Journal of Global Nutrition (JGN)
Volume 6 No 1 (2026) April: page 766-775
ISSN: 2776-7051
Published by *Ikatan Sarjana Gizi Indonesia (ISAGI)* – The Indonesian Nutrition Scholars Association

Original Research

The Relationship between Energy Intake, Macronutrient Intake, Nutritional Status, and Work Fatique among *Shift* Security Officers at State University of Surabaya

Hubungan Tingkat Asupan Energi, Zat Gizi Makro, dan Status Gizi terhadap Tingkat Kelelahan Kerja pada Pegawai Shift Satuan Pengamanan Universitas Negeri Surabaya

Lusia Estu Ariningtyas[1], Lini Anisfatus Sholihah[1]
[1]Program Study of Nutrition, State University of Surabaya, Surabaya, Indonesia

* Email corresponding author: lusiaestu.22025@mhs.unesa.ac.id

Abstract:
Work fatigue is a critical issue that can reduce productivity, increase the risk of occupational accidents, and negatively affect workers' health, particularly among shift workers. Work fatigue is influenced by various factors, including inadequate nutritional status and nutrient intake. Security personnel are a vulnerable occupational group due to high alertness demands and circadian rhythm disruption caused by shift work systems. This quantitative study employed a cross-sectional design and involved the total population of security personnel working morning, afternoon, and night shifts (24 respondents per shift) at State University of Surabaya. Data collection instrument using the Industrial Fatigue Research Committee questionnaire, 2×24-hour food recall, microtoice, and a digital scale. The results showed significant associations between carbohydrate intake (p = 0.004; r = 0.334) and protein intake (p = 0.003; r = 0.346) with work fatigue levels, while energy intake, fat intake and nutritional status was not significantly associated with work fatigue among shift security personnel at State University of Surabaya. The findings of persistently deficient dietary intake, overweight nutritional status, and high levels of work fatigue particularly among night shift workers highlights the need for regular health monitoring of workers by the outsourcing company.

Key word: *Work Fatigue, Energy Intake, Macronutrient Intake, Nutritional Status, Shift Workers*.

1. INTRODUCTION

Human resources play a crucial role in determining the success of organizational performance therefore, maintaining workers' health and safety is essential to ensure optimal productivity [1]. Occupational health focuses on promoting and maintaining the physical, mental, and social well-being of workers, which directly influences their work efficiency and productivity. According to the International Labour Organization (ILO) and World Health Organization (WHO), occupational health is closely related to workplace conditions and work activities that may affect the health status and performance of employees [2].

One of the major issues affecting worker productivity is work fatigue, which is commonly experienced by employees who work under demanding conditions, particularly those with shift work schedules [3]. The International Labour Organization reports that work fatigue contributes to approximately 32% of occupational accidents globally, with around 374 million work-related injuries occurring each year. In Indonesia, data from Employment Social Security Agency of Indonesia shows a

significant increase in occupational accident cases from 117,161 cases in 2020 to 234,270 cases in 2021 [4]. Highlighting the importance of identifying factors associated with work fatigue among workers [5].

Nutrient intake and nutritional status are important factors that may influence the level of work fatigue among workers. Previous studies have shown that shift workers still experience various nutritional problems, including obesity (21.8%), overweight (19.5%), and underweight (5.7%), which are associated with work fatigue and irregular eating patterns [5]. Adequate intake of macronutrients, particularly carbohydrates, proteins, and fats, is essential for the body to produce energy through metabolic processes that support muscle activity and the formation of adenosine triphosphate (ATP). Insufficient energy intake can reduce ATP production and increase the accumulation of lactic acid in muscles, which may contribute to the onset of work fatigue [6]. In addition, shift workers are more susceptible to disruptions in circadian rhythms that can affect sleep patterns, dietary habits, and health-related behaviors, thereby increasing the risk of chronic diseases such as obesity, hypertension, and diabetes [7]. Other factors, including excessive energy intake, smoking habits, and low levels of physical activity, may also elevate the risk of central obesity among workers [8].

