The Indonesian Journal of Occupational Safety and Health
2025, 14 (1): 79-88
p ISSN: 2301 8046, e ISSN: 2540 7872
http://doi.org10.20473/ijosh.v14i1.2025.79-88

ORIGINAL ARTICLE

The Impact of Physical Workload and Personal Factors on Nutritional Status Among Manufacturing Workers: A Cross-Sectional Study

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ABSTRACT

Introduction: Occupational health must be considered in the workplace. Cases of overweight and obesity among workers in the manufacturing sector have increased. This study analyzes the relationship between physical workload and personal factors related to nutritional status among manufacturing workers. **Methods:** This study used an observational analytic study with a cross-sectional design. The variables of this study were physical workload, nutritional status, and personal factors such as gender, educational level, exercise habits, and smoking habits. The sample in this study was 239 workers in the manufacturing industry, and it was obtained using random sampling techniques. Data were analyzed using the Spearman correlation and coefficient contingency test. **Result:** More than half of the total cases of overweight and obesity occur in manufacturing workers who have a low physical workload. More than half of the respondents are female, do not have a high school education, and have never exercised. Most do not have a smoking habit. The results showed that physical workload (p=0.001), exercise habits (p=0.001), gender (p=0,004), and educational level (p=0.037) were related to nutritional status. In contrast, manufacturing workers' smoking habits were not associated with nutritional status (p>0.05). *Conclusion:* Physical workload, exercise habits, gender, and educational level have a relationship with nutritional status among workers, it is recommended that workers must increase their exercise routine such as implementing scheduled sports shifts for workers and providing sports facilities in companies so the case of being obesity can be decreased.

Keywords: manufacturing workers, nutritional status, obesity, personal factor, physical workload

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INTRODUCTION

Nutritional status is a person's health condition determined by the balance between nutrient intake and the body's nutritional needs. Obesity is one of the negative indicators of nutritional status. This condition indicates an imbalance between energy intake and the body's energy requirements, where energy intake greatly exceeds what the body needs. As a result, the excess energy is stored as body fat, which, in the long term, can increase the risk of various chronic diseases such as diabetes, hypertension, and heart disease. Obesity is an important public health problem in the industrial sector because of its size, rapid growth, and negative impact on the health of people who suffer from it in both industrialized and developing countries. Obesity is a condition in which the calculation of Body Mass Index is more than 27 (Armenta-Hernandez *et al.*, 2020). Obesity has been increasing worldwide since 1975. As many as 1.9 billion adults in the world are overweight, with more than 650 million of them classified as obese according to the WHO (Ahmed and Konje, 2023). The prevalence of obesity in adults over 18 years old in Indonesia has increased from year to year, starting from 2013 (19.6% male, 32.90% female), 2016 (24.00% male, 41.60% female) to 2018 (26.60% male, 44.40%

Cite this as: *Lutfiya, I., et al. (2025) 'The Impact of Physical Workload and Personal Factors on Obesity Among Manufacturing Workers: A Cross-Sectional Study', The Indonesian Journal of Occupational Safety and Health, 14(1), pp. 79-88.*

 doi:10.20473/ijosh.v14i1.2025.79-88. Received December 22, 2024; 1st revision March 14, 2025; 2nd revision March 17, 2025; Accepted April 28, 2025; Published: April 2025. Published by Universitas Airlangga.

female) (BPS, 2021). Total losses due to obesity in Indonesia are around Rp78.478 billion/year or equivalent to 0.9% of Indonesia's Gross Domestic Product (Wulansari, Martianto and Baliwati, 2016).

One of the companies affected by obesity is a manufacturing company. Manufacturing is the third-largest sector and consistently the largest contributor to Indonesia's economic growth. (Satrya *et al.*, 2024). The manufacturing industry refers to the sector involved in the large-scale production of goods, which utilizes various processes and technologies to convert raw materials into finished products. The industry is characterized by fierce competition and the need to adapt to the rapidly changing business environment. (Pramanik *et al.*, 2019).

