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Behind the Hammer's Swing: Work Fatigue Among Traditional Stone Breakers in the Coastal Region of the Selayar Islands, Indonesia

Di Balik Godaman Palu: Kelelahan Kerja pada Pemecah Batu Tradisional di Wilayah Pesisir Kepulauan Selayar, Indonesia

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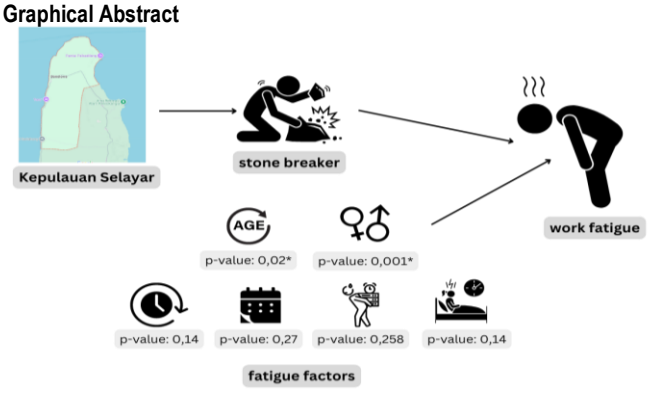
Abstract
The work of stone breakers involves heavy and repetitive physical activity, which can increase the risk of injuries and health problems, one of which is work fatigue. Before work fatigue becomes more severe, it is essential to identify its causes. This study aims to analyze work fatigue and the factors that influence it. The study uses an observational analytic approach with a total of 50 respondents. The variables measured include age, length of work, years of service, workload, total sleep time, and work fatigue. Data collection was carried out through questionnaires and specific workload observations. The results of the study indicate that 25 people (50%) experienced high work fatigue. Further analysis showed that age (p-value = 0.020) and gender (p-value = 0.001) significantly influenced work fatigue. The results also showed that there was no significant effect of length of work (p-value = 0.140), years of service (p-value = 0.27), workload (p-value = 0.258), and total sleep time (p-value = 0.401) on work fatigue. This study concludes that work fatigue among traditional stone breakers is influenced by age and gender. Interventions are needed to reduce work fatigue through adjustments to the work environment and rest periods. This study reinforces the understanding of Q.S. Al-Baqarah/2:286, which emphasizes that every individual has limitations. The fatigue experienced is proof that the human body has limits and needs adequate rest to function optimally.

Abstrak
Pekerjaan pemecah batu memerlukan aktivitas fisik yang berat dan berulang sehingga dapat meningkatkan risiko cedera dan masalah kesehatan, salah satunya kelelahan kerja. Sebelum kelelahan kerja menjadi lebih parah, maka perlu diperhatikan penyebab dari hal ini. Penelitian ini bertujuan untuk menganalisis kelelahan kerja dan faktor yang mempengaruhinya. Penelitian ini menggunakan pendekatan observasional analitik dengan jumlah responden sebanyak 50 orang. Variabel yang diukur meliputi umur, lama kerja, masa kerja, beban kerja, total waktu tidur, dan kelelahan kerja. Pengumpulan data dilakukan melalui kuesioner dan observasi khusus beban kerja. Hasil penelitian menunjukkan bahwa sebanyak 25 orang (50%) mengalami kelelahan kerja tinggi. Analisis lebih lanjut menunjukkan bahwa terdapat pengaruh umur (p-value = 0,02) dan jenis kelamin (p-value = 0,001) terhadap kelelahan kerja. Hasil juga menunjukkan bahwa tidak terdapat pengaruh lama kerja (p-value = 0,14), masa kerja (p-value = 0,27), beban kerja (p-value = 0,258), dan total waktu tidur (p-value 0,401) terhadap kelelahan kerja. Penelitian ini menyimpulkan bahwa kelalahan kerja pada pemecah batu tradisional dipengaruhi oleh umur dan jenis kelamin. Diperlukan intervensi untu menguragni kelelahan kerja melalui penyesuaian lingkungan kerja dan waktu istirahat. Penelitian ini menguatkan pemahaman terhadap Q.S. Al-Baqarah/2:286 yang menekankan bahwa setiap individu memiliki batas kemampuan. Kelelahan yang dialami adalah bukti bahwa tubuh manusia memiliki batas dan membutuhkan istirahat yang cukup untuk berfungsi optimal.