Although several studies have investigated the relationship between nutritional intake, nutritional status, and work fatigue among workers, research focusing specifically on security personnel working in educational institutions with shift systems is still limited. Security officers have job characteristics that involve both physical and mental demands, prolonged working hours, and rotating shifts that can disrupt sleep patterns and daily routines [1]. In addition, certain lifestyle factors commonly found among security personnel, such as smoking habits and low physical activity, may further influence oxygen supply and physical endurance, potentially worsening fatigue conditions. Central obesity, characterized by excessive fat accumulation in the abdominal area, is also frequently observed among security personnel and may reduce their physical work capacity [9].

Considering these conditions, identifying the relationship between nutritional intake, nutritional status, and work fatigue among shift workers is important to support workplace health promotion and improve worker productivity. Therefore, this study aims to analyze the relationship between energy intake, macronutrient intake, nutritional status, and the level of work fatigue among shift security personnel at State University of Surabaya. The findings of this study are expected to contribute to the understanding of nutritional and occupational factors associated with work fatigue and provide evidence for developing effective interventions to improve the health and productivity of shift workers.

2. METHODS

This study was a quantitative research using an analytic observational design with a cross-sectional approach. Data collection was conducted in September 2025 at the Universitas Negeri Surabaya campus located in Lidah Wetan. The sampling technique applied was cluster sampling, in which samples were selected based on personnel in each shift that had been previously scheduled. The population consisted of 72 security personnel at Universitas Negeri Surabaya, who were divided into three groups according to their work shifts: Group A (morning shift), Group B (afternoon shift), and Group C (night shift), with each group comprising 24 employees. Sample selection was

conducted based on predefined inclusion and exclusion criteria. The inclusion criteria were as follows: participants provided informed consent to take part in the study, were shift-working security personnel at Universitas Negeri Surabaya, were aged between 18 and 50 years, had a minimum of one year of work experience, and were in a conscious state with adequate communication abilities. The exclusion criteria included personnel aged over 50 years, as well as those who were currently ill or had a medically diagnosed history of type 2 diabetes mellitus or cardiovascular disease. Data on work fatigue levels were collected using the Industrial Fatigue Research Committee (IFRC) questionnaire. Data on energy intake and macronutrient intake were obtained through interviews using a 2×24-hour food recall instrument conducted on both weekdays and weekends. Anthropometric data used to determine nutritional status were collected by measuring respondents' body weight and height. Body weight was measured using a digital scale, while height was measured using a microtoise. Nutritional status was then calculated using the Body Mass Index (BMI) formula. Data analysis was performed using univariate and bivariate approaches. Univariate analysis was used to describe the distribution and percentage of each variable, and the results were presented in tabular form, including descriptions of age, length of employment, education level, and history of disease. Bivariate analysis was conducted to examine the relationship between energy intake, macronutrient intake, and nutritional status with the level of work fatigue among shift security personnel at Universitas Negeri Surabaya. The analysis employed the Spearman rank correlation test using SPSS version 27 software.

3. RESULTS

Univariate analysis was conducted to determine the distribution of data such as age, education level, history of disease, length of employment, smoking habits, and coffee consumption. The characteristics of the respondents are presented as follows.

Table 1. Frequency Distribution of Respondent Characteristics

Characteristics	Morning Shift		Afternoon Shift		Night Shift		n	%
	n	%	n	%	n	%		
Age								
18–25 years	14	58,3	12	50	9	37,5	35	48,6
>25–35 years	7	29,2	10	41,7	8	33,3	25	34,7
>35–50 years	3	12,5	2	8,3	7	29,2	12	16,7
Educational History								
Senior High School	16	66,7	13	54,2	10	41,7	39	54,2
Vocational High School	7	29,2	10	41,7	10	41,7	27	37,5
Bachelor's Degree	1	4,2	1	4,2	4	16,7	6	8,3
Medical History								
Hypercholesterolemia	5	20,8	1	4,2	5	20,8	11	15,3
Gout Arthritis	0	0	2	8,3	2	8,3	4	5,6
No history of disease	19	79,2	21	87,5	17	70,8	57	79,1
Length of Employment								
1 – 3 years	13	48,6	10	41,7	10	41,7	33	45,8
> 3 – 5 years	6	34,7	8	33,3	8	33,3	22	30,6
> 5 years	5	16,7	6	25	6	25	17	23,6
Smoking Habits								
1–6 cigarettes/day	8	33,3	6	25	5	20,8	19	26,4
7-12 cigarettes/day	10	41,7	6	25	7	29,2	23	31,9
> 12 cigarettes/day	1	4,2	4	16,7	8	33,3	13	18,1
Non-smoker	5	20,8	8	33,3	4	16,7	17	23,6
Coffee Consumption								
1 – 2 times/day	11	45,8	11	45,8	6	25	28	38,9