Some of the impacts caused include metabolic syndrome, hypertension, increased cholesterol, sleep apnea, Low Back Pain, knee osteoarthritis, gallstone formation and complications of diseases that cause obesity can result in death (Kawai, Autieri and Scalia, 2021). Obesity is also associated with symptoms of low self-esteem, increased healthcare costs for workers and employers, and decreased employee productivity (Mukhopadhyay, 2021). Obesity and long-term health conditions have a longitudinal relationship with presenteeism, regardless of socio-demographic confounding health, lifestyle, and occupation (Keramat *et al.*, 2020). Workplace injuries can also be associated with obesity. Employees who are obese may be at higher risk of work injuries for several reasons, including impaired gait and mobility, fatigue due to sleep apnea, poor ergonomics, and the use of potentially calming medications to treat obesity-related diseases. In addition, obesity can alter the risk of injury because the body's ability to tolerate harmful energy exposure is impaired, especially among employees who are already engaged in dangerous and/or physically demanding work (Boocock *et al.*, 2024). Obesity has a different impact on productivity and costs, depending on the type of work (Mazhar and Rehman, 2022).

Many factors are related to obesity and productivity. Obesity and high physical workload are associated with poor workability and have synergistic and negative effects on workability (Tonnon *et al.*, 2019). Body mass index and worker activity level are significantly related to physical workload. At the beginning of a working career, neither BMI nor activity level affects personal workload. However, in addition to age-related declines in function, BMI and activity levels, together and separately, affect workload during a working career, and the effects are more pronounced in women (Mänttäri *et al.*, 2019). Workers with a high physical workload are more likely to smoke, and have high alcohol consumption, but are less likely to be overweight, obese, and less active (Proper *et al.*, 2020). People who engage in shift work are more likely to be overweight or obese (O'Brien *et al.*, 2020).

The increase in obesity and overweight cases in the manufacturing sector has led to a decrease in worker productivity. Therefore, an appropriate prevention program is needed so that a healthy lifestyle culture in the company can continue to be encouraged. The right health promotion strategy based on problems in the workplace will increase the likelihood of program success indicators (Basi Nska-Zych and Springer, 2021). Preliminary research found that the high percentage of overweight and obesity at PT ABD Surabaya in 2023 showed that the percentage of overweight was almost 60% of the 374 workers of PT ABD Surabaya, Indonesia. An understanding of existing risk factors such as physical workload and personal factors such as gender, education level, smoking habits, or exercise habits can be used as policy considerations in reducing the incidence of obesity in workers. Obesity is one of the indicators of a person's nutritional status. In general, nutritional status reflects the condition of the body as a result of the balance between nutrient intake and the body's nutritional needs. Obesity occurs when energy intake exceeds the body's needs, and the excess energy is stored in the form of fat. This study analyzes the relationship between physical workload and personal factors related to nutritional status among manufacturing workers.

METHODS

This study is an observational analytic study using a cross-sectional study design. Data collection was conducted in April 2024. This research was conducted after obtaining approval for the implementation of research from the Research Ethics Code Committee of the Faculty of Nursing, Universitas Airlangga with number No: 2963-KEPK/2023.

Respondents involved in this study are 239 workers at the manufacturing sector PT ABD, Surabaya, East Java, Indonesia who were taken using a simple random sampling technique from 504 population size. Researchers used a simple random

sampling technique to ensure that the samples taken were representative of the population so that the results of the analysis could be generalized to the population as a whole. Apart from that, every worker at PT ABD has the same opportunity to become a research respondent.

The independent variables in this study are personal factors (age, gender, educational level, exercise habits, and smoking habits) and physical workload. Meanwhile, the dependent variable is nutritional status. Data on personal factors (age, gender, educational level, exercise habits, and smoking habits) were obtained through a questionnaire. In this case, a questionnaire was also employed by instructing the respondent to answer the questions according to the circumstances experienced by the respondent.

