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WORK FATIGUE LEVELS AMONG ROAD CONSTRUCTION WORKERS EXPOSED TO SUNLIGHT

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ABSTRACT

Work Fatigue Levels Among Road Construction Workers Exposed To Sunlight. *The development of the construction and construction sector between contractors in Indonesia is growing rapidly and the death rate is increasing compared to the previous year. In general, the mortality rate is caused by the factor of length of work and the age of the worker. The reason is that age is no longer young when faced with a long job in a day, of course, it will also burden the physical, it's just that the difference caused by age will be decisive. This study aims to determine the relationship between the length of work and the age of workers with the level of work fatigue in road construction workers exposed to sunlight in North Hulu Sungai Regency. This study is an analytical test, with a cross sectional design. The population in this study amounted to 30 road construction workers and the research sample was taken from all populations. Data analysis using the Chisquare test. The results of the Chi-square statistical test showed that there was a relationship between working length and work fatigue p = 0.023 < 0.05 and there was a relationship between working age and work fatigue p = 0.029 < 0.05. It is recommended to optimize their rest time and be able to stretch their muscles between jobs. For companies, there is a limit on working hours of a maximum of 8 hours/day and urges workers to exercise before work.*

INTRODUCTION

The construction sector in Indonesia has experienced rapid growth, driven by intense competition among contractors and the demand for fast and efficient project completion. As a result, construction processes often run continuously—sometimes up to 24 hours—to meet project deadlines. However, alongside this advancement, the number of occupational accidents in this sector has also shown an increasing trend. In 2021, there were 234,370 reported cases of occupational accidents, resulting in 6,552 fatalities—an increase of 5.7% compared to the previous year[1]. These statistics underscore the urgent need to prioritize occupational health and safety (OHS), particularly in the construction industry.

One of the primary issues in the construction sector is work fatigue, especially among field workers who are directly exposed to environmental factors such as intense sunlight. Work fatigue is defined as a decline in physical and mental capacity due to excessive workloads, non-ergonomic work environments, and individual factors such as age and health status. Older workers tend to have lower physical endurance, making them more susceptible to fatigue, particularly when working long hours or under extreme conditions. Additionally,

extended working hours beyond the standard limits further increase the risk of fatigue, which in turn can reduce productivity and elevate the likelihood of workplace accidents [2-11].

This issue is also observed in local road construction projects in Hulu Sungai Utara Regency, South Kalimantan, where most workers labor for more than eight hours per day and are exposed to sunlight for prolonged periods. The open working environment, lack of heat protection, and tight work schedules form a high-risk combination that threatens the health and safety of the workers.

According to the World Health Organization (WHO, 2018), chronic fatigue resulting from sustained occupational stress can lead to physical and mental health disorders, including depression, which is recognized as the second leading cause of death after heart disease[12]. Previous studies have revealed that age and working duration are significantly associated with levels of work fatigue[13]. Besides age, the length of exposure to heat is also a contributing factor to fatigue levels among construction workers[14-15].

Nevertheless, there is still a lack of research specifically examining the relationship between age and working duration with work fatigue levels among road construction workers exposed to sunlight in South Kalimantan. Given the region's geographic and tropical climate conditions, which intensify heat exposure and fatigue risks, such studies are crucial.

Therefore, this study aims to determine the relationship between working duration and workers' age with the level of work fatigue among road construction workers exposed to sunlight in Hulu Sungai Utara Regency, South Kalimantan.

MATERIALS AND RESEARCH METHODS

This research is a quantitative study employing an analytical observational approach to analyze the relationship between age and working duration with work fatigue levels among road construction workers. A cross-sectional design was used, wherein data were collected at a single point in time to describe and examine relationships among variables within the study population.

The study was conducted from May to June 2024 at a road construction project managed by CV. Aimri Archteam, located in Hulu Sungai Utara Regency, South Kalimantan. The population included all road construction workers involved in the project, totaling 30 individuals. Due to the relatively small and homogeneous population, a total sampling technique was employed, where all members of the population were included as research subjects.

Data collection was carried out using the KAUPK2 (General Analysis Questionnaire of Work Fatigue Potential), developed by the Ministry of Manpower of the Republic of Indonesia. This questionnaire is designed to subjectively measure work fatigue levels, covering physical, psychological, and environmental aspects. Each item is assessed using a specific scale, and the overall results are classified into three fatigue levels: mild, moderate, and severe. The instrument has undergone content validity testing by a panel of experts and internal reliability testing using Cronbach's Alpha, with values ≥ 0.7 indicating acceptable consistency.