3 – 5 times/day	3	12,5	5	20,8	16	66,7	24	33,3
No coffee consumption	10	41,7	8	33,3	2	8,3	20	27,8

Based on the results presented in Table 1, all respondents in this study were male (n=72). The majority were aged 18–25 years, categorized as late adolescents for 35 respondents (48.6%). Most respondents had completed senior high school education, with a total of 39 respondents (54.2%). In terms of health status, the majority of respondents reported no history of disease, totaling 57 respondents (79.2%). Furthermore, most respondents had a length of employment of 1–3 years, comprising 33 respondents (45.8%). Regarding smoking behavior, the largest group of respondents consumed 7–12 cigarettes per day, amounting to 23 respondents (31.9%). In addition, the majority of respondents reported consuming coffee 1–2 times per day, with 28 respondents (38.9%). The types of coffee commonly consumed included both brewed coffee and instant coffee.

Table 2. Frequency Distribution of Energy Intake, Macronutrient Intake, Nutritional Status, and Work Fatigue Categories among Shift Security Personnel at UNESA

Adequacy Level	Morning Shift		Afternoon Shift		Night Shift		n	%
	n	%	n	%	n	%		
Energy								
Deficit	8	33,3	16	66,7	9	37,5	33	45,8
Adequate	12	50	8	33,3	13	54,2	33	45,8
Excess	4	16,7	0	0	2	8,3	6	8,4
Carbohydrate								
Deficit	14	58,3	17	70,8	7	29,2	38	52,8
Adequate	9	37,5	4	16,7	6	25	19	26,4
Excess	1	4,2	3	12,5	11	45,8	15	20,8
Protein								
Deficit	16	66,7	12	50	10	41,7	38	52,8
Adequate	6	25	9	37,5	5	41,7	20	27,8
Excess	2	8,3	3	12,5	9	16,7	14	19,4
Fat								
Deficit	8	33,3	7	29,2	1	4,2	16	22,2
Adequate	4	16,7	9	37,5	5	20,8	18	25
Excess	12	50	8	33,3	18	75	38	52,8
Nutritional Status								
Unerweight	2	8,4	0	0	3	12,5	5	6,9
Normal	11	45,8	10	41,7	10	41,7	31	43,1
Overweight	11	45,8	14	58,3	11	45,8	36	50
Work Fatigue								
Mild	7	29,2	11	45,8	8	33,3	26	36,1
Moderate	15	62,5	9	37,5	6	25	30	41,7
Severe	2	8,3	4	16,7	10	41,7	16	22,2

Based on Table 2, the distribution of energy intake shows that most respondents were classified in the deficit and normal categories, each comprising 33 individuals (45.8%). By work shift, normal energy intake was more common among morning and night shift, while the afternoon shift was predominantly by energy deficit. Carbohydrate intake was largely deficient (52.8%), particularly among morning and afternoon shifts. Protein intake also tended to be deficient (52.8%), with deficit categories dominating the morning and afternoon shifts. In contrast, fat intake was predominantly excessive (52.8%), especially among morning and night shift workers. Based on Body Mass Index

(BMI), half of the respondents (50%) were classified as overweight across all shifts. Regarding work fatigue, moderate fatigue was the most prevalent category (41.7%), with morning shift workers mostly experiencing moderate fatigue, afternoon shift workers experiencing mild fatigue, and night shift workers showing the highest prevalence of severe fatigue.