Physical workload was measured using Physical Workload Assessment Based on National Standard Indonesia (SNI 7269:2009). Physical workload assessment based on SNI 7269:2009 is an assessment of workload based on calorie levels according to energy expenditure. SNI 7269:2009 is an Indonesian national standard set by the National Standardization Agency. It is widely used in Indonesia and frequently used in workplaces to identify worker's physical workload. Physical Workload Assessment Based on SNI 7269:2009 is categorized into four categories: low, moderate, heavy, and very heavy.

Nutritional status can be calculated using the Body Mass Index (BMI) with the formula BMI = weight (kg) ÷ (height (m)^2), then compared to the Indonesian Ministry of Health Standard, categories: Underweight (<18.5); Normal (18.5-25.0); Overweight (25–27.0) and Obesity (≥27.0). The enumerators conducting height and weight measurements of workers are K3 laboratory assistants who have been trained in performing the nutritional status measurement practicum and in reading weight scales and stadiometers. A height-measuring device is called a stadiometer, which consists of a measuring pole with a scale and an adjustable sliding headpiece. To use it, first, ensure the device is placed on a flat surface, then remove footwear for more accurate results. Next, stand upright with heels, buttocks, back, and head aligned against the measuring pole while keeping your gaze straight ahead. Lower the sliding headpiece until it touches the top of the head, then read the measurement in centimeters. Then, To use a weighing scale correctly, place it on a flat and hard surface for accurate results, and ensure the display shows zero before use, especially for analog scales. Remove footwear and any heavy items such as jackets or bags that may affect the measurement, then stand upright in the center of the scale with both feet parallel and your body balanced. Stay still until the numbers on the scale stabilize, then read and record the weight in kilograms (kg). If necessary, repeat the measurement to ensure accuracy, and use either a digital or analog scale depending on the requirement.

Data were analyzed both univariately and bivariate. Bivariate analysis was carried out with the Spearman statistical test with a significance level of 0.05. Univariate analysis was carried out to present data on personal factors, namely frequency distribution and percentage of gender, age, educational level, smoking habits, exercise habits, physical workload, and nutritional status. Bivariate analysis was carried out to analyze the relationship between personal factors, physical workload, and workers' nutritional status using the Spearman correlation test. The Spearman correlation test analyzes the relationship between two variables with a minimum ordinal data scale such as physical workload, educational level, exercise habit, and smoking habit. Each variable with an ordinal data scale was tested for its relationship with the nutritional status variable. Meanwhile, the contingency coefficient test analyzes the relationship between the two variables with a nominal data scale such as gender. Each variable with a nominal data scale was tested for its relationship with the nutritional status variable.

RESULT

Characteristics of Manufacturing Workers

The personal worker factors consisting of gender, educational level, smoking habits, and exercise habits can be seen in Table 1. Cases of overweight and obesity among manufacturing workers were 68.2%. The physical workload of workers was mostly in the low category (52.7%). The characteristics of the respondents were that more than half of the total respondents were female (51.9%), had a high school education (56.5%), and had never exercised (62.8%). Most did not have a smoking habit (70.9%).

The characteristics of workers based on gender are divided into two, namely men and women. In terms of percentage, the two groups are almost the

same, namely 51.9% of female workers and 48.1% of male workers. There are slightly more female workers at PT ABD than male workers. The majority of workers at ABD are high school graduates. More than half of the total workforce who were respondents had a high school education (56.5%). Only a few workers are university graduates (5.9%). There are still 29.1% of workers at PT ABD who have the habit of smoking, almost a third of the total workers who were respondents. The total number of cigarettes consumed each day varies from 3 cigarettes per day to 1 pack of cigarettes per day. In terms of exercise habits, only 9.6% of workers regularly exercise, the rest are dominated by workers who never exercise (62.8%).

