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Influence of Energy Intake and Nutritional Status on Work Productivity Among Construction Workers: A Case Study of the Merdeka Square Revitalization Project, Medan

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ABSTRACT

Workers involved in revitalization projects are vulnerable to reduced productivity due to physically demanding tasks, time constraints, and challenging environmental conditions such as heat, noise, and long hours. These factors can lead to fatigue, stress, metabolic disorders, and poor nutritional intake, which in turn reduce endurance and focus. This study examines the influence of energy intake and nutritional status on work productivity among workers at the Merdeka Square Revitalization Project in Medan City. A quantitative cross-sectional design was used, involving 77 respondents. Data were analyzed using univariate, bivariate, and multivariate logistic regression tests. After controlling for confounders, both energy intake and nutritional status significantly affected work productivity ($p < 0.05$). Although excess energy intake was not statistically significant (Exp(B) = 1.319; 95% CI: 0.375–4.642), it still posed a 1.3 times greater risk of reduced productivity compared to adequate intake. In contrast, insufficient energy intake was significant ($p = 0.030$; Exp(B) = 5.375), with a 5.4 times greater risk of lower productivity. Nutritional status, both overnutrition ($p = 0.009$; Exp(B) = 10.039) and undernutrition ($p = 0.002$; Exp(B) = 14.898), significantly affected productivity. The Nagelkerke R^2 value of 0.354 indicates that these variables explain 35.4% of the variance in work productivity.

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Introduction

Project workers often experience a decline in productivity due to a range of internal and external factors. Productivity in revitalization projects is particularly critical, as it directly influences the efficiency of time, cost, and the quality of construction outcomes. Given the complexity and strict deadlines typical of revitalization work, achieving optimal project goals depends heavily on the productivity of both individuals and teams [1]. Productivity challenges are therefore a key concern in such projects, where delays, budget overruns, and compromised work quality can result from poor performance [2].

Globally, labor productivity has fluctuated significantly over the past five years, shaped by post-pandemic economic recovery and persistent structural challenges. In 2020, productivity rose by 3.8%, largely due to the temporary shutdown of low-productivity service sectors during the COVID-19 pandemic. However, this gain was short-lived. As these sectors reopened in 2021 and 2022, productivity stagnated or even declined, as extended working hours were not matched by improved efficiency [3].

In 2023, Indonesian labor productivity was recorded at USD 14 per hour worked, placing the country fifth among Association of Southeast Asian Nations (ASEAN) member states, behind Singapore, Brunei, Malaysia, and Thailand. Nationally, Indonesia's labor productivity rate reached 87.96%, while in North Sumatra, the rate was slightly lower at 79.77% [4]. Among the various factors influencing productivity, the physical condition or nutritional status of workers plays a significant role [5].

Work productivity is shaped by a complex interplay of factors, typically grouped into three main categories: individual, organizational, and environmental. Individual factors encompass skills, experience, motivation, discipline, and the physical and mental health of workers. Higher competence and morale generally contribute to increased productivity [6]. Organizational factors include management systems, leadership styles, workplace policies, incentive structures, and communication processes. Organizations that implement supportive and efficient systems tend to foster better performance. Environmental factors pertain to the physical condition of the workplace, access to equipment and technology, and occupational health and safety. A clean, safe, and well-equipped work environment enhances concentration and efficiency [7].

Energy intake and nutritional status are critical factors influencing work productivity, particularly in physically demanding jobs such as construction. Inadequate nutritional intake can reduce stamina, concentration, and endurance, making workers more prone to fatigue, distraction, and illness.

Poor nutritional status directly impair work capacity and delay task completion. A lack of energy from nutritious food can also hinder cognitive function and motor coordination, which are essential in high-pressure and high-risk construction activities [8].

A decline in worker productivity on construction sites can have significant negative consequences for project outcomes. One of the most immediate impacts is project delays, which can extend completion timelines and inflate operational costs. Poor work efficiency may also compromise construction quality, increase the likelihood of technical errors, and lead to wasted materials and labor. Over time, these issues can damage the reputation of construction service providers and diminish stakeholder satisfaction [9].