Table 3. The Relationship between Energy Intake, Macronutrient Intake, and Nutritional Status and Work Fatigue Levels among Shift Workers at UNESA

Adequacy Level	Work Fatigue						n		*p-value*	ρ
	Mild		Moderate		Severe					
	n	%	n	%	n	%	n	%		
Energy										
Deficit	13	50	15	50	5	31,3	33	45,8	0,384	-
Adequate	11	42,3	12	40	10	62,5	33	45,8		
Excess	2	7,7	3	10	1	6,3	6	8,3		
Carbohydrate										
Deficit	17	65,4	16	53,3	5	31,3	38	52,8	0,004	0,334
Adequate	8	30,8	8	26,7	3	18,8	19	26,4		
Excess	1	3,8	6	20	8	50	15	20,8		
Protein										
Deficit	16	61,5	20	66,7	2	12,5	38	52,8	0,003	0,346
Adequate	8	30,8	5	16,7	7	43,8	20	27,8		
Excess	2	7,7	5	16,7	7	43,8	14	19,4		
Fat										
Deficit	5	19,2	8	26,7	3	18,8	16	22,2	0,842	-
Adequate	7	26,9	8	26,7	3	18,8	18	25		
Excess	14	53,8	14	46,7	10	62,5	38	52,8		
Nutritional Status										
Unerweight	1	3,8	3	10	1	6,3	5	6,9	0,457	-
Normal	11	42,3	14	46,7	6	37,5	31	43,1		
Overweight	14	53,8	13	43,3	9	56,3	36	50		

Based on Table 3. The results of the bivariate analysis indicate that there is a significant relationship between carbohydrate intake (p=0.004; ρ=0.334) and protein intake (p=0.003; ρ=0.346) with work fatigue levels, showing a positive direction and moderate strength of correlation. This suggests that lower adequacy of carbohydrate and protein intake is associated with higher levels of work fatigue. Meanwhile, energy intake (p=0.384), fat intake (p=0.842), and nutritional status (p=0.457) were not significantly associated with work fatigue levels among shift security personnel at Universitas Negeri Surabaya.

4. DISCUSSION

This study found characteristics that most respondents were in the late adolescence age group (18–25 years), indicating that security personnel are generally in a phase of relatively high productivity, with the majority reporting no history of disease. Late adolescence has a high potential for productivity, supported by optimal physical condition, cognitive abilities, and motivation [10]. This productivity may not yet be maximized due to limited work experience and emotional maturity, and therefore still requires adaptation to the work environment. However, a considerable proportion of personnel reported smoking 7–12 cigarettes per day. This habit may contribute to pulmonary tissue damage and reduced oxygen supply, thereby increasing susceptibility to fatigue [11]. The nicotine content in cigarettes can elevate heart rate and blood pressure, placing additional strain on the cardiovascular system.

Furthermore, coffee consumption, due to its caffeine content, may inhibit the action of adenosine, a compound involved in regulating alertness [12]. Once the effects of caffeine subside, individuals may experience increased fatigue, decreased energy levels, and impaired sleep quality [13].

This study found Energy intake plays a crucial role in supporting metabolic processes and physiological functions, with the findings indicating that the majority of respondents were classified in the deficit and normal categories (45.8%). These results are consistent with studies by Susanti and Yanti (2024), which reported a predominance of energy deficits among shift workers due to irregular eating patterns. In terms of carbohydrate intake, most respondents were categorized as deficient. However, night shift workers tended to exhibit excessive intake due to the consumption of simple carbohydrate-rich foods, which is associated with the influence of circadian rhythm on dietary patterns [14]. Protein intake was also predominantly deficient, reflecting inadequate protein consumption that may adversely affect physical fitness [15]. Meanwhile, fat intake was largely excessive, particularly among night shift workers, which can be attributed to frequent consumption of high-fat foods and midnight snacking due to circadian rhythm disruption and hormonal regulation [16]. Nutritional status was predominantly classified as overweight, indicating a high prevalence of excess body weight among workers, likely due to imbalanced dietary patterns and low physical activity levels [17]. Furthermore, work fatigue was mostly observed at a moderate level, with the highest prevalence of severe fatigue found among night shift workers, suggesting that night work increases the risk of fatigue due to circadian rhythm disturbances [18]. This study found that energy intake was not found to be significantly associated with work fatigue levels among shift security personnel at Universitas Negeri Surabaya ($p>0.05$). This finding may be attributed to the relatively normal distribution of dietary intake and fatigue levels among respondents. The results are consistent with previous studies by Farihatin and Subandriani (2023) and Sari et al. (2023), which also reported no significant association, possibly due to generally low energy intake and limited nutritional knowledge among workers. Physiologically, energy intake serves as a source of glycogen and oxygen required for muscle contraction, particularly when blood glucose levels decrease [6]. Glycogen is subsequently broken down into glucose through glycolysis to produce pyruvate and Adenosine Triphosphate (ATP). In conditions of insufficient oxygen availability, pyruvate is converted into lactic acid, leading to its accumulation in muscles, which can disrupt contraction processes and reduce energy availability. This imbalance between energy supply and oxygen demand may increase the risk of work fatigue, although it was not found to be significantly associated in this study [19]. Carbohydrate intake in this study showed a significant and moderately positive relationship with work fatigue levels among shift workers ($p<0.05$). This finding is consistent with Ayu and Djamalus (2025), who reported that night shift work is associated with a higher risk of severe work fatigue. Carbohydrates serve as the primary energy source for the body, where they are converted into glucose, absorbed into the bloodstream, and metabolized through oxidation and the Krebs cycle to produce energy required for work activities [20]. Furthermore, carbohydrate intake is closely related to metabolic conditions among night shift workers, as consumption that is not aligned with circadian rhythms is associated with chrononutrition, which may reduce glucose tolerance and increase insulin resistance [21]. This condition is also linked to increased stress hormones such as cortisol and activation of the sympathetic nervous system, which can influence appetite-regulating hormones such as ghrelin, thereby increasing hunger and affecting dietary patterns.