Nutritional Status Among Manufacturing Workers

Based on Figure 1, PT ABD workers are dominated by overweight and obese workers with a total percentage of almost 70% (27.2% of overweight workers and 41% of obese workers).

Table 1. Characteristics Manufacturing Workers in PT ABD in 2024

Category	Frequency n= 239	Percentage (%)
Gender		
Male	115	48.1
Female	124	51.9
Educational Level		
Elementary School	9	3.8
Junior High School	81	33.9
Senior High School	135	56.5
Bachelor Degrees	14	5.9
Smoking Habits		
Have No Smoking Habits	265	70.9
Have Smoking Habits	109	29.1
Exercises Habits		
Never	150	62.8
Seldom	66	27.6
Always	23	9.6
Physical Workload's Level		
Low	126	52.7
Moderate	72	30.1
Heavy	33	13.8
Very Heavy	8	3.3
Total	239	100.0

This is by the results of annual health examinations from external laboratories collaborating with PT ABD which show that the majority of PT ABD workers are classified as obese.

Factors Associated with Nutritional Status among Manufacturing Workers

Several factors related to worker nutritional status can be seen in Table 2. Field data results show that gender, educational level, exercise habits, and physical workload level have a significant relationship with worker nutritional status, whereas factors that are not related are smoking habits. In terms of gender, obesity in women tends to be higher than in men. In terms of education level, the lower a person's education level (Elementary School), the higher the obesity level, while the higher the education level, the lower the percentage of obesity cases. The exercise habits category is divided into three, namely (1) never (in the last week or month have never done sports), (2) Seldom (doing sports activities 0-2 times a week), and (3) always (doing sports 2- 7 times a week). In terms of exercise habits, the more regularly workers exercise each week, the better their nutritional status will be, thereby avoiding the risk of obesity. This is shown by the total number of workers who exercise regularly, 82.6% are classified as having normal status. In terms of physical workload, the lighter the worker's physical workload, the risk of obesity will increase.

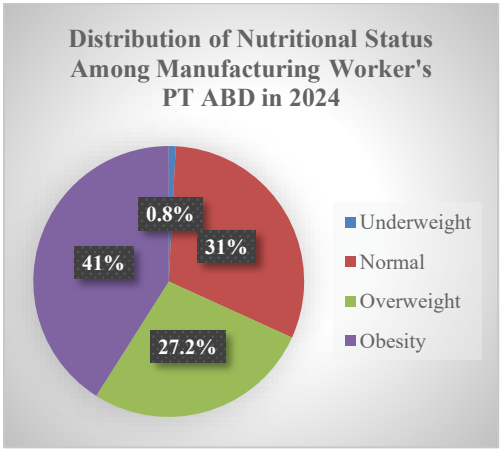

Figure 1. Distribution of Nutritional Status Among Manufacturing Workers at PT ABD in 2024

DISCUSSION

Characteristics of Workers PT ABD

More than half of the workers are overweight and obese. More than half of the respondents were female, had a senior high school education, and had never been exercised. Other research finds different things. From the 10,381 urban workers who participated in the study, 24.2% of them were obese and 75.8% of them were urban workers who were not obese. This prevalence is almost the same as the prevalence of obesity over the age of 18 years in urban areas in Indonesia, based on Basic Health Research (Riskesdas) in 2018 of 25.1% (Rosmiati *et al.*, 2023). Rosmiati *et al.* (2023) conducted an analysis of research results based on secondary data from the Family Life Survey (IFLS). Based on the results of their analysis, one of the workers at risk of obesity is urban workers. This is due to low physical activity and high Western dietary patterns culture.