Graphical Abstract



Keyword
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INTRODUCTION

With the advent of globalization and the Fourth Industrial Revolution, there is a tendency to focus on advanced technology and the latest innovations. However, behind the glittering progress of technology, there remain numerous traditional jobs that involve high health risks. Stone breaking is one such example. The challenge in achieving the SDGs in this context is how to integrate technological advancements with efforts to protect the health and safety of workers, especially those in the informal sector (Ávila-Gutiérrez et al., 2022). Stone breaking is a job that requires heavy and repetitive physical activity (Njaka et al., 2021). Workers in this industry are responsible for operating stone-breaking machines to convert large stones into smaller ones that are easier to transport and use in various constructions. However, this work is often carried out in harsh and dusty environments, which can lead to high physical and respiratory stress on the workers. The use of heavy machinery and exposure to stone dust also increase the risk of injuries and long-term health problems, such as lung disease (Joshi et al., 2021). Additionally, stone breakers often work in conditions that demand long working hours and lack adequate rest to meet high production targets. The combination of work pressure, exposure to unhealthy environments, and insufficient rest time can significantly increase the risk of work fatigue (Xing et al., 2020).

In addition to using heavy machinery, some stone breakers still use manual tools in their work or traditional methods. One such place is in Selayar Regency, South Sulawesi Province. Workers must labor under physical strain, such as prying stones with manual tools and relatively simple equipment, using crowbars/wood to lift the stones. After prying the stones, the workers then use a hammer weighing 5 kg – 20 kg to break the stones. To break the stones, the workers must stand while lifting the hammer, which weighs 5 kg – 20 kg, to effectively crush the stones. The broken stones are then gathered around the workers until they have accumulated enough to fill a truck, which sometimes has to be completed within one to two days. They typically work 8 hours a day.

Various physical exposures during work are inherently associated with increased fatigue after work (Bláfoss et al., 2019). Physical exposures such as bending or twisting the back, working with arms at shoulder height or above, pushing/pulling/lifting/carrying, squatting or kneeling, neck flexion, repetitive hand/arm movements, and standing in one place contribute to fatigue. Considering the conditions and work processes of traditional stone breakers in the Selayar Islands, who use manual tools, engage in monotonous and repetitive work, and have non-ergonomic working positions, there is a risk of work fatigue. Repetitive and monotonous work can lead to injury and work fatigue. This is supported by preliminary data obtained by the researchers, which shows that most stone breakers experience complaints and symptoms of work fatigue, such as headaches, dizziness, muscle aches, and drowsiness. Work fatigue is a serious issue in occupational health and safety, characterized by decreased work performance and reduced physical capacity to continue the same work activities. Fatigue or tiredness is a functional response from the center of consciousness (Baraniuk, 2022). The feeling of fatigue experienced by these workers is one indicator of work fatigue (Xing et al., 2020).

Work fatigue experienced by workers can be physiological or psychological (Anwer et al., 2020; Argyle et al., 2020). Both physiological and psychological fatigue can cause various symptoms, with common symptoms of work fatigue among workers being headaches, shoulder stiffness, and back pain (Guduru et al., 2022; Leivas et al., 2022). Additionally, symptoms of work fatigue can be observed in reduced activity, motivation, and physical strength (Behrens et al., 2023; Koohsari et al., 2021). Work fatigue is influenced by several factors, including physical work activity, mental work activity, work posture, work environment, psychological factors, caloric needs, working hours and rest time, nutrition, workload, work facilities, recreational facilities, work shifts, sleep quality, worker health monitoring, and individual characteristics such as age, years of service, and length of work (Kar et al., 2020; Krishnan et al., 2021; Souchet et al., 2023; Xing et al., 2020)

