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ARTIKEL PENELITIAN

Analisis Elektrokardiogram dalam Memonitor Kelelahan pada Pekerja Pembuatan Rumah

Electrocardiogram Analysis-Based to Track Fatigue during Commercial Home Construction Tasks

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Abstract

The presence of fatigue among workers in the commercial house construction industry presents substantial obstacles to both the personal welfare of individuals and the overall efficiency of construction projects. The objective of this study is to investigate how individual factors, namely nutritional status, affect degrees of fatigue in this specific occupational group. Data was gathered from 45 construction workers in November 2023 using a cross-sectional methodology. Total sampling approaches were employed, and persons with pre-existing health issues were excluded. Analyzed were the univariate and bivariate data, which uncovered a noteworthy correlation between nutritional status and tiredness level (p-value=0,028). Although there were no significant correlations between age and sleep quality, the results emphasize the significance of dietary determinants in influencing tiredness levels among construction workers. Implications arise from the necessity of implementing specific interventions for example wellness and occupational diet program to encourage adequate nutrition and improve the well-being and productivity of workers in the construction sector. These findings enhance the progress of occupational health research and offer potential applicability for guiding standard of procedure and practical methods to prevent fatigue-related hazards especially in construction environments.

Keywords: *sonstruction worker, occupational health, sleep quality, tiredness, nutrition status*

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Abstrak

Kehadiran kelelahan di kalangan pekerja di industri konstruksi rumah komersial menimbulkan hambatan besar baik bagi kesejahteraan pribadi individu maupun efisiensi proyek konstruksi secara keseluruhan. Tujuan dari penelitian ini adalah untuk mengetahui bagaimana faktor individu, yaitu status gizi, mempengaruhi tingkat kelelahan pada kelompok pekerjaan tertentu. Data dikumpulkan dari 45 pekerja konstruksi pada bulan November 2023 dengan menggunakan metodologi *cross-sectional*. Pendekatan sampel total digunakan, dan orang-orang dengan masalah kesehatan yang sudah ada sebelumnya dikeluarkan dari penelitian. Data yang dianalisis adalah data univariat dan bivariat, yang menunjukkan adanya korelasi penting antara status gizi dan tingkat kelelahan *(p-value=0,028)*. Meskipun tidak ada korelasi yang signifikan antara usia dan kualitas tidur, hasil penelitian ini menekankan pentingnya faktor penentu pola makan dalam mempengaruhi tingkat kelelahan di kalangan pekerja konstruksi. Implikasinya timbul dari perlunya penerapan intervensi khusus untuk mendorong kecukupan nutrisi dan meningkatkan kesejahteraan dan produktivitas pekerja di sektor konstruksi. Temuan ini meningkatkan kemajuan penelitian kesehatan kerja dan menawarkan potensi untuk memandu metode praktis untuk mengurangi bahaya terkait kelelahan di lingkungan konstruksi.

Kata Kunci: kelelahan, kesehatan kerja, kualitas tidur, pekerja konstruksi, status gizi

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PENDAHULUAN

The construction industry faces significant challenges, with worker fatigue being a critical concern due to its impact on safety, productivity, and health. Studies have demonstrated various innovative approaches to monitor and mitigate fatigue among construction workers (Latief *et al.*, 2022; Ma *et al.*, 2023). Integrating subjective and objective fatigue measurements can provide real-time fatigue data for improved safety management in construction sites (Seong *et al.*, 2022). The broader implications of fatigue extend to the well-being and retention of the workforce, with factors such as organizational culture, workload, and working hours influencing work-life balance (WLB) (Adha *et al.*, 2025). Furthermore, the quality of sleep and its impact on cognitive and rational abilities of construction laborers have been studied, emphasizing the need for improved sleep health to enhance productivity and decision-making capabilities (Chandra *et al.*, 2023).

Addressing worker fatigue in the construction industry requires a multisectoral approach, incorporating technological innovations, management practices, and an understanding of the psychological and physical well-being of workers. These efforts are essential for improving safety, productivity, and retaining a skilled workforce in the construction industry (Namian *et al.*, 2021; Escobar-Linero *et al.*, 2022). This study would address whether the finding of fatigue among workers could be more assesed with portable tool and other factors related could be related and should be prevented in daily works especially in construction works.