The Medan Merdeka Square Revitalization Project was initiated to restore the function of public space as a hub for social, cultural, and recreational activities. The project also aims to preserve the area's historical value, enhance the quality of the urban environment, and stimulate local economic growth by strengthening its role as an iconic landmark of Medan. The development includes the construction of a central square, supporting facilities, and a basement area. In addition to restoring historical sites, the project is designed to create green open spaces. The revitalization plan incorporates a public stage and complementary facilities, combining the preservation of historic urban elements with contemporary design principles.

Medan Merdeka was selected as the study site due to its prominence as a large-scale, high-profile urban revitalization project that involves intensive manual labor under physically demanding conditions. The complexity and scale of the project, along with its critical deadlines, make it an ideal setting to investigate how factors such as energy intake and nutritional status influence worker productivity. Furthermore, as a central public space with significant community impact, the project's success has broad implications for urban development and labor management in Indonesia.

Interviews conducted with 10 workers at the project site revealed notable variations in nutritional status. Five workers were classified as severely obese, one as mildly obese, and four had normal nutritional status. Many workers reported frequent consumption of junk food, caffeinated beverages, and a tendency to skip breakfast. These unhealthy dietary patterns contribute to nutritional imbalances that can impair both physical and cognitive performance. Suboptimal nutritional status, whether due to excess weight or inadequate intake of essential nutrients, can reduce the body's capacity to perform physical tasks efficiently. Workers who are underweight or obese may have limitations in stamina, agility, and resilience to work-related stress, which negatively affects productivity. Inadequate daily nutritional intake, in terms of both portion size and food diversity, also undermines energy levels and morale.

Several workers additionally reported feeling excessively fatigued and prone to procrastination, which may be linked to insufficient energy intake and limited food choices at the worksite. These findings suggest that poor nutritional status and dietary habits affect not only physical health but also motivation and job performance. Based on these concerns, this study aims to examine the effect of energy intake and nutritional status on work productivity among workers at the Medan Merdeka Square Revitalization Project.

Literature Review

Project workers frequently experience decreased productivity, often linked to insufficient energy intake resulting from irregular eating habits, skipping breakfast, and frequent consumption of junk food. These dietary patterns can lead to fatigue, reduced concentration, and diminished endurance, directly impairing workers' performance in physically demanding environments [10]. Supporting this, a study at PT Propack Kreasi Mandiri Cikarang demonstrated a significant relationship between energy intake and work productivity, reporting a p-value of 0.014, indicating that better nutritional intake corresponds with improved productivity levels [11].

Similar findings emerge from international contexts. For example, a study among highway workers in Kenya found that supplementing energy intake by 1000 kilocalories per day increased worker productivity by 12.5%, compared to a control group receiving only 200 kilocalories daily [12]. This evidence underscores the tangible benefits of adequate energy consumption in enhancing physical work capacity and output.

Nutritional status also plays a critical role in influencing work productivity. Imbalanced nutrition, whether in the form of undernutrition or overnutrition, impair both physical endurance and cognitive function. Workers who are either underweight or overweight are more susceptible to rapid fatigue, decreased focus, and a higher incidence of health issues, all of which reduce overall productivity. This relationship was confirmed in a study conducted at gas stations, which found a significant association between workers' nutritional status and their productivity levels [13].

Further highlighting this issue, a recent UK study by Wills et al. (2022) examined the nutritional practices of construction workers and revealed a prevalent pattern of fast food consumption, caffeinated drink intake, and habitual breakfast skipping. These habits contributed to poor nutritional status among workers, which in turn negatively impacted their energy levels, concentration, and work performance [14]. Such findings emphasize the importance of promoting healthy eating behaviors and adequate nutritional intake to sustain productivity, especially in labor-intensive industries like construction.

Collectively, the existing literature demonstrates a consistent link between energy intake, nutritional status, and worker productivity. Addressing dietary habits and improving nutritional support for workers could therefore serve as a practical intervention to enhance efficiency and reduce fatigue in physically demanding jobs.

Material and Methods

This study employed a quantitative cross-sectional design to examine the effect of energy intake and nutritional status on work productivity among construction workers. Ethical approval was obtained from the Research Ethics Review Committee of Institut Kesehatan Medistra Lubuk Pakam and documented in Letter No.: 040.D/KEP-MLP/VI/2025.