Protein intake showed a significant association with work fatigue levels among shift workers ($p<0.05$). This finding is consistent with Hasanah et al. (2024), which reported that workers tend to have higher energy levels in the morning compared to the night. When energy declines and work performance decreases due to fatigue and inadequate protein intake [22]. Night shift workers are more likely to experience severe fatigue alongside protein deficiency. Insufficient protein intake may impair cell regeneration processes, while work-related stress during night shifts can increase cortisol levels, stimulating the breakdown of body protein into amino acids[23]. These amino acids are subsequently utilized in gluconeogenesis in the liver to produce glucose as an energy source, which, if sustained over time, may accelerate fatigue among night shift workers [24]. During night shifts, tissue maintenance demands tend to increase due to circadian rhythm disruption and inadequate rest periods [25]. Amino acids derived from protein metabolism play a crucial role in maintaining muscle function and metabolic enzyme activity; therefore, protein deficiency may further accelerate the onset of work fatigue as the body is unable to recover optimally [26].

Fat intake was not significantly associated with work fatigue levels among shift workers ($p>0.05$). This finding is consistent with Farihatin et al. (2022), which also reported no significant relationship between fat intake and work fatigue. This may be because daily fat intake does not match the body's nutritional needs [26]. Night shift workers often consume high-fat and practical foods such as fried snacks and instant noodles. Although excessive fat intake may increase the risk of severe fatigue and contribute to health problems such as obesity, hypertension, and hypercholesterolemia, its direct association with fatigue was not observed in this study [11]. Excess dietary fat is stored as triglycerides in adipose tissue, which is distributed in various parts of the body, including subcutaneous, visceral, and intramuscular regions [27]. High-fat consumption may lead to increased visceral fat accumulation, contributing to central obesity [28]. The accumulation of visceral fat can exert pressure on the diaphragm, limiting optimal lung expansion and impairing oxygen exchange. Reduced oxygen availability may disrupt physiological and metabolic processes, particularly in muscle tissue [19]. Under hypoxic conditions, muscle energy metabolism shifts to anaerobic pathways, resulting in lactic acid production. The accumulation of lactic acid in muscles and circulation can reduce muscle performance and increase the risk of work fatigue [29].

Nutritional status was not significantly associated with work fatigue levels among shift workers ($p>0.05$). This finding is consistent with Wulandari (2022), who also reported an association between nutritional status and work fatigue among production workers, where the majority of respondents were classified as overweight and experienced high levels of fatigue. Excess nutritional status is linked to an increased metabolic burden and impaired metabolic regulation, particularly among night shift workers who experience circadian rhythm misalignment [18]. Workers engaged in night shift systems have a higher risk of developing obesity due to disrupted circadian rhythms [30]. Obesity is also associated with a greater risk of metabolic diseases, which may reduce work performance among night shift employees [31]. Changes in sleep patterns, dietary habits, and daily activities contribute to metabolic imbalances that increase the risk of weight gain [32]. Among security personnel, irregular meal schedules and unbalanced food choices further contribute to the increased risk of overweight [33]. Imbalanced nutritional status not only affects physical fitness but may also reduce productivity and work performance, highlighting the importance of addressing nutritional factors in occupational health improvement efforts.