Addressing fatigue among commercial home construction workers is crucial due to its significant impact on individual well-being, safety, and project efficiency. High-level fatigue, leading to poor judgment, increased risk of injuries, decreased

productivity, and lower quality of work (Bangaru *et al.*, 2022). Certain worker populations, including those in construction, are at a disproportionate risk of fatigue due to factors like irregular shifts and socioeconomic barriers, highlighting the need for targeted research and interventions (Cunningham *et al.*, 2022). The construction industry, known for its hazardous conditions, requires workers to perform physically and mentally demanding tasks, exacerbating the risk of fatigue (Namian *et al.*, 2021). The development of a fatigue assessment scale specifically for construction workers supports the need for reliable and valid tools to assess and address fatigue (Zhang *et al.*, 2015).

This study introduces a pioneering method to assess the impact of individual traits on fatigue levels among commercial home construction workers through electrocardiogram (ECG) analysis (Seong *et al.*, 2022). By incorporating ECG analysis, the research aims to capture these diverse influences, offering a comprehensive assessment of fatigue. This approach is supported by findings that link ECG parameters with various fatigue-related factors, such as mental fatigue (Anwer *et al.*, 2021), sleepiness among drivers, and the physical exertion of construction workers.

The relevance of this approach is underscored by the high incidence of fatigue within the construction industry, which significantly affects workers' safety, productivity, and health (Yamaura, 2023). Traditional fatigue monitoring methods have limitations, as they often fail to capture the complex, multifaceted nature of fatigue (Bangaru *et al.*, 2022). These technologies offer a non-invasive, continuous way to assess workers' fatigue levels in real-time, providing a more nuanced understanding of how individual differences such as age, health status, and personal resilience might influence fatigue.

METODE

The study utilized a cross-sectional research methodology to examine how individual variables affect tiredness levels among commercial house building workers. The population under consideration consisted of all construction workers involved in commercial house construction projects of the Intermilan Silaberanti and Chelsea Plaju Darat Housing. The research was done in November 2023, using a total sampling approach that includes 45 eligible persons in the population as the subject. The inclusion were the workers whom active as mason during collecting data period. The exclusion criteria were the workers with history of cardiovascular, thyroid, diabetic diseases; using beta blocker or other anti hypertension medicines; workers with history of injury.

The process of gathering data entailed the application of a portable electrocardiogram (ECG) device manufactured under the brand name Kardia®. The utilization of this portable electrocardiogram (ECG) device enabled the non-intrusive assessment of heart rate variability, thereby furnishing objective indicators of physiological reactions linked to fatigue. Data analysis involved the use of univariate and bivariate analyses using Chi Square and Fischer Exact tes as the alternative. Univariate analysis entailed the independent evaluation of individual characteristics and tiredness levels, yielding descriptive statistics such as nutritional status, age, rest duration, and work fatigue. Bivariate analysis examines the connection between certain characteristics and tiredness levels. It use statistical methods including correlation analysis and chi Square testing to evaluate relationships and discover potential predictors of fatigue. The number of ehtical clearance was 137/EC/KBHKI/FK-

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HASIL DAN PEMBAHASAN

Subject characteristics

The findings of the research offer significant contributions to the understanding of fatigue levels and personal attributes of laborers engaged in the construction of commercial homes. The results of the univariate analysis indicated that a significant proportion of the participants (54,3%) had a normal nutritional status. Specifically, the age group of 35 years and older had the highest frequency distribution (58,7%). Furthermore, a considerable segment of the workforce indicated that they had adequate rest periods (97,8%), whereas the highest proportion (58,7%) did not experience fatigue according to subjective assessments of fatigue.

Table 1. Subject characteristics' of nutritional status, age, rest duration, and work fatigue of construction workers (n=45)

Variables	Status	Frequency (f)	Percentage (%)
Nutritional status	Obese	18	39,1%
	Normal	25	54,3%
	Underweight	2	4,3%
Age	≥ 35	27	58,7%
	≤ 35	18	40,0%
Rest Duration	Good	44	97,8%
	Bad	1	2,2%
Work Fatigue	Tired	18	39,1%
	Not tired	27	58,7%

Source: Primary data, 2023

The relationship between nutritional knowledge and fatigue level in Constructor

The correlation between fatigue levels and individual characteristics was clarified through the use of bivariate analysis. Although there were no statistically significant correlations observed between fatigue levels and sleep quality or age, a noteworthy association was identified between nutritional status and fatigue level ($p = 0,028$, $p < 0,05$). More precisely, employees who had inadequate nutritional intake were found to have a greater propensity for experiencing elevated levels of fatigue. This finding highlights the potential influence of dietary factors on occupational fatigue within the construction sector.