A number of studies have examined the phenomenon of work fatigue in laborers, such as those conducted by Rezaie et al. (2020), Song et al. (2021), and Xia et al. (2023). These studies provide important insights into the impact of work fatigue on the health and productivity of workers in various sectors. However, there is still a research gap on the topic of occupational fatigue in stone-crushing workers, especially in developing countries. Stone crushing workers face extreme working conditions with heavy physical exposure and often inadequate working environments. Given their important role in the construction and development sectors, studies on occupational fatigue in this group are urgently needed.

This research attempts to fill this gap by focusing on stone-crushing workers in developing countries, who are often overlooked in scientific studies. This approach not only makes a new contribution to the literature on occupational fatigue but also raises a globally relevant issue of occupational health and safety in the informal sector. As such, this research has the potential to not only

Table 1
Respondent Characteristics

Characteristics	n	%
Age		
Teenagers (12-25 years old)	15	30
Mature (26-45 years old)	20	40
Elderly (46-65 years old)	15	30
Gender		
Male	46	92
Female	4	8
Length of employment		
Abnormal (>8 hours)	22	44
Normal (≤ 8 jam)	28	56
Length of service		
New (5 years)	6	12
Old (>5 years)	44	88
Workload		
Heavy (350-500 kcal/hr)	3	6
Medium (200-340 kcal/hour)	47	94
Total Sleep Time		
Less (<7h)	12	24
Sufficient (≥7h)	38	76
Work Fatigue		
Low	6	12
Medium	16	32
High	25	50
Very high	3	6

enrich our understanding of occupational fatigue in laborers but also provide a solid basis for the development of more inclusive and adaptive policies for workers in the informal sector, especially in developing countries such as Indonesia. It is expected to contribute to the improvement of the quality of life and well-being of stone-crushing workers, as well as pave the way for further studies in this area. The researcher conducted a study aimed at analyzing the factors influencing work fatigue among traditional stone breakers in the coastal areas of the Selayar Islands, Indonesia. By understanding these factors, it is expected to provide effective recommendations to reduce the risk of work fatigue and improve workers' health and productivity.

METHODS

This study employs an observational analytic approach. The research was conducted in Kassabumbung Hamlet, Bungaiya Village, Bontomatene District, Selayar Islands Regency. The location was chosen based on the nature of the work, which aligns with the research objectives, and the significant number of stone breakers in this area, providing a representative sample for the study. The population of stone breakers in Kassabumbung Hamlet totals 100 individuals, and based on purposive sampling with established inclusion criteria, a sample of 50 individuals was selected.

The inclusion criteria include: having the primary occupation as a traditional stone breaker in Kassabumbung Hamlet, a minimum of 5 years of work experience, female workers not currently menstruating, postpartum, or breastfeeding, and a willingness to participate as respondents until the completion of the study. The criterion of "primary occupation as a stone breaker" was chosen to ensure that the fatigue experienced by respondents primarily stems from stone breaking activities, rather than from side jobs or other activities. Workers with more than 5 years of experience are likely to have greater exposure to risk factors, potentially leading to different levels of fatigue compared to newer workers. Additionally, the selection of female respondents "not menstruating, postpartum, or breastfeeding" was based on the hormonal factors specific to women. Hormonal changes during the menstrual cycle can cause various physical symptoms such as cramps, fatigue, and mood swings, allowing researchers to more accurately identify whether fatigue is due to work or bodily conditions. During pregnancy and breastfeeding, women's bodies undergo significant hormonal and physical changes, such as weight gain, changes in the center of