Collected data were analyzed using univariate analysis to describe respondent characteristics and variable distributions. Bivariate analysis was then conducted using the Chi-square test to examine the relationship between working duration and age with work fatigue levels. Statistical significance was determined by a p-value of less than 0.05 ($\alpha = 0.05$).

RESEARCH RESULTS AND DISCUSSION

This study was conducted on 30 road construction workers involved in a development project supervised by CV. Aimri Archteam, located in Hulu Sungai Utara Regency, South Kalimantan. The aim of this study was to evaluate the relationship between working hours and worker age with the level of work fatigue, using a standardized instrument, namely the

KAUPK2 Questionnaire (General Analysis Questionnaire of Work Fatigue Potential) issued by the Ministry of Manpower of the Republic of Indonesia.
Based on the univariate analysis, it was found that the majority of workers had a working duration of ≤8 hours per day, with a total of 19 people (63%), while the remaining 11 people (37%) worked more than 8 hours per day.

Table 1. Frequency Distribution of Working Hours Among Road Construction Workers at CV. Aimri Archteam, Hulu Sungai Utara Regency

No.	Working Duration (hours)	Number (of workers)	Percentage (%)	Threshold Limit Value (TLV)
1.	> 8	11	37	≤ 8 jam/hari
2.	≤ 8	19	63	
	Total	30	100	

In terms of age, 23 workers (77%) were in the ≥40 years age group, while only 7 workers (23%) were under 40 years of age**.**

Table 2. Frequency Distribution of the Age of Road Construction Workers at CV. Aimri Archteam, Hulu Sungai Utara Regency

No.	Worker Age (years)	Number (of workers)	Percentage (%)
1.	≥ 40	7	23
2.	≤ 40	23	77
	Total	30	100

The level of work fatigue measured using the KAUPK2 instrument indicates that the majority of respondents experienced severe fatigue, namely 19 people (63%). The remaining 11 people (37%) were categorized as experiencing moderate fatigue. None of the respondents showed signs of mild fatigue. These results highlight the high workload in road construction environments, especially under open working conditions with direct exposure to sunlight.

Table 3. Frequency Distribution of Work Fatigue Levels among Road Construction Workers of CV. Airchteaim, Hulu Sungai Utara District, 2024

No.	Work Fatigue Level	Number (of workers)	Percentage (%)
1.	Severe (63-83)	19	63
2.	**MODERATE** (40-62)	11	37
	Total	30	100

Relationship Between Working Hours and Work Fatigue
Bivariate analysis using the Chi-square test showed a statistically significant relationship between working hours and the level of work fatigue, with a significance value of p = 0.023. Furthermore, the odds ratio (OR) calculation resulted in an OR value of 11.111, indicating that workers who work more than 8 hours per day have an 11-fold higher risk of experiencing severe work fatigue compared to those who work ≤8 hours per day.

Table 4. Frequency Distribution of Working Hours Based on the Level of Work Fatigue Among Road Construction Workers at CV. Aimri Archteam, Hulu Sungai Utara District.

No.	Working Hours (hours)	Work Fatigue				TOTAL	Percentage (%)
		sEVERE	%	Moderate	%		
1	> 8	10	33,3	1	3,3	11	36,7
2	≤ 8	9	30,1	10	33,3	19	63,3
	Jumlah		p = 0,023 < α = 0,05			30	100

These findings reinforce the notion that prolonged working hours without adequate breaks significantly contribute to work fatigue. This aligns with the fundamental principles of ergonomics, which state that work fatigue is a physiological and psychological response to workloads exceeding an individual's adaptive capacity. The longer a person works, especially in physically demanding outdoor jobs, the higher the accumulation of muscular fatigue,

circulatory disturbances, and thermal stress[14-17]. Prolonged working hours increase cardiovascular strain, as indicated by elevated systolic blood pressure and vascular responses. Although adequate rest can help mitigate these effects, its effectiveness diminishes with increasing work duration[18].

Standing for extended periods may also lead to muscle fatigue, discomfort, and vascular problems; therefore, limiting standing time to less than three hours is recommended to prevent such adverse effects[19]. Skipping or interrupting scheduled rest breaks has been linked to various health complaints, including back pain, general fatigue, and physical exhaustion[20]. Continuous cognitive activity without adequate breaks may lead to mental fatigue, reduced cognitive efficiency, and decreased brain activity, with short breaks often insufficient to prevent these negative outcomes[21]. Excessively long working hours may also result in stress, depression, and loss of concentration, which adversely impact occupational health and safety[22].