The study population consisted of 361 workers from various divisions, including the iron team, wood team, Hebel stone workers, operators, daily civil and occupational and health safety (*Kesehatan dan Keselamatan Kerja* - K3) workers, dewatering crew, MEP (Mechanical, Electrical, and Plumbing) team, paint and ceiling workers, injection workers, void membrane workers, trowel workers, field implementers, ceramic workers, and stamp concrete workers. The sample size was calculated using the Lameshow formula with a 95% confidence level, 10% margin of error, and an expected prevalence of inadequate energy intake of 50%, resulting in a minimum sample size of 77 respondents. Participants were selected through simple random sampling using a random number generator to ensure equal selection probability.

The independent variables in this study were energy intake and nutritional status, while the dependent variable was work productivity. Data collection was conducted through structured interviews using a validated and reliable questionnaire. Energy intake was measured by a single 24-hour food recall, where respondents detailed all foods and beverages consumed in the previous 24 hours. Nutrient intake was then calculated using the NutriSurvey application, which utilizes a comprehensive food composition database. While a single 24-hour recall may be subject to recall bias and day-to-day variability, it provides a practical estimate of the usual intake in field settings. A Recommended Dietary Allowance (RDA) based on Indonesian standard (*Angka Kecukupan Gizi – AKG*) was used to assess the energy intake.

Nutritional status was assessed through Body Mass Index (BMI), calculated by measuring body weight using a calibrated digital scale and height using a stadiometer following standardized procedures. BMI was classified according to World Health Organization (WHO) criteria into underweight (<18.5), normal weight (18.5–22.9), and overweight/obese (>23.0).

While BMI is a widely used and practical tool for categorizing nutritional status at the population level, it does not fully capture the complexity of body composition, such as muscle mass, fat distribution, or micronutrient status. Therefore, its use in this study represents a general indicator rather than a comprehensive measure of nutritional health.

Work productivity was categorized into two levels: "less productive," defined by low output, slow work pace, and failure to meet targets; and "productive," characterized by high output, timely task completion, and efficient work performance. Productivity assessments were obtained via self-report questionnaires (See Table 1) and corroborated with supervisor evaluations to increase reliability. An overall score of >40.6 (mean) indicates a productive worker, while an overall score of ≤40.6 (mean) indicates a less productive worker.

Table 1. Work productivity questionnaire.

Statement
Ability
I am less able to complete tasks properly.
I perform my job to the fullest.
The tasks and jobs assigned by my supervisor match my abilities.
Lack of ability significantly affects work productivity.
Improving Results Achieved
I take my work seriously.
I strive to achieve better work results than before.
I always improve the quality of my work.
Work Enthusiasm
I am always disciplined in carrying out tasks.
I do not think about how to improve my work results.
I do my work as expected.
I complete tasks on time.
Self-Development
I am always creative in performing tasks.
I apply my skills in doing my job.
The tasks I perform require high-level skills.
Quality
The quality standards set by the company are achievable for me.
I strive to improve the quality of my work results.
Efficiency
I complete tasks within the time standard set by the company.
I work to increase results within the set timeframe.
I complete work in an efficient manner.
I feel disturbed by external factors (e.g., coworkers' distractions, noise, etc.).

Scoring = (5) SA: Strongly Agree; (4) A: Agree; (3) N: Neutral; (2) D: Disagree; (1) SD: Strongly Disagree

Primary data were collected between January and March 2025 by trained enumerators through direct interviews. Data quality was ensured through interviewer training, pilot testing, and daily data verification.

Data analysis included univariate analysis to describe the frequency distribution of variables, bivariate analysis using chi-square tests to assess associations between independent variables and work productivity, and multivariate logistic regression to determine the simultaneous effects of energy intake and nutritional status on productivity while controlling for confounders. Variables with p-values less than 0.25 in bivariate analysis were included in the multivariate model, and confounders were retained if their removal altered odds ratios by more than 10%. Statistical analyses were performed using SPSS version 27, with significance set at $p < 0.05$. Research permission was granted by PT Mirtada Sejahtera KSO, documented in letter number 022/CSK-KSO/K3/III/2025.

