,0 milliseconds, light work fatigue (LWF) with a value range of 240,0 ≤ x < 410,0 milliseconds, moderate work fatigue (MWF) with a value range of 410,0 ≤ x < 580,0 milliseconds, and severe work fatigue (SWF) with a value range of ≥580,0 milliseconds.[5] Moderate level of work fatigue is the most common category. More than half of the respondents experienced fatigue or did not carry out their work activities in the smoking section. In general, in carrying out their work activities, female workers are not directly exposed to sunlight, but the smoking of fish and its removal are still done traditionally or manually, which causes a large need for manpower to carry out their work activities. In addition, female workers also tend to spend a lot of their working time in a sitting position and repetitive movements. These things can affect the level of work fatigue encountered.

Based on the results of the study, there was no relationship between age and the level of work fatigue in female workers at the Bandarharjo Fish Smoking Center, Semarang City. The age variable is categorized into two, namely elderly (≥40 years) and young (<40 years).[6] More than half of the respondents are elderly. Work activities at the Bandarharjo Fish Smoking Center in Semarang City do not discriminate between the ages of female workers. Young and elderly female workers carry out relatively the same activities and working hours with a length of exposure of 8-10 hours per day. In addition, the working period of female workers at each smoking place tends to be the same, which is more than 10 years. These things can affect the found no significant relationship between age and the level of work fatigue. However, elderly respondents tend to experience work fatigue, namely the level of moderate to severe work fatigue as the largest category.

This research is not in line with Wahyu Kusgiyanto on workers in the spring roll skin making section in the Kranggan Village who stated that there is a relationship between age and the level of work fatigue. The influence of age on work fatigue occurs due to the physiological functions of the body which can change due to age, thereby affecting the body's endurance and work capacity of an individual. An individual with a relatively young age has the ability to carry out strenuous work activities, whereas an individual with an elderly age will decrease his ability to carry out strenuous work activities. This happens because an individual with elderly age is quicker to feel tired and unable to move nimbly when carrying out their duties, thereby affecting their performance.[1] This research is also not in line with Rini Widiastuty in workers at the Bandarharjo Fish Smoking Center in Semarang City who stated that age is a risk factor for work fatigue. Workers aged above or equal to 40 years have a higher risk of experiencing burnout compared to those aged under or equal to 40 years.[5] Other research that is not in line is Nabila's research on workers in the Eretan Kulon Indramayu Aluminum Smelting Industry which states that there is a significant relationship between age and fatigue. The age of an individual will affect the condition of his body, an individual with a young age will be able to carry out heavy work activities and vice versa.[7]

Based on the results of the study, there was no relationship between nutritional status (BMI) and the level of work fatigue in female workers at the Bandarharjo Fish Smoking Center, Semarang City. The nutritional status variable (BMI) is categorized into two, namely overweight to obese (>25,0 kg/m^2)

and very skinny to normal (≤25,0 kg/m^2).[5] More than half of the respondents have nutritional status with an obese BMI. In addition, female workers also tend to carry out activities and work hours that are relatively the same. These things can affect the found no significant relationship between nutritional status (BMI) with the level of work fatigue. However, respondents with overweight to obese nutritional status (BMI) tend to experience work fatigue, namely moderate to severe work fatigue as the most common category.