5. CONCLUSION

The results of this study show that most security personnel at Universitas Negeri Surabaya were in the late adolescence age group, had no history of disease, and demonstrated lifestyle habits such as smoking and coffee consumption that may contribute to fatigue. The study found that energy intake, fat intake, and nutritional status were not significantly associated with work fatigue levels among shift workers. In contrast, carbohydrate and protein intake showed a significant relationship with work fatigue, indicating that inadequate intake of these nutrients may contribute to increased fatigue among shift personnel. Overall, work fatigue was predominantly at a moderate level, with the highest proportion of severe fatigue observed among night shift workers. These findings suggest that nutritional intake, particularly carbohydrate and protein consumption, should receive greater attention in efforts to reduce work fatigue and support the health and productivity of security personnel. It is recommended that outsourcing companies improve regular health monitoring for shift workers to detect health problems early. Nutrition education is also important, especially about meeting energy and macronutrient needs. Future research should explore other factors related to work fatigue, such as sleep quality, work accidents, and chronotype, which may affect fatigue in shift workers.

REFERENCES

[1] R. W. Setianingtyas, B. I. Kandarina, and Y. Hartriyanti, "Hubungan antara Asupan Energi, Protein, dan Status Gizi Terhadap Produktivitas Kerja Pada Pekerja Shift Petugas Pusat Keamanan, Keselamatan, Kesehatan Kerja dan Lingkungan (PK4L) UGM," *J. Ilm. Gizi dan Kesehat.*, vol. 43, no. 1, pp. 97–102, 2023.

[2] N. C. Momen *et al.*, "The Effect of Occupational Exposure to Welding Fumes on Trachea, Bronchus and Lung Cancer: A Systematic Review and Meta-Analysis From the WHO/ILO Joint Estimates of The Work-Related Burden of Disease and Injury," *Environ. Int.*, vol. 170, no. July 2024, p. 109216, 2022, doi: 10.1016/j.envint.2022.107565.

[3] E. D. Safira, R. M. Pulungan, and C. Arbitera, "Kelelahan Kerja pada Pekerja di PT. Indonesia Power Unit Pembangkitan dan Jasa Pembangkitan (UPJP) Priok," *J. Kesehat.*, vol. 11, no. 2, pp. 265–271, 2020, doi: 10.26630/jk.v11i2.2134.

[4] S. Y. Arini, "The Causes of Work Incident According to Work Shift System on Operator of a Woven Bag Company, Sidoarjo," *Indones. J. Occup. Saf. Heal.*, vol. 10, no. 2, pp. 233–239, 2021, doi: 10.20473/ijosh.v10i2.2021.233-239.

[5] W. N. Bahy, A. P. Prabandari, and K. C. S. Wibawa, "The Impact of ILO Convention No. 182 (1999) on Safeguarding Against Child Labor in Indonesia," *Int. J. Multidiscip. Res. Anal.*, vol. 07, no. 04, pp. 1472–1477, 2024, doi: 10.47191/ijmra/v7-i04-06.

[6] M. R. Dengo, M. Kau, and W. Hafid, "Hubungan Asupan Energi dan Status Gizi terhadap Kelelahan Kerja pada Penyapu Jalan," *Gorontalo J. Public Heal.*, vol. 6, no. 1, pp. 59–66, 2023.

[7] J. K. Devine, J. Choynowski, and S. R. Hursh, "Potential Effects of Permanent Daylight Savings Time on Daylight Exposure and Risk during Commute Times across United States Cities in 2023–2024 Using a Biomathematical Model of Fatigue," *Safety*, vol. 9, no. 3, 2023, doi: 10.3390/safety9030059.

[8] A. D. Anindya, T. Sudiarti, S. A. Pujonarti, W. K. Y. Putra, A. Regita, and D. D. Raside, "Faktor Dominan yang Berhubungan dengan Obesitas Sentral pada Anggota Polri Laki-Laki di Kepolisian Resort X Provinsi Jawa Timur Tahun 2024," *J. Kesehat. Masy.*, vol. 1, no. 1, p. 149, 2024.