Work fatigue caused by excessive working hours also increases the risk of errors and workplace accidents, especially in high-risk work environments such as healthcare and emergency services[23,24]. Conversely, the implementation of optimized work-rest schedules has been proven to improve work efficiency, employee satisfaction, and task completion times[25,26]. In this context, road construction work is characterized by high physical demands, varied working postures—both static and dynamic—and is often carried out without protection from direct sun exposure, along with a lack of proportional work-rest time management. The World Health Organization (2018) emphasizes that chronic fatigue can result in various health disorders, including sleep disturbances, depression, and decreased cardiac function. Therefore, these findings are crucial for consideration in evaluating and revising work time management policies in construction projects.

Relationship Between Worker Age and Work Fatigue

Statistical analysis also revealed a significant relationship between worker age and level of work fatigue ($p = 0.029$). The odds ratio (OR) of 1.917 indicates that workers aged ≥40 years have nearly twice the risk of experiencing severe fatigue compared to younger workers.

Table 5. Frequency Distribution of Workers' Age by Work Fatigue Level at CV. Airchteam, Hulu Sungai Utara District

No.	Working Age (years)	Kelelahan Kerja				TOTAL	Percentage (%)
		Severe	%	MODERATE	%		
1	> 40	7	23,3	0	0	7	23,3
2	≤ 40	12	40	11	36,7	23	76,7
	TOTAL		$p = 0{,}029 < \alpha = 0{,}05$			30	100

Worker age has been shown to be associated with work fatigue. This relationship can be explained through the lens of work physiology. As individuals age, cardiovascular capacity, muscle flexibility, and the body's ability to perform thermoregulation tend to decline. These changes make older workers more susceptible to fatigue, particularly when working in hot conditions or under high physical workloads[13,15,27,28]. Age is also related to changes in energy metabolism, decreased muscle enzyme levels, and hormonal alterations that impact bodily efficiency. Repeated and unmanaged fatigue in older individuals increases the risk of degenerative diseases, which can further reduce work capacity.

Aging also affects energy metabolism through changes in body composition and energy requirements. Older adults typically experience a decline in metabolic efficiency, resulting in increased energy expenditure for the same physical activities[29,30]. Additionally, there is a significant reduction in both anaerobic and aerobic enzyme activity among older adults, contributing to decreased muscle performance. This decline is not solely caused by reduced physical activity but is also influenced by the underlying metabolic changes[31,32].

Overall, the findings of this study indicate that two main factors—working hours and age—have a significant impact on the level of work fatigue among road construction workers.

These findings have practical implications for occupational safety and health (OSH) management in the construction sector. In the Indonesian context, the maximum working hours are regulated under Labor Law No. 13 of 2003, which limits daily work to no more than 8 hours. However, field implementation often violates these regulations due to project deadlines and cost-efficiency considerations.

A multidimensional approach is necessary to mitigate work fatigue risks, including limiting working hours, adjusting workloads based on age, providing adequate rest periods, and educating workers about the importance of bodily recovery. Additionally, employers should provide heat-protection facilities, such as work canopies or lightweight protective clothing, to reduce direct sun exposure.

Workers should also be encouraged to perform muscle stretching or light exercises before beginning work as a form of warm-up and injury prevention. These activities not only enhance physical readiness but also raise awareness among workers about the importance of long-term health maintenance.

In the medium to long term, further studies should consider additional variables such as body mass index (BMI), actual workload, microclimate conditions at the worksite, and hydration status. Moreover, fatigue assessment should not rely solely on subjective tools (e.g., questionnaires), but also incorporate objective methods such as heart rate monitoring, blood pressure variability, or biochemical markers (e.g., cortisol or lactate levels).

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the research conducted on road construction workers in Hulu Sungai Utara Regency, a significant relationship was found between working hours and worker age with the level of work fatigue. Workers who worked more than 8 hours per day had an eleven-fold higher risk of experiencing severe work fatigue compared to those who worked within the standard duration. Additionally, workers aged ≥40 years had nearly twice the risk of fatigue compared to younger workers. These findings indicate that long working hours and older age are major risk factors for work fatigue, particularly in demanding outdoor work conditions with exposure to heat and sunlight.