Other research by Zubery, Kimiywe and Martin (2021) conducted on 305 workers found that the overall prevalence of overweight and obesity among adult workers was 68.9% (31.1% overweight and 37.8% obese). A higher prevalence of overweight or obesity (74.5%) was found among women compared to men (54.9%) (Zubery, Kimiywe and Martin, 2021). Based on table 1, the characteristics of workers in terms of physical workload are classified as low category. This is in accordance with the research conducted on 42 brick-making business workers stating that the majority of physical workloads are classified as low category. Differences in physical activity of workers in each division can affect performance productivity which is also related to obesity (Devi, Setyaningsih and Widjasena, 2023).

Relationship Between Gender and Nutritional Status Among Manufacturing Workers

Types of work that involve different physical activities can affect the risk of obesity. Jobs with low physical activity tend to increase the risk of obesity, one of indicator from nutritional status. Obesity rates increase among female workers with longer working hours and those who work at night. Female workers who work more than 60 hours a week are at 2.68 times greater risk of obesity compared to female workers who work more than 40 hours a week. In Korea, unfairness in the division of household chores leaves working women exhausted, which negatively impacts their

Table 2. Factors Associated with Nutritional Status among Manufacturing Workers

Variable	Nutritional Status										Sig	
	Underweight		Normal		Overweight		Obesity		Total			
	n	%	n	%	n	%	n	%	N	%		
Educational Level												
Elementary School	1	11.1	1	11.1	2	22.2	5	55.6	9	100		
Junior High School	0	0.0	22	27.2	18	22.2	41	50.6	81	100	0.037	Significant
Senior High School	1	0.7	47	34.8	39	28.9	48	35.6	135	100		
Degrees	0	0.0	4	28.6	6	42.9	4	28.6	14	100		
Smoking Habits												
Have Smoking Habits	1	2.3	15	34.1	9	20.5	19	43.2	44	100	0.826	Not significant
Not Have Smoking Habits	1	0.5	59	30.3	56	28.7	79	40.5	195	100		
Exercises Habits												
Never	2	1.4	40	26.7	46	30.7	62	41.3	150	100	0.001	Significant
Seldom	0	0.0	15	22.7	16	24.6	35	53.0	66	100		
Always	0	0.0	19	82.6	3	13.0	1	4.3	23	100		
Physical Workload's Level												
Low	0	0.0	32	25.4	35	27.8	59	46.8		100		
Moderate	0	0.0	28	38.9	19	26.4	25	34.7		100	0.023	Significant
Heavy	2	6.0	12	36.4	9	27.3	10	30.3		100		
Very Heavy	0	0.0	2	25.0	2	25.0	4	50.0		100		

* Significance (α) < 0.05

weight management. Although many support fair division of chores, only 20% actually do so, making it important for society to pay more attention to the health and weight management of working women (Eum and Jung, 2020). The prevalence of obesity is high in the female working population and is associated with low levels of education and lack of physical activity (Safi *et al.*, 2022). Women are more likely to experience overweight and obesity than men (Jepchumba, Munyaka, and Kamuhu, 2023). From the results of the existing study, female workers at PT ABD experiencing excess nutrition have a correlation and relationship with the type of work activities of workers. On the other hand, some contradictory research results show that female workers are predominantly obese. Several factors can affect worker obesity including mental health factors or stress. The obesity factor of female workers is influenced by exposure to stress. It was found that work-related stress and night shift work were associated with obesity in female shift workers. In addition, the prevalence of obesity was quite high among female shift workers. From previous studies that support this study, it can be concluded that women who have longer working hours, work in shifts, especially those who work night shifts, and experience work stress tend to be obese. So gender is not the only factor related to the incidence of obesity among workers (Da Silva *et al.*, 2021).

On the other hand, other theories show that unmarried female workers have lower obesity rates than married women (Annurullah *et al.*, 2021). The existing theoretical studies show that the level of nutritional status in workers is influenced by the physical activity of each worker, both men and women. The burden of physical activity at work will affect the nutritional status needed by workers.