The results of this study enhance our comprehension of the complex and varied aspects of fatigue experienced by construction workers. This underscores the importance of incorporating personal attributes, such as nutritional status, into investigations pertaining to occupational health. These insights have significant implications for practical interventions and theoretical frameworks that seek to improve the well-being and productivity of workers in construction environments.

The analysis of the study's findings highlights the intricate relationship between personal attributes and levels of fatigue among laborers engaged in commercial home construction, with a specific emphasis on the influence of nutritional status. Although the research did not identify any statistically significant correlations between fatigue levels and age or sleep quality, it is worth noting the correlation between inadequate

nutrition and heightened fatigue. The aforementioned correlation is substantiated by extant scholarly works, one of which examined the substantial advantages of vitamin and mineral supplementation in alleviating fatigue among diverse demographic groups. This review concluded that nutrients are pivotal in addressing fatigue, both physiological and psychological (Chandra *et al.*, 2023).

Table 2. Relationship between subjects characteristics and work fatigue of construction workers using an ECG

Variables		Work Fatigue				*p–value*
		Tired		Not Tired		
		N	%	N	%	
Age	≥ 35 Years	11	10,8%	16	16,2%	*1,000*
	≤ 35 Years	7	7,2%	11	1,80%	
Rest Duration	Good	17	38,6%	27	61,4%	*0,400*
	Bad	1	100,0%	0	0,0%	
Nutritional status	Obese	12	66,7%	6	33,3%	*0,028*
	Normal	5	20%	20	80%	
	Underweight	1	50%	1	50%	

Source: Primary data, 2023

Moreover, a study examining nutrition practices among construction workers emphasizes the significance of taking dietary factors into account in occupational health research. The study uncovered unhealthy nutrition-related behaviors among workers and a strong desire among them to enhance their eating habits through nutrition interventions (Barnish and Scholey, 2023). These findings are consistent with research on other occupational groups, which has shown that exhaustion may be caused by factors such as poor nutrition, inflammation, and problems with the body's energy production system. This suggests that fatigue may be a result of malnutrition depleting the individual's metabolic resources (Wronska *et al.*, 2022).

Furthermore, the complex nature of fatigue in work environments is emphasized by research conducted on various groups of workers. For instance, studies have shown that construction laborers who have irregular work hours often suffer from poor sleep quality (Gatari *et al.*, 2023). Similarly, Latin (x) day laborers who face unstable work conditions are also affected by fatigue (Sathvik *et al.*, 2022). Additionally, occupational drivers at construction sites frequently experience excessive daytime sleepiness (Ramierez *et al.*, 2023). These studies emphasize the need of implementing complete occupational health treatments that target not just sleep and work schedules, but also nutritional status and other individual factors in order to reduce tiredness (Ahn *et al.*, 2021; Azzolino *et al.*, 2022; Forthun *et al.*, 2023).

Overall, the study's results, supported by evidence from other sources, emphasize the significant impact of nutritional status on fatigue levels among commercial home construction workers. This underscores the necessity of incorporating dietary factors into occupational health research and interventions. Occupational diet management can be achieved through wellness program in the workplace where calorie needs between workers would be adjusted based on occupational factors and per individually. Initial target BMI should be at least max 25 and evaluated periodically untill ideal BMI. Fat burning exercises such as aerobic, calisthenic, running, and cycling are suggested to be in consideration. In other words, not only occupational diet will be performed but also weight control program.

The results of the examined research emphasize the substantial influence of nutritional status and lifestyle determinants on the physical and mental health, as well as the efficiency, of construction workers. This highlights the necessity for comprehensive workplace wellness programs. The research conducted by Ma *et al*. (2023) illustrates that tracking fatigue using biomarkers in sweat can offer valuable information about the hydration and nutritional condition of workers. This suggests that timely interventions, such as consuming fluids or nutrients, can alleviate the negative effects of fatigue, ultimately improving safety and productivity in the construction sector (Ma *et al.*, 2023). Furthermore, Hannes *et al*. (2023) study demonstrates that the use of fortified rice can have a beneficial effect on the health and nutritional well-being of migrant construction workers in Singapore. This research suggests that by correcting nutritional inadequacies, there is a notable improvement in the overall health outcomes of these individuals (Hannes *et al.*, 2023). Furthermore, the ChooseWell 365 RCT provides evidence that interventions targeting healthy eating habits can enhance the nutritional value of cafeteria purchases made by employees, irrespective of their risk for chronic diseases. This suggests that such programs can effectively encourage construction workers to make healthier lifestyle choices (Sommer *et al.*, 2023).