[9] A. Alifyanti, K. Safitri, L. M. Saleh, F. Naiem, and S. S. Russeng, "The Influence of Individual Characteristics , Workload , Work Shift , and Work Fatigue on The Performance of Aviation Security Employees at Sultan Hasanuddin International Airport in Makassar," vol. 23, pp. 1807–1821, 2025.

[10] S. M. Arsanti, Farapti, and Q. Rachmah, "Relationship between Adequacy Level of Nutritional Intake, Hydration Status, and Work Fatigue with Employee Productivity of PT. PAL Indonesia (Persero)," *Media Gizi Indones.*, vol. 18, no. 1, pp. 28–37, 2023, doi: 10.20473/mgi.v18i1.28-37.

[11] K. Tidur, D. A. N. Beban, K. Dengan, and C. K. Permata, "Hubungan Kebiasaan Merokok, Konsumsi Kopi, Kualitas Tidur, dan Beban Kerja dengan Kelelahan Kerja Operator Dump Truck Pt Wijaya Inti Nusantara," *J. Kesehat. Unggul Gemilang*, vol. 9, no. 3, pp. 19–35, 2025.

[12] H. H. Assegaf, . S., and . M., "The Effect of Coffee Consumption on Blood Pressure and Sleep Duration of Baristas in Majalengka," *J. Appl. Food Nutr.*, vol. 2, no. 2, pp. 60–66, 2021, doi: 10.17509/jafn.v2i2.42721.

[13] J. J. Knapik, R. A. Steelman, D. W. Trone, E. K. Farina, and H. R. Lieberman, "Prevalence of Caffeine Consumers, Daily Caffeine Consumption, and Factors Associated with Caffeine use among Active duty United States military Personnel," *Nutr. J.*, vol. 21, no. 1, pp. 1–19, 2022, doi: 10.1186/s12937-022-00774-0.

[14] E. P. Sunansyah, T. P. Harjatmo, G. K. W. Kamboja, and S. Wiyono, "Hubungan Asupan Energi, Zat Gizi Makro, dan Zat Gizi Mikro dengan Status Gizi Pada Pegawai di Kantor Kebangpol Kota Tangerang Selatan," *J. Gizi dan Kesehat.*, vol. 4, no. 1, pp. 78–86, 2024.

[15] A. Farihatin, D. N. Subandriani, and Y. Setiadi, "Hubungan Status Gizi, Beban Kerja, Asupan Energi dan Zat Gizi Makronutrien dengan Kelelahan Kerja Pada Tenaga Produksi," *J. Ris. Gizi*, vol. 10, no. 2, pp. 143–152, 2022, doi: 10.31983/jrg.v10i2.10744.

[16] L. A. Schrader, S. M. Ronnekleiv-kelly, J. B. Hogenesch, C. A. Bradfield, and K. M. C. Malecki, "Circadian Disruption, Clock Genes, and Metabolic Health," *J. Clin. Investig.*, vol. 134, no. 14, pp. 1–18, 2024.

[17] K. Ayu and H. Djamalus, "Faktor Risiko Kelelahan Kerja pada Pekerja Satuan Pengamanan," *J. Ilm. Indones.*, vol. 10, no. 6, pp. 8481–8493, 2025.

[18] A. Ulandari, M. S. Noor, I. H. Noor, and M. A. Nisa, "Hubungan Beban Kerja, Durasi Kerja, dan Ritme Sirkadian terhadap Kelelahan Kerja Perawat," *Media Kesehat. Masy. Indones.*, vol. 15, no. 1, pp. 8–20, 2024.

[19] A. Farihatin and D. N. Subandriani, "Hubungan Status Gizi, Beban Kerja, Asupan Energi dan Zat Gizi Makronutrien dengan Kelelahan Kerja pada Tenaga Produksi di Pt. Selaras Citra Lestari Bawen," *J. Compr. Sci.*, vol. 2, no. 6, pp. 1907–1920, 2023.

[20] W. Widyaningrum, T. U. Kusuma, A. C. Mustikaningrum, and R. Moviana, "Hubungan antara Asupan Makan dan Kelelahan Kerja dengan Produktivitas Tenaga Kerja di Tempat

Produksi Kerupuk Rambak Wilayah Kecamatan Pegandon Kabupaten Kendal," *J. Surya Muda*, vol. 6, no. 1, pp. 90–101, 2024.