Relationship Between Educational Level and Nutritional Status Among Manufacturing Workers

The nutritional status education program for workers has a positive impact on improving the nutritional status and health of workers (Hassani *et al.*, 2020). Education has a significant relationship with nutritional status and the risk of obesity in workers. Knowledge and awareness of workers Education can improve workers' knowledge and awareness about balanced nutrition, healthy food choices, and the impact of nutrition on health. This knowledge can help workers make better eating choices and prevent excess calorie intake that can lead to obesity.

Research in Europe showed that among women, there is a relationship between lower education levels and both overall and central obesity. Meanwhile, in men, the relationship between lower education and central obesity is weaker than overall obesity. The relationship between lower education and obesity is stronger in women than in men (Witkam *et al.*, 2021).

A study in Taiwan also found that compared to both older men and women with 12 years or less of education, those with 16 years or more of education were at higher risk of obesity. The odds increased as the years of education decreased, and the trend was more pronounced in women (Hsieh *et al.*, 2020).

Women with low education have twice the risk of obesity (34.3%) compared to women with high education (16.0%). This difference is caused by two main factors: differences in personal characteristics which contribute 38.2%, and differences in the influence of factors such as lifestyle and stress which contribute 55.8%, where lifestyle contributes the most (43.6%) and stress is the most significant factor (23%) (Chung and Lim, 2020).

Nutrition education improves workers' health by raising awareness about healthy eating, reducing obesity risk. Lower education levels, especially in women, are linked to higher obesity rates due to lifestyle factors and stress.

Relationship Between Smoking Habit and Nutritional Status Among Manufacturing Workers

Based on the results of the literature review regarding smoking habits carried out by workers, it can be seen that there is a relationship with the nutritional status of workers. Obesity is one of indicator nutritional status. Smokers show a desire for and more consumption of simple carbohydrate foods, while the consumption of complex carbohydrates is lower (Ortega Anta *et al.*, 2021). Workers who smoke coexist with unhealthy behaviors that contribute to poor health and quality of life. The specific mechanism by which workers who smoke affect nutritional status is a person's health condition determined by the balance between nutrient intake and the body's nutritional needs. Obesity is one of the negative indicators of nutritional status. This condition indicates an imbalance between energy intake and the body's energy requirements, where energy intake greatly exceeds what the body needs. As a result, the excess energy is stored as body fat, which, in the long term,

can increase the risk of various chronic diseases such as diabetes, hypertension, and heart disease. status may vary between personals, depending on factors such as smoking duration and intensity, diet, lifestyle, and other health conditions. Although smoking is generally associated with various health problems, some things do not directly affect obesity in workers. Based on research by Susanto, Sari and Prastiwi (2021), smoking activity does not affect central obesity. Increasing the intensity and amount of cigarette consumption has an impact on weight loss (Mantey, Omega-Njemnobi and Kelder, 2020). On the other hand, some workers, such as construction or agricultural workers, may have high levels of physical activity in their jobs, which can help prevent obesity even if they smoke. It is relevant at PT ABD that field data shows that smoking does not affect the nutritional status of workers.

Relationship Between Physical Activity and Nutritional Status Among Manufacturing Workers