As a follow-up to these findings, it is recommended that companies adjust work schedules so they do not exceed 8 hours per day and implement regular break procedures during working hours, such as taking a 15–30 minute rest every two to three hours. Companies should also provide heat protection facilities, adequate access to drinking water, and physical fitness training programs, such as light warm-ups before work. For workers, it is important to maintain physical fitness by managing sleep patterns, nutritional intake, and performing stretches during work activities. For future research, it is suggested to use more objective methods of measuring fatigue and involve a larger population to produce results that are more representative and applicable.

REFERENCES

1. Fadhlurrahman A. Faktor-faktor yang Berhubungan dengan Kejadian Kecelakaan Kerja pada Petugas Pemadam Kebakaran di Kota Padang tahun 2024. 2024;
2. Setyaningsih Y, Imas K, Suroto. Working climate, physical workload and its relation to heat strain on construction workers at airport development project. International Journal of Civil Engineering and Technology [Internet] 2018;9(9):37–42. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85054373777&partnerID=40&md5=98da9d1e7f0882d8bc81b5d247017418
3. Yasmeen S, Liu H, Wu Y, Li B. Physiological responses of acclimatized construction workers during different work patterns in a hot and humid subtropical area of China. Journal of Building Engineering [Internet] 2020;30. Available from:

https://www.scopus.com/inward/record.uri?eid=2-s2.0-85080037956&doi=10.1016%2Fj.jobe.2020.101281&partnerID=40&md5=43efbf71e9859e7dcd846342e4c5e76b

4. Ryoo BY, Chung HC. Wireless/mobile sensors for monitoring worker's health and safety in construction [Internet]. In: Proceedings of the 28th International Symposium on Automation and Robotics in Construction, ISARC 2011. 2011. page 572–3.Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84863741483&doi=10.22260%2Fisarc2011%2F0105&partnerID=40&md5=b9e0e41d021f2f33a85d1f7a1cfa9338
5. Khan M, Ibrahim A, Nnaji C, Aryal A. Developing Prediction Models for Monitoring Workers' Fatigue in Hot Conditions [Internet]. In: Computing in Civil Engineering 2023: Resilience, Safety, and Sustainability - Selected Papers from the ASCE International Conference on Computing in Civil Engineering 2023. 2024. page 623–30.Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85184097856&doi=10.1061%2F9780784485248.075&partnerID=40&md5=a3312aeffbedf099474719d425199725
6. Ouyang Y, Luo X. Effects of physical fatigue superimposed on high temperatures on construction workers' cognitive performance. Saf Sci [Internet] 2025;181. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85207915892&doi=10.1016%2Fj.ssci.2024.106705&partnerID=40&md5=dbe34d13c38af57c53ebaabe100302fe
7. Zong H, Yi W, Chan APC, Yang H, Wu P, Xiao B. Developing a Fatigue Model for Construction Workers: An Interpretable Machine Learning Approach. Journal of Management in Engineering [Internet] 2025;41(4). Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-105004639182&doi=10.1061%2FJMENEA.MEENG-6662&partnerID=40&md5=fffdaa59a12a0055fcb0603bc0fcab74
8. Pooladvand S, Hasanzadeh S. Effects of Heat Stress on Workers' Physical Fatigue and Attentiveness: Multimodal Roofing XR Simulation [Internet]. In: Construction Research Congress 2024, CRC 2024. 2024. page 812–21.Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85188787020&doi=10.1061%2F9780784485293.081&partnerID=40&md5=3f6004a718598301379bdef3cf47a172
9. Gumasing MJJ, Llamas CMA, Martin CAA. The effects of energy expenditure on the mental fatigue of construction workers [Internet]. In: Proceedings of the International Conference on Industrial Engineering and Operations Management. 2020. page 1210–20.Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85088963646&partnerID=40&md5=accce229ffa251477e91202da6d594f3
10. Specht JW, Garcia SA, Tourula E, Hite MJ, Walker C, Yoder HA, et al. Heat stress and strain in commercial construction workers in the summer: A pilot study. J Occup Environ Hyg [Internet] 2025;Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-105007009072&doi=10.1080%2F15459624.2025.2500613&partnerID=40&md5=0f12e5ea5272aa84089a9eb6ba9c0513
11. Karthick S, Kermanshachi S, Pamidimukkala A. Analysis of the Health and Safety Challenges Faced by Construction Workers in Extreme Hot Weather Conditions. Journal of Legal Affairs and Dispute Resolution in Engineering and Construction [Internet] 2023;15(1). Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-