In addition, the review conducted by Barnish and Scholey (2023) about the advantages of vitamin and mineral supplementation in reducing fatigue provides further evidence of the impact of nutrition on improving worker performance and well-being (Barnish and Scholey, 2023). The research also emphasizes the significance of addressing additional lifestyle aspects, such as the quality of sleep and mental well-being, which are strongly interconnected with diet and general health. The studies conducted by Chandra *et al*. (2023) highlight the detrimental effects of inadequate sleep quality and mental health problems on cognitive behavior, logical capacity, and productivity. These findings suggest that treatments aimed at enhancing worker well-being should also address these factors (Greiner *et al.*, 2022).

The qualitative study conducted by Hon *et al*. (2024) on psychosocial risks and the investigation of dietary habits by Wronska *et al*. (2022) offer valuable understanding into the intricate relationship between work environment, nutrition, and psychological well-being, emphasizing the necessity for customized interventions that target the unique requirements and difficulties encountered by construction workers (Wronska *et al.*, 2022; Hon *et al.*, 2024). The systematic literature review conducted by Newaz *et al*. (2022) and the controlled trial conducted by Cedstrand *et al*. (2022) emphasize the potential of focused mental health interventions and the significance of collaboratively developing occupational health programs with stakeholders to guarantee their efficacy and long-term viability (Cedstrand *et al.*, 2022; Newaz *et al.*, 2022).

The limitations mentioned, such as the use of small sample sizes and dependence on self-reported measures, are undoubtedly important when assessing how applicable and trustworthy the findings are in research on tiredness, sleep quality, and nutritional status. The utilization of self-reported attributes and symptoms in evaluating post-COVID-19 syndrome (PCS) patients highlights the possibility of subjective prejudice, which may influence the dependability of conclusions about tiredness and its influence on health-related quality of life (Grimaldi *et al.*, 2023). Similarly, the study's use of self-reported weariness or low energy to investigate the causes of exhaustion using Mendelian randomization highlights the importance of using more reliable objective measurements to determine causation (Gatari *et al.*, 2023). In addition, studies that focus on specialized populations such as stroke survivors Sommer *et al.* (2023) or those with stress-induced exhaustion condition Wallace *et al.* (2023) may have limited sample

sizes, which might restrict the generalizability of their findings to larger populations. This constraint is exacerbated by the varied expressions of exhaustion in different settings and demographic groups, as demonstrated by research on chronic fatigue in connection to different illnesses Walker *et al.* (2023) and the distinct influence of sleep patterns on chronic fatigue among workers (Barnish and Scholey, 2023).

Future research should prioritize the use of bigger sample sizes to increase the statistical power and generalizability of findings. Objective approaches, such as using actigraphy data to evaluate rest-activity rhythms Lindsäter *et al.* (2023) or conducting assessments of objective fatigability and autonomic nervous system dysfunction Millet *et al.* (2023), have the potential to offer more accurate and exact evaluations of tiredness and its underlying causes. Longitudinal investigations, as proposed by the longitudinal examination of tiredness and health outcomes among young individuals with chronic pain Teng *et al.* (2023), would provide useful knowledge about the temporal patterns of fatigue, its development, and its long-term effects. By addressing these constraints, we may greatly enhance our comprehension of weariness, including its fundamental processes and its impact on the health and well-being of individuals.

KESIMPULAN

In summary, this research provides insight into the impact of personal attributes, specifically nutritional status, on the levels of fatigue experienced by laborers in the commercial home construction industry. The results emphasize the importance of dietary considerations in occupational health research and the potential efficacy of nutrition interventions in the construction industry to alleviate fatigue and boost productivity. The specific recommendations regarding the result of this study are occupational diet management with the calorie needs among workers and the weight control program with fat burning exercises to achieve ideal BMI.

In the future, it is crucial to implement practical approaches that integrate these research outcomes into strategies that enhance the well-being and productivity of employees. An approach to consider is the incorporation of nutrition education programs into wellness initiatives within the workplace, which would equip construction personnel with the necessary information and tools to adopt more nutritious dietary practices. Furthermore, in order to guarantee individuals' access to nourishing food choices while working on construction sites, employers may also establish support systems that facilitate meal preparation and planning.

In addition, it is recommended that forthcoming investigations strive to overcome the constraints of this study through the utilization of more extensive subject sizes and objective metrics for assessing individual attributes and fatigue levels. By offering more comprehensive insights into the temporal dynamics of fatigue and its determinants, longitudinal studies have the potential to guide the development of interventions that are more precise and efficacious.

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