This research is not in line with Rini Widiastuty in workers at the Bandarharjo Fish Smoking Center in Semarang City who stated that nutritional status is a risk factor for work fatigue. Workers with abnormal nutritional status have a higher risk of experiencing fatigue than those with normal nutritional status.[5] This study is also not in line with Natizatun on home industry workers in the Raya Indramayu Aluminum Metal Smelting home industry which states that there is a relationship between nutritional status and work fatigue. Most of the nutritional status of the workforce is in the category of abnormal nutritional status, namely 63,3%. Nutritional status is influenced by food consumption and the use of nutrients in the body. If the body obtains enough nutrients and uses them efficiently, optimal nutritional status will be achieved which allows physical growth, brain development, work ability, and general health at the highest level.[8] Furthermore, this research is also not in line with Fury Herliani on gamelan making industry workers in Wirun Sukoharjo who stated that there is a relationship between nutritional status and work fatigue. Based on this research, workers with poor nutritional status experience work fatigue, both light and moderate. This is because the workforce has too little nutritional status in terms of food consumption, so the amount of nutrients that enter the body is also less than the amount of energy expended when carrying out work activities.[9] Other research that is also not in line is with Bayu on the weaving work force at PT. Iskandar Indah Printing Textile Surakarta which states that there is a relationship between nutritional status and work fatigue. With a relatively good nutritional status, the majority of workers will have a light level of fatigue after carrying out work activities because it can help the body's work power to be more enthusiastic and stamina in carrying out its work activities.[10]

The majority of fish smoking places in the Bandarharjo Fish Smoking Center in Semarang City are home industries so that the variety of food as well as energy and macronutrients (carbohydrates, fats, and proteins) intake tend to be the same due to the adjacent living environment. In addition, female workers also tend to carry out relatively the same activities and work time as rest periods at each of the equally uncertain fish smoking places.

Based on the results of the study, no relationship was found between the level of energy adequacy and the level of work fatigue in female workers at the Bandarharjo Fish Smoking Center, Semarang City. The energy adequacy level variable is categorized into two, namely less (<90% energy requirement) and normal to over (≥90% energy requirement) in units of kilocalories (Kcal).[11] More than half of the respondents have a percentage level of energy sufficiency that is less than energy requirement/day. Respondents EAL also tended not to have differences in work fatigue, but most occurred in less EAL with normal to light levels of work fatigue.
This research is not in line with Sri Maywati's research on female workers in the production section at the shoe manufacturing factory PT 'X' Bandung which states that there is a significant relationship between the amount of calorie intake during the day and the level of fatigue. This is because the average calorie intake during the day during work activities is still far from the recommended standard. The highest energy requirement is during the initial work shift and decreases until a steady state is reached, sometimes it can even continue to decrease as work activities continue due to the elimination of the oxygen part which is an accumulation of debt during the initial work shift.[2] In addition, Daniel Tasmi research on permanent workers at PT. Perkebunan

Nusantara I Palm Oil Mill (POM) Pulau Tiga also states that there is a relationship between energy intake and work fatigue. This is because the energy intake of the workforce affects its ability to carry out work activities. Energy needs for carrying out work activities must be met from the food and drinks consumed. If this intake is not met, the ability of the workforce to carry out work activities will be reduced and it will be easier to feel tired. The more the energy intake of the workforce is not in accordance with its needs in carrying out work activities for eight hours, the higher the fatigue feeling of the workforce.[3] Other research that is also not in line is Dyah Umiyarni Purnamasari's research on female workers in the false eyelash industry at PT. Hyup Sung Purbalingga, who stated that there is a relationship between the level of energy consumption and fatigue. Female workers with a deficit calorie consumption level will have a risk of experiencing fatigue of 77,8%. Meanwhile, a deficit in energy consumption can result in a reduced supply of glycogen and oxygen to muscle tissue, making it difficult for the muscles to perform the contractions needed to carry out work activities. The more physical activity that involves muscle function, the more energy is needed.[12]

Based on the results of the study, there was no relationship between the level of protein adequacy and the level of work fatigue in female workers at the Bandarharjo Fish Smoking Center, Semarang City. Protein adequacy level variables are categorized into two, namely less (<90% protein requirement) and normal to over (≥90% protein requirement) in gram units.[11] More than half of the respondents have a percentage of protein adequacy level that is less than the protein requirement/day. However, respondents with PAL who were less likely to experience work fatigue, namely the level of moderate to severe work fatigue as the largest category.