Results

A. Univariate Analysis

Univariate analysis was conducted to examine the frequency distribution of respondents' characteristics, energy intake, nutritional status, and work productivity.

Table 2. Respondents' characteristics of workers at the Merdeka Square revitalization project, Medan City.

Respondent Characteristics	Frequency (f)	Percentage (%)
Gender		
Male	70	90.9
Female	7	9.1
Age of Worker		
19–29 years	51	66.2
30–49 years	26	33.8
Education Status		
Elementary School	3	3.9
Junior High School	6	7.8
High School	39	50.6
Vocational School	16	20.8
Bachelor's Degree	13	16.9
Total	**77**	**100**

Table 2 shows that the majority of respondents were male (90.9%), with only 9.1% female. Most workers were aged between 19 and 29 years (66.2%), while the remaining 33.8% were aged 30 to 49 years.

Regarding education, half of the workers had completed high school (50.6%), followed by vocational school (20.8%), bachelor's degree (16.9%), junior high school (7.8%), and elementary school (3.9%).

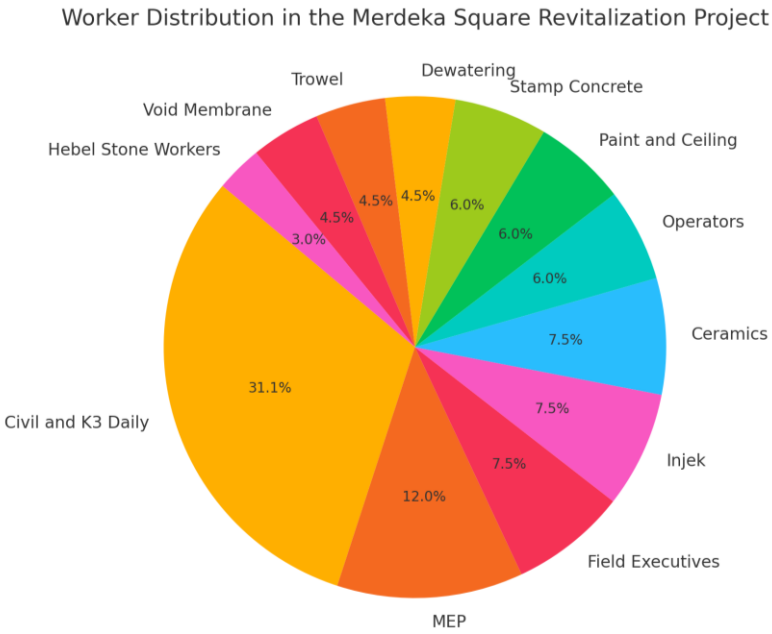


Figure 1. Frequency distribution by job section.

Table 3. Frequency distribution of nutritional status, energy intake, and work productivity.

Variable	Frequency (f)	Percentage (%)
Energy Intake		
RDA 80–110% (Adequate)	25	32.5
RDA > 110% (Over)	22	28.6
RDA < 80% (Insufficient)	30	39.0
Nutritional Status		
BMI 18.5–22.9 (Normal Weight)	31	40.3
BMI > 23.0 (Overweight/Obese)	27	35.1
BMI < 18.5 (Underweight)	19	24.7
Work Productivity		
Less Productive	41	53.2
Productive	36	46.8
Total	**77**	**100.0**

Figure 1 illustrates the distribution of workers by job category. The largest group was the Civil and K3 Daily workers, comprising 27% of the sample. Other significant groups included MEP workers (10.4%), and Field Executives, Injection Molding (*Injek*), and Ceramic workers, each accounting for 6.5%.

Operators, Paint and Ceiling, and Stamp Concrete workers each made up 5.2%, while Dewatering, Trowel, and Void Membrane workers contributed 3.9%. Hebel Stone workers represented the smallest group at 2.6%. This distribution highlights a diverse workforce with a predominance of general and technical labor.

Based on Table 3, the largest proportion of workers (39.0%) had insufficient energy intake (RDA < 80%), followed by 32.5% with adequate energy intake (RDA 80–110%), and 28.6% with excessive energy intake (RDA > 110%). Regarding nutritional status, 40.3% of respondents were classified as having a normal BMI, while 35.1% were overweight or obese, and 24.7% were underweight. In terms of work productivity, a majority of workers (53.2%) were categorized as less productive, whereas 46.8% were considered productive.