Based on the results of the percentage of nutritional status of workers at PT ABD, there is a relationship between the physical activity habits of workers. The nutritional status of workers is influenced by physical activity. The health and obesity of Korean adult men is affected by sedentary sitting (Jeong, Lee, and Yoon, 2022). Jeong, Lee, and Yoon, (2022) emphasize the correlation between sedentary hours and various health indicators, suggesting that extended periods of sitting could exacerbate nutrition-related health issues. This underscores the importance of balancing physical activity and sedentary habits to maintain optimal health and nutrition among workers. Physical activity can increase the body's metabolism which causes stored energy reserves to be burned as calories. This is what makes the relationship between physical activity and nutritional status (Roring, Posangi, and Manampiring, 2020). In addition, excessive energy intake and not balanced with balanced energy expenditure will cause weight gain (Bosy-Westphal, Hägele and Müller, 2021). One of the main causes of nutritional imbalances in workers is a lack of physical activity, for example not doing sports or having a tendency to use private transportation (Zulfa, Dardjito, and Prasetyo, 2022). While physical activity generally has a relationship with nutritional status, there are some situations where the relationship is not significant in workers. Some workers may have genetic or metabolic problems that may make it difficult for them to control their weight, despite regular physical activity. Genetic factors have a 25%-75% effect on the incidence of central obesity (Loos and Yeo, 2022). Genetic heredity can affect the level of obesity in workers. Genetic heredity can affect the level of obesity in workers. This study emphasizes that genetic factors play a significant role in determining nutritional status among workers, influencing their susceptibility to weight gain and related health conditions. Lifestyle and environmental factors are important, genetic predisposition can amplify the risk of obesity in office workers, especially when combined with unhealthy habits. This highlights the need for tailored interventions that consider both genetic and lifestyle factors to effectively address nutritional status in the workplace (Annurullah *et al.*, 2021).

Relationship Between Physical Workload and Nutritional Status Among Manufacturing Workers

Physical workload can affect nutritional status through several mechanisms, one of which is in terms of energy expenditure. Work that involves heavy physical activity will increase the body's energy expenditure. This can lead to increased calorie and nutrient requirements to replace the energy expended during work (Most and Redman, 2020). Physical workload can affect nutritional status through several mechanisms, one of which is in terms of energy expenditure. Work that involves heavy physical activity will increase the body's energy expenditure. This can lead to increased calorie and nutrient requirements to replace the energy expended during work. Physical workload can influence nutritional status in workers. Physical activity and normal body weight can protect workers from excessive physical workload (Mänttäri *et al.*, 2019). There is a relationship between physical work activity and the level of nutritional status among worker (Tonnon *et al.*, 2019). Nutritional status is associated with the onset of musculoskeletal symptoms (Boocock *et al.*, 2024). This condition can lead to overweight or obesity in workers with low physical workloads. In general, workers with low physical workloads tend to have a higher risk of obesity than workers with high physical workloads. However, workers with high physical workloads can also become obese if they do not pay attention to calorie intake and a healthy lifestyle.

Physical activity with an unbalanced diet that is not balanced can cause less energy to be expended. This causes a positive energy balance that is disproportionate to the energy entering the body so it can cause obesity conditions. This condition is certainly independent of the knowledge they have about the importance of a healthy lifestyle. Another factor that affects the nutritional status of workers is mental health. When workers experience stress they will feel hungry which causes a lot of eating resulting in obesity (Nohra *et al.*, 2022). Mental health issues, such as depression and anxiety can lead to unhealthy eating behaviors and increase the risk of obesity, regardless of education level.

CONCLUSION

Physical workload, exercise habits, gender, and educational level have a relationship with nutritional status among workers, it is recommended that workers must increase their exercise routine such as implementing scheduled sports shifts for workers and providing sports facilities in companies so the case of obesity can be decreased.

CONFLICT OF INTEREST

The authors declare that there are no significant competing financial, professional, or personal interests that might have affected the performance.

AUTHORS' CONTRIBUTION

IL: Conceptualization, Data Collection, Introduction, Methodology, Result, Ethical Clearance, Original Draft Preparation. MI: Data Curation, Data Analysis, Software, Validation. NAR: Writing Introduction, Editing Mendeley and Bibliography, Reviewing and Editing. RD: Writing Introduction, Data Collection. TAEP: Writing Discussion. IAK: Writing Discussion.

ACKNOWLEDGMENTS

The author thanks the management and manufacturing workers of PT ABD Surabaya for giving permission and helping smooth the data collection process. The author would like to congratulate Universitas Airlangga for providing funding assistance for the Airlangga Research Fund grant for the 2024 Beginner Lecturer Research Scheme. The author also would like to congratulate Universitas Nahdlatul Ulama Surabaya for supporting this research.

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