This research is not in line with Yolan Gempita Sari on cleaning service employees at Esa Unggul University, West Jakarta which states that there is a relationship between the level of protein adequacy and the level of fatigue.[13] On the other hand, this study is in line with Dyah Umiyarni Purnamasari's research on female workers in the false eyelash industry at PT. Hyup Sung Purbalingga who stated that there was no relationship between the level of protein consumption and fatigue.[12]

Based on the results of the study, there was no relationship between the percentage of carbohydrate intake and the level of work fatigue in female workers at the Bandarharjo Fish Smoking Center, Semarang City. The variable percentage of carbohydrate intake was categorized into two, namely less (<50% energy intake/day) and normal to over (≥50% energy intake/day) in kilocalorie units.[11] More than half of the respondents have a normal percentage of carbohydrate intake based on energy intake/day. However, respondents with a normal percentage of carbohydrate intake were more likely to experience work fatigue, namely the level of moderate to severe work fatigue being the most common category.

This research is not in line with Michael Malone who stated that dietary carbohydrates interact with body fat to reduce sleep and increase fatigue. The conclusion of this study is that an individual with low carbohydrate intake can increase fatigue and reduce sleep.[14] On the other hand, this research is in line with Rizki Sri Wulandari work in the production department at PT. Coca Cola Bottling Indonesia which states that there is no relationship between carbohydrate intake and work fatigue.[15]

Based on the results of the study, there was no relationship between the percentage of fat intake and the level of work fatigue in female workers at the Bandarharjo Fish Smoking Center, Semarang City. The variable percentage of fat intake is categorized into two, namely over (>30% energy intake/day) and less to normal (≤30% energy intake/day) in kilocalorie units.[11] More than half of the respondents had a higher percentage of fat intake based on energy intake/day. However, respondents with the percentage of fat intake were more likely to experience work fatigue, namely the level of moderate

to severe work fatigue as the highest category.

This research is not in line with Michael Malone who stated that dietary fat interacts with body fat to increase fatigue, and at the same time reduce sleep. Fat diets increase fatigue to a much higher degree than carbohydrate diets. The conclusion of this study is that the lower the fat intake, the higher the fatigue that occurs, and vice versa.[14] On the other hand, this study is in line with Diana Puspita Langgar on employees of Bu Pudji tofu baxo company in Ungaran who stated that there was no relationship between fat intake and work fatigue.[16]

Conclusion

It can be concluded that there is no relationship between the level of energy adequacy (EAL) and the level of protein adequacy (PAL) as well as the percentage of carbohydrate intake and the percentage of fat intake with the level of work fatigue in female workers at the Bandarharjo Fish Smoking Center, Semarang City. However, the higher the age, nutritional status (BMI), the percentage of carbohydrate intake, and the percentage of fat intake, the higher the level of work fatigue, and vice versa. Meanwhile, the lower the percentage of PAL, the higher the level of work fatigue that will occur, and vice versa. Meanwhile, in the EAL respondents tended to have no difference in the level of work fatigue.

Therefore, it is necessary to maintain and regulate the intake of energy and macro-nutrients (carbohydrates, fats and proteins) for the workforce according to their actual needs. In addition, each fish smoking place needs to make definite rest time arrangements for workers, namely 1 hour or 2 hours after work activities or at least after 4 hours of work activities due to reduced or depleted workforce energy during carrying out these work activities, in order to avoid or prevent significant work fatigue to support optimal work productivity.

Ethics approval

This research has been declared ethically feasible according to 7 (seven) WHO Standards 2011, namely: (1) Social Value; (2) Scientific Value; (3) Equalization of Burden and Benefits; (4) Risk; (5) solicitation/exploitation; (6) Confidentiality and Privacy; (7) Consent After Explanation; which refers to the 2016 CIOMS Guidelines. This is demonstrated by the fulfillment of indicators for each standard. This research has a Certificate of Passing Ethics Review with Number 314/EA/KE PK-FKM/2022.

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Author Contribution

SF analyzes and interprets data, develops research methods, explores strategies and observational studies, creates research instruments, collects research data and discusses research data, as well as processes writing and selects research samples. S, AFA, MIK assessed the quality of the data as well as checked the data and analyzed the writing.

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