85141846770&doi=10.1061%2FJLADAH.LADR-882&partnerID=40&md5=31bbab143339da1c71bc7a6dbe5eb9ed
12. Bellingrath S, Weigl T, Kudielka BM. Chronic work stress and exhaustion is associated with higher allostastic load in female school teachers. Stress 2009;12(1):37–48.
13. Haluza D, Blasche G. Fatigue and insufficient leisure opportunities in older employees. J Occup Environ Med 2016;58(7):e268–74.
14. Lu Y, Li Z, Chen Q, Fan Y, Wang J, Ye Y, et al. Association of working hours and cumulative fatigue among Chinese primary health care professionals. Front Public Health 2023;11.
15. Sorokin GA, Chistyakov ND. The duration of work-related fatigue as a criterion for assessing the workload and the cause of chronic diseases of workers. Meditsina Truda I Promyshlennaya Ekologiya 2022;62(9):594–600.
16. Wicaksono HP, Lestantyo D, Setyaningsih Y. Fatigue Occurring in Construction Workers. Media Publikasi Promosi Kesehatan Indonesia 2024;7(5):1254–8.
17. Salve UR. Relationship of Duration of Work Exposure and Feeling of Subjective Fatigue: A Case Study on Jewelry Manufacturing Workers in India. Int J Environ Health Eng 2017;6(1).
18. Liu X, Ikeda H, Oyama F, Wakisaka K, Takahashi M. Hemodynamic Responses to Simulated Long Working Hours with Short and Long Breaks in Healthy Men. Sci Rep 2018;8(1).
19. Garcia MG, Läubli T, Martin BJ. Muscular and Vascular Issues Induced by Prolonged Standing With Different Work–Rest Cycles With Active or Passive Breaks. Hum Factors 2018;60(6):806–21.
20. Vieten L, Wöhrmann AM, Wendsche J, Michel A. Employees' work breaks and their physical and mental health: Results from a representative German survey. Appl Ergon 2023;110.
21. Brazaitis M, Satas A. Regular short-duration breaks do not prevent mental fatigue and decline in cognitive efficiency in healthy young men during an office-like simulated mental working day: An EEG study. International Journal of Psychophysiology 2023;188:33–46.
22. Palathoti SR, Al-Aghbari A, Otitolaiye VO. Effect of Long Extended Working Hours on the Occupational Health and Safety of Oil and Gas Workers in the Sultanate of Oman. Int J Occup Saf Health 2023;13(4):419–28.
23. Caruso CC. Negative impacts of shiftwork and long work hours. Rehabilitation Nursing 2014;39(1):16–25.
24. Weaver MD, Barger LK. Sleep health as an issue of public safety. Sleep and Health 2019;489–99.
25. Abuwarda Z, Mostafa K, Morita P, Hegazy T. Optimizing Construction Work–Rest Schedules and Worker Reassignment Utilizing Wristband Physiological Data. J Constr Eng Manag 2024;150(11).
26. Li K, Xu S, Fu H. Work-break scheduling with real-time fatigue effect and recovery. Int J Prod Res 2020;58(3):689–702.
27. Porter RW. The aging workforce: Secondary ergonomics risk factors and solutions [Internet]. In: ASSE Professional Development Conference and Exposition 2009. 2009. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85058387646&partnerID=40&md5=fd451830a69521a9805a556ae7beea4a
28. Blok MM, de Looze MP. What is the evidence for less shift work tolerance in older workers? Ergonomics 2011;54(3):221–32.

29. Chow CK. Fat-soluble vitamins: Part II: Vitamin E. Nutritional Aspects of Aging 2018;1:213–25.
30. Schuch CP, Balbinot G, Boos M, Peyré-Tartaruga LA, Susta D. The role of anthropometric changes due to aging on human walking: Mechanical work, pendulum and efficiency. Biol Sport 2011;28(3):165–70.
31. Kaczor JJ, Ziolkowski W, Antosiewicz J, Hac S, Tarnopolsky MA, Popinigis J. The effect of aging on anaerobic and aerobic enzyme activities in human skeletal muscle. Journals of Gerontology - Series A Biological Sciences and Medical Sciences 2006;61(4):339–44.
32. W. Russ D, R. Lanza I. The Impact of Old Age on Skeletal Muscle Energetics: Supply and Demand. Current Aging Sciencee 2012;4(3):234–47.