Table 2
Factors Affecting Work Fatigue in Traditional Stone Breakers

Variable	Work Fatigue								Total		p-value
	Low		Medium		High		Very High				
	n	%	n	%	n	%	n	%	n	%	
Age											
Teenagers (12-25 years old)	3	6	5	10	7	14	0	0	15	30	0.020*
Mature (26-45 years old)	2	4	9	18	9	18	0	0	20	40	
Elderly (46-65 years old)	1	2	2	4	9	18	3	6	15	30	
Gender											
Male	3	6	15	30	25	50	3	6	46	92	0.001*
Female	3	6	1	2	0	0	0	0	4	8	
Length of employment											
Abnormal (>8 hours)	2	4	5	10	13	26	2	4	22	44	0.140
Normal (≤ 8 jam)	4	8	11	22	12	24	1	2	28	56	
Length of service											
New (5 years)	0	0	1	2	5	10	0	0	6	12	0.270
Old (>5 years)	6	12	15	30	20	40	3	6	44	88	
Workload											
Heavy (350-500 kcal/hr)	1	2	1	2	1	2	0	0	3	6	0.258
Medium (200-340 kcal/hour)	5	10	15	30	24	48	3	6	47	94	
Total Sleep Time											
Less (<7h)	1	2	3	6	7	14	1	2	12	24	0.401
Sufficient (≥7h)	5	10	13	26	18	36	2	4	38	76	

gravity, and increased nutritional needs, which can elevate fatigue risk and reduce physical capacity.

The variables in this study include age, length of work, years of service, workload, total sleep time, and work fatigue. Age, length of work, years of service, and total sleep time were collected through questionnaires. Workload refers to physical workload, measured through the workers' body weight and observation of physical activities during 4 hours of work. The workload data was then adjusted according to SNI 7269:2009 on Workload Assessment Based on Caloric Needs According to Energy Expenditure. Work fatigue in this study refers to the condition resulting from the work performed by stone breakers, characterized by decreased capacity or a feeling of fatigue in performing tasks, as assessed through the Subjective Self Rating Test (SSRT) questionnaire from the Industrial Fatigue Research Committee (IFRC). The data analysis used in this study is Ordinal Regression Analysis, chosen based on the data scale of the variables being studied. Informed consent was obtained from the respondents prior to conducting the interviews, with a strong emphasis on adhering to research ethics.

RESULTS

Table 1 illustrates that the majority of respondents are adults (20 people, 40%), male (46 people, 92%), have a normal working duration of ≤ 8 hours (28 people, 56%), have a long work tenure of >5 years (44 people, 88%), moderate workload (47 people, 94%), sufficient total sleep time (38 people, 75%), and high work fatigue (25 people, 50%).

Table 2 shows that most respondents in the adolescent age group experience high work fatigue, totaling 7 people (14%). Additionally, the majority of respondents in the adult age group experience moderate work fatigue, totaling 9 people (18%), while most respondents in the elderly age group experience high work fatigue, totaling 9 people (18%). The test results yielded a p-value of 0.02, indicating that age has a significant influence on work fatigue. Moreover, a large portion of the male respondents experience high work fatigue, totaling 25 people (50%), while female respondents primarily experience low work fatigue, totaling 3 people (75%). The test results yielded a p-value of 0.001, indicating that gender has a significant influence on work fatigue.

The study results also show that the majority of respondents with abnormal working hours experience high work fatigue, totaling 13 people (26%), while respondents with normal working hours experience high work fatigue, totaling 12 people (24%). The test results yielded a p-value of 0.14, indicating that there is no significant influence of working hours on work fatigue. Additionally, most workers with a shorter tenure experience high work fatigue, totaling 5 people (10%), while most workers with a longer tenure experience high work fatigue, totaling 20 people (40%). The

test results yielded a p-value of 0.27, indicating that work tenure has no significant influence on work fatigue.

Furthermore, workers with a heavy workload experience light, moderate, and high work fatigue equally, with 1 person (10%) in each category. In contrast, most workers with a moderate workload experience high work fatigue, totaling 24 people (48%). The test results yielded a p-value of 0.258, indicating that workload has no significant influence on work fatigue. Finally, the results show that most respondents with insufficient sleep experience high work fatigue, totaling 7 people (14%), while respondents with sufficient sleep experience high work fatigue, totaling 18 people (36%). The test results yielded a p-value of 0.401, indicating that total sleep time has no significant influence on work fatigue.