B. Bivariate Analysis

Bivariate analysis was conducted to examine the relationships between energy intake, nutritional status, and work productivity. Table 4 presents the distribution of productivity levels across different categories of energy intake and nutritional status.

Regarding energy intake, workers with less energy intake showed a high proportion of low productivity, with 20 respondents (66.7%) classified as less productive and 10 respondents (33.3%) as productive. Similarly, among workers with more energy intake, 14 respondents (63.6%) were less productive, while 8 respondents (36.4%) were productive. In contrast, workers with sufficient energy intake demonstrated better productivity outcomes, with 7 respondents (28.0%) experiencing less productivity and 18 respondents (72.0%) categorized as productive. The chi-square test indicated a statistically significant relationship between energy intake and work productivity ($p = 0.009 < 0.05$).

Table 4. The relationship between energy intake, nutritional status, and worker productivity.

Variable	Productivity				Total		p-value
	Less Productive		Productive				
	N	%	N	%	N	%	
Energy Intake							
Adequate	7	28.0	18	72.0	25	100.0	0.009
Over	14	63.6	8	36.4	22	100.0	
Insufficient	20	66.7	10	33.3	30	100.0	
Nutritional Status							
Normal Weight	11	35.5	20	64.5	31	100.0	
Overweight/Obese	13	48.1	14	51.9	27	100.0	0.001
Underweight	17	89.5	2	10.5	19	100.0	

For nutritional status, workers classified as having poor BMI status predominantly experienced low productivity, with 17 respondents (89.5%) less productive and only 2 respondents (10.5%) productive. Workers with above-poor nutritional status had a more balanced distribution, where 13 respondents (48.1%) were less productive and 14 respondents (51.9%) productive. Meanwhile, workers with normal nutritional status showed a higher rate of productivity, with 11 respondents (35.5%) less productive and 20 respondents (64.5%) productive. The chi-square test also showed a significant association between nutritional status and work productivity ($p = 0.001 < 0.05$).

C. Multivariate Analysis

Multivariate analysis was conducted to assess the simultaneous effect of multiple independent variables on the dependent variable, work productivity. This approach allows identification of variables that significantly influence productivity after adjusting for other factors in the model.

Variables with a p-value less than 0.25 in the bivariate analysis were included in the initial multivariate model. Variables with p-values equal to or greater than 0.05 were sequentially removed unless their removal caused a change of 10% or more in the odds ratio (OR) of other variables, in which case they were considered confounders and retained in the model.

Table 5. Final multivariate model.

Variable	B	Sig	Exp(B)	Confidence Interval (CI) 95%
Adequate Energy Intake	Ref.	0.030	Ref.	Ref.
More Energy Intake	0.277	0.667	1.319	0.375 – 4.642
Insufficient Energy Intake	1.682	0.011	5.375	1.478 – 19.545
Normal Weight	Ref.	0.008	Ref.	Ref.
Overweight/Obese	2.306	0.009	10.039	1.781 – 56.579
Underweight	2.707	0.002	14.898	2.697 – 83.306
Omnibus Test: 0.000			**Nagelkerke R Square: 0.354**	

Based on Table 5, the final multivariate model demonstrates that both energy intake and nutritional status significantly affect work productivity, with p-values less than 0.05 after controlling for other variables. The Omnibus test ($p = 0.000$) indicates that the model fits the data well and is statistically significant.

For the energy intake variable, “more energy intake” did not show a significant effect on productivity ($p = 0.667$), with an odds ratio (Exp(B)) of 1.319 (95% CI: 0.375 – 4.642), suggesting a non-significant 1.3 times higher likelihood of lower productivity compared to sufficient energy intake.

However, “insufficient energy intake” was significantly associated with lower productivity (p = 0.030), with an OR of 5.375 (95% CI: 1.478 – 19.545), indicating that workers with insufficient energy intake were over 5 times more likely to be less productive than those with sufficient intake.