[21] N. B. Cunha *et al.*, "A High-Protein Meal during a Night Shift Does Not Improve Postprandial Metabolic Response the Following Breakfast : A Randomized Crossover Study with Night Workers," *Nutrients*, vol. 12, no. 1, pp. 1–16, 2020.

[22] Y. P. Daswin, N. Rany, and S. Desfita, "Relationship Of Nutritional Status, Energy Intake And Work Activities Towards Work Fatigue Of Employees At Nutritional Installations Of Awal Bros Hospital Pekanbaru," *Media Kesmas (Public Heal. Media)*, vol. 1, no. 3, pp. 10–12, 2021.

[23] S. O. Sari, R. Kurniasari, and L. R. Sefrina, "Asupan Zat Gizi Makro dan Status Gizi dengan Tingkat Kelelahan pada Pekerja Dinas Tenaga Kerja Kota Bekasi," *Media Publ. Promosi Kesehat. Indones.*, vol. 6, no. 11, pp. 2201–2209, 2023, doi: 10.56338/mppki.v6i11.3885.

[24] G. M. O. Mangeka, "Gambaran Asupan Zat Gizi Makro, Serat, dan Natrium pada Pekerja di Site Awak Mas PT Masmindo Dwi Area," *J. Kesehat. Masy. Gizi*, vol. 1, no. 8, pp. 1–15, 2023.

[25] Asmani, A. S. Raksanagara, and S. Wiramihardja, "Hubungan Shift Kerja Dengan Tingkat Kelelahan Pada Cleaning Service di Terminal 2D Bandar Udara Soekarno-Hatta," *J. Sist. Kesehat.*, vol. 5, no. 4, pp. 176–183, 2020.

[26] M. S. Thorkildsen, L. T. Gustad, and J. K. Damås, "The Effects of Shift Work on the Immune," *Brazilian Sleep Assoc.*, vol. 16, no. 3, pp. 368–374, 2023.

[27] R. Amela, V. Melani, L. Sitoayu, M. Kuswari, and R. Nuzrina, "Hubungan Kontribusi Energi, Zat Gizi Makro dan Persentase Lemak Total Tubuh terhadap Indeks Massa Tubuh Karyawan Departemen Operasional (Shift) di Pt. Jakarta International Container Terminal (JICT)," *JNH (Journal Nutr. Heal.*, vol. 1, no. 1, pp. 1–8, 2021.

[28] P. Kurniasanti, "Hubungan Asupan Energi, Lemak, Serat, dan Aktivitas Fisik dengan Visceral Fat pada Pegawai Uin Walisongo Semarang," *J. Gizi Pangan dan Apl.*, vol. 4, no. 2, pp. 139–152, 2020, doi: 10.21580/ns.2020.4.2.7150.

[29] N. K. Susanti and R. Yanti, "Hubungan Shift Kerja, Kualitas Tidur dan Asupan Energi dengan Kelelahan Kerja pada Karyawan Bidang Produksi (Studi di PT. Q Kalimantan)," *JGK (Jurnal Gizi dan Kesehatan)*, vol. 16, no. 1, pp. 61–69, 2024.

[30] M. G. de Rijk *et al.*, "Macronutrient Intake and Alertness During Night Shifts – The Time Interval Matters," *Front. Nutr.*, vol. 10, no. 3, pp. 1–12, 2023, doi: 10.3389/fnut.2023.1245420.

[31] S. Ramadhan and I. Yuliana, "Hubungan antara Asupan Energi dan Zat Gizi dengan Kejadian Obesitas pada Pekerja Shift di Pt . Pelabuhan Tanjung Priok Cabang Palembang," *J. Heal. Sci. Gorontalo J. Heal. Sci. Community*, vol. 3, no. 1, p. 21, 2021.

[32] B. N. Harding *et al.*, "Metabolic Profiling of Night Shift Work," *Chronobiol. Int.*, vol. 39, no. 11, pp. 1508–1516, 2022, doi: 10.1080/07420528.2022.2131562.

[33] K. Desmarta *et al.*, "Status Gizi dan Kebutuhan Energi Pekerja Pabrik di Indonesia," *Nutr. (Nutrition Res. Dev. Journal)*, vol. 3, no. 3, pp. 58–65, 2023.