DISCUSSION

Fatigue has a significant impact on workers' health. It is characterized by a decline in energy when performing tasks or activities, which can lead to increased errors and even fatal workplace accidents (Allison et al., 2022; Xing et al., 2020). Fatigue also reduces work capacity and endurance, with symptoms such as physical exhaustion, decreased motivation, slow responses, and difficulties in decision-making, all of which result in decreased productivity and increased error rates. Consequently, work fatigue can become a serious issue in the industrial sector (Bendak & Rashid, 2020). The research findings indicate that the majority of respondents experience high levels of work fatigue. The questionnaire responses revealed that the most common feeling of fatigue was extreme thirst, caused by the hot working environment, leading workers to frequently feel thirsty during work. The symptoms of work fatigue experienced by the workers include overall body fatigue, which is attributed to the extended time spent performing job tasks.

Other common symptoms experienced by workers include stiffness in the shoulders and back pain, indicating reduced activity due to tools that do not fit the workers' body sizes, causing them to frequently feel overall fatigue and back pain. Back pain refers to the sensation of discomfort and stiffness that occurs along the spine, from the base of the neck to the upper waist, which may be localized in the neck or spread to the upper or lower back (Krasin et al., 2022). Back pain results from stimulation of sensory nerve fibers triggered by irritation of muscles and bones. One of the causes of such pain is prolonged standing. Back pain originates from the stimulation of sensory nerve fibers triggered by irritation of muscles and bones. Excessive standing duration is one of the factors contributing to this pain (Zhen et al., 2022). The findings of this study are consistent with another study showing that there are more stone workers with high fatigue levels compared to those with low fatigue levels, with a very high percentage of 87 respondents (68.5%) (Pratiwi & Diah, 2023).

The research results reveal that there is an influence of age on work fatigue. The relationship between age and work fatigue among stone breakers is due to the decline in muscle strength that occurs with aging, leading to health complaints and increased feelings of fatigue. A person's age affects the condition and capacity of their body to perform activities. As age increases, fatigue is more quickly felt (International Labour Organization, 2016). Younger individuals have the capacity to perform heavy work, whereas this capacity diminishes with age (Antoni & Widanarko, 2023).

Fatigue generally becomes more apparent in older adults, with increased complaints or fatigue as they age. The decline in muscle strength and endurance that occurs with aging is a major factor that increases the risk of fatigue (Behm et al., 2021). It is also noted that physical work affects older workers more than younger ones because physical capacity significantly decreases with age (Cunningham et al., 2020; Wilkinson et al., 2018). This decline in physical capacity, in terms of strength and power, is due to the loss of muscle fibers and muscle atrophy (Shur et al., 2021). Furthermore, age plays a crucial role in the onset of work fatigue, as it impacts reaction time and fatigue levels. The aging process affects performance because organ function decreases with age. As a result, work becomes more exhausting and potentially reduces productivity and performance (Rino Komalig & Mamusung, 2020).

This study's findings align with research that demonstrates an influence of age on work fatigue (Amalianah et al., 2022). Research by Rini and Lanita (2023) also shows that there is a significant relationship between age and work fatigue in both formal and informal workers. Studies have found that workers aged ≥35 years' experience much higher fatigue compared to those under 35 years of age (Antika & Prameswari, 2023). Workers aged ≥35 years have a 2.04 times higher risk of experiencing moderate work fatigue compared to those under 35 years old (Rini et al., 2023). These findings are consistent with this study, which includes the adult (26-45 years) and elderly (46-65 years) age groups.

The study also reveals that gender has an influence on work fatigue. Both male and female workers experience work fatigue, but at different levels. Both men and women experience work fatigue (Karyati et al., 2021). Stone breaking is a manual labor job that involves the use of tools and maximizes muscle work, so in this study, moderate,

high, and very high levels of work fatigue were more commonly felt by male workers.