Regarding nutritional status, both “more nutritional status” (p = 0.009, OR = 10.039, 95% CI: 1.781 – 56.579) and “less nutritional status” (p = 0.002, OR = 14.898, 95% CI: 2.697 – 83.306) showed significant associations with lower productivity. This means workers with poorer nutritional status had a 10 to almost 15 times greater likelihood of being less productive compared to those with normal nutritional status.

The Nagelkerke R Square value of 0.354 indicates that approximately 35.4% of the variation in work productivity can be explained by the combined effects of energy intake and nutritional status.

Discussion

The findings of this study indicate that 53.2% of revitalization project workers exhibited low productivity, suggesting that the majority of workers were classified as less productive. This highlights a significant concern regarding the overall productivity levels within this labor group.

Further analysis using multivariate modeling revealed that both energy intake and nutritional status had a significant impact on work productivity. Workers with insufficient energy intake and poor nutritional status were more likely to exhibit lower productivity levels compared to those with adequate intake and normal nutritional status. These results emphasize the critical role of proper nutrition and energy sufficiency in maintaining optimal work performance.

A. The Effect of Energy Intake on Work Productivity

The results of this study indicate that, after controlling for other variables, energy intake had a statistically significant effect on work productivity (p = 0.030 < 0.05). This finding is consistent with previous research conducted at PT PAL Indonesia involving 64 workers, which found a significant relationship between energy adequacy and work productivity (p = 0.010), as well as between iron intake and productivity (p = 0.024), although no significant associations were observed with hydration status or work fatigue levels [15].

Interestingly, this study found that excess energy intake did not show a statistically significant effect on productivity (p = 0.667), yet the odds ratio (OR = 1.319; 95% CI: 0.375–4.642) suggested a tendency toward lower productivity among workers with excessive energy intake compared to those with sufficient intake. This finding contrasts with the study by Maghfiroh (2019) at PT Timur Megah Steel, which reported that male workers with higher-than-required energy intake demonstrated significantly higher productivity (p = 0.020; r = 0.716) [11].

In contrast, insufficient energy intake was significantly associated with lower productivity (p = 0.011), with an OR of 5.375 (95% CI: 1.478–19.545), indicating that workers with inadequate energy intake were over five times more likely to exhibit low productivity than those with sufficient intake. This aligns with findings from Ilmawati and Adi at PT X Lamongan, where employees with lower energy consumption had lower productivity levels. Their analysis using the Spearman test showed a strong and significant association between energy intake and work productivity (p = 0.000).

Both excessive and insufficient energy intake can negatively impact productivity by affecting workers' physical and cognitive performance. Insufficient energy intake can result in reduced stamina, fatigue, and impaired physical function, while excess energy intake may lead to overweight or obesity, which is linked to chronic fatigue, reduced mobility, and increased risk of non-communicable diseases. These conditions can compromise work efficiency.

Supporting this, data from the Household, Income and Labour Dynamics in Australia (HILDA) Survey Wave 17, involving 11,211 adults aged 20–65 years, found that obesity was significantly associated with reduced work productivity, including fewer working hours and lower job performance [16]. Similarly, Himaya and Wirjatmadi (2020) reported that inadequate energy intake was significantly correlated with low work productivity, reinforcing the importance of maintaining balanced energy intake to support optimal occupational performance [17].

B. The Effect of Nutritional Status on Work Productivity

The findings of this study demonstrate that, after controlling for other variables, nutritional status has a significant effect on work productivity. This supports the growing body of evidence that both undernutrition and overnutrition are detrimental to workers' performance and efficiency.

A study by Maedah et al. (2021) among startup employees in Jakarta found a significant relationship between nutritional status (measured by BMI and body fat percentage) and work productivity. Their results showed a p-value of 0.005 for BMI and 0.010 for body fat percentage, indicating a strong association between nutritional status and employee performance [18].

In this study, workers with overnutrition (above-normal nutritional status) were significantly more likely to be less productive, with a p-value of 0.009 and an odds ratio (Exp(B)) of 10.039 (95% CI: 1.781–56.579). This suggests that workers with overnutrition were more than 10 times as likely to experience reduced productivity compared to those with normal nutritional status. Supporting this, a large-scale study in Canada involving 56,971 respondents found that workers with class III obesity (BMI ≥40) had a 1.6 times greater risk of absenteeism. Furthermore, presenteeism (reduced performance while at work) increased significantly in workers with class I obesity (OR = 1.49) [19]. The current study also found that undernutrition had a significant negative impact on productivity (p = 0.002), with an odds ratio of 14.898 (95% CI: 2.697–83.306), indicating nearly 15 times higher likelihood of low productivity among undernourished workers compared to those with normal status. This is consistent with findings from a 2023 study in Kenya involving 224 road construction workers, where 67% were found to weigh less than 85% of their ideal body weight. The study reported that increased upper arm circumference and higher hemoglobin levels were positively associated with productivity, and that supplementation with 1,000 kcal per day resulted in a 12.5% increase in productivity among male workers [20].

The broader economic implications of malnutrition have also been highlighted by the International Labour Organization (ILO), which reported that undernutrition contributes to annual productivity losses of $10–28 billion in India (equivalent to 3–9% of the country's GDP). Iron deficiency, commonly found among undernourished laborers, is associated with productivity losses of up to 17% in physically demanding jobs [21].

Both under- and overnutrition impair work productivity by affecting physical strength, endurance, and mental focus. Undernourished workers are more prone to fatigue, poor stamina, and reduced physical performance, while overnourished workers, particularly those with obesity, are at higher risk of chronic diseases such as diabetes and cardiovascular conditions, which can impair mobility and efficiency [22]. These findings underscore the importance of maintaining optimal nutritional status as a key component of workforce health and productivity.

Conclusion

Based on the final analysis, after controlling for other variables, both energy intake and nutritional status were found to significantly affect work productivity, with p-values less than 0.05. Although excess energy intake did not have a statistically significant effect on productivity (Exp(B) = 1.319; 95% CI: 0.375 to 4.642), it was associated with a 1.3 times higher likelihood of low productivity compared to adequate energy intake. In contrast, insufficient energy intake showed a significant effect (p = 0.030; Exp(B) = 5.375; 95% CI: 1.478 to 19.545), indicating a more than fivefold increase in the likelihood of low productivity.

Regarding nutritional status, both overnutrition (p = 0.009; Exp(B) = 10.039; 95% CI: 1.781 to 56.579) and undernutrition (p = 0.002; Exp(B) = 14.898; 95% CI: 2.697 to 83.306) were significantly associated with reduced productivity. The Nagelkerke R Square value of 0.354 indicates that energy intake and nutritional status together account for 35.4 percent of the variation in work productivity. It is recommended that workers ensure adequate energy intake and maintain an ideal nutritional status to support optimal performance and productivity.

Limitations and Suggestions

This study has several limitations that should be acknowledged. First, the use of a cross-sectional design restricts the ability to infer causal relationships between energy intake, nutritional status, and work productivity. Longitudinal or experimental designs would be more appropriate to determine causality. Second, the assessment of energy intake was based on a single 24-hour dietary recall, which may not accurately reflect habitual intake due to daily variations and potential recall bias. Although practical for field settings, this method could underestimate or overestimate actual energy consumption.

Third, nutritional status was measured solely using BMI, which, while widely used, does not distinguish between muscle mass and fat mass or assess micronutrient status. Therefore, it may not capture the full complexity of an individual's nutritional health. Fourth, work productivity was partially based on self-reported questionnaires, which are susceptible to social desirability bias. Although corroborated by supervisor assessments, objective productivity metrics (e.g., task output, attendance records) were not incorporated.

Lastly, the study did not control for other potentially influential variables such as workload intensity, sleep quality, chronic illnesses, or psychological stress, all of which may confound the observed relationships. Future research should adopt a more holistic and multi-dimensional approach to better understand the complex factors influencing labor productivity. Future research should adopt a more comprehensive approach, possibly incorporating qualitative methods or physiological assessments, to better understand the multifaceted determinants of work productivity.

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Conflict of Interest

The authors declare that there is no conflict of interest that could influence the findings or interpretation of this study. All stages of the research, from planning and data collection to analysis and reporting, were conducted objectively and transparently, in accordance with established scientific standards and research ethics.

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