Gender influences the level of muscle fatigue, as physiologically, women's muscles generally have lower capacity compared to men's muscles (Jones et al., 2021). This difference in muscle strength affects the ability to perform heavy physical work. The results of this study are consistent with studies that show a relationship between gender and work fatigue (Rahmawati & Afandi, 2019). Additionally, another study also shows a relationship between gender and work fatigue (Lestari et al., 2021). The influence of gender on work fatigue is crucial for designing effective occupational health policies through re-evaluation of workloads and health support programs.

The research findings indicate that there is no influence of work duration on work fatigue. This is because stone breakers in Kassabumbung Hamlet primarily focus on stone breaking work and do not have other jobs or side work to do after returning from their main job. This allows workers to rest immediately without any additional activities or work, and most stone breakers work for less than 8 hours, which reduces the risk of fatigue.

Although stone breakers exert physical effort in their work, as they work in the informal sector, they can determine their daily work duration according to their needs and capacity. In other words, stone breakers can adjust their work rhythm according to their needs once they feel tired. This study is consistent with other research that shows no relationship between working hours and work fatigue among workers producing bolu talas cakes (Santriyana et al., 2023).

The study results show no significant influence of work tenure on work fatigue among stone breakers in Kassabumbung Hamlet, Selayar Islands Regency. Additionally, based on the data obtained on work tenure, the majority of workers have been employed for more than 5 years.

Five years in a workplace is a sufficiently long period for workers to adapt to the work environment and daily routines. This adaptation process can provide positive benefits, such as reducing tension and increasing productivity. The reduction in tension and increased activity allows workers to adapt well and work according to their capacity, thus reducing the risk of work fatigue. The 5-year adaptation period enables stone breakers to effectively recover from work fatigue. These findings are consistent with other research showing no relationship between work tenure and work fatigue (Juliana et al., 2018).

The research findings indicate no significant influence of workload on work fatigue. The workload of stone breakers is already adjusted to the workers' physical abilities, so it does not lead to work fatigue because the workers are able to meet the demands of the task and have adapted to their daily work routine. This aligns with view of López-Núñez et al. (2020) that the workload should be aligned and balanced with the physical, mental, and human capacity to bear it. Stone breakers make the best use of their rest time, often taking vacations together and scheduling proper leave for at least 2 days after working continuously for a week. Every workload assigned to an individual must be tailored to their physical abilities and limitations. If a person is given a workload that exceeds their capacity, it is likely that they will experience fatigue (Ibáñez et al., 2020).

Assessing physical workload involves measuring body weight, observing work activities, and calculating calorie needs based on energy expenditure according to national standards. The level of workload should be adjusted to the individual's ability and capacity. If the workload exceeds a person's capacity, it will lead to work fatigue. Research by Prakoso et al. (2018) indicates that there is no relationship between workload and work fatigue. This is also consistent with studies showing a negative relationship between workload and work fatigue among workers (Widiyanti et al., 2021).

The test results show no significant influence of total sleep time on work fatigue. A possible factor in this condition is that stone breakers have sufficient daily rest time to recover from the fatigue they experience, so sleep quality does not affect the level of fatigue. Interviews revealed that most stone breakers have sufficient sleep, with a total sleep time of ≥7 hours. Sufficient sleep can refresh workers after their daily tasks (Harknett et al., 2020). Adequate sleep time indicates good sleep quality as well. Sleep is a basic biological process necessary for human survival and development (Agostini et al., 2019; Darchia et al., 2018; Jean-Louis et al., 2020).

Generally, adults need 7-8 hours of sleep each day to maintain health and optimal performance. The body can recover during the sleep process. Recovery is considered successful if a person feels more refreshed and energized when working (Völker et al., 2024). While we sleep, the body undergoes repair and regeneration of damaged cells. This is the time when the body replenishes the energy used throughout the day. This recovery process is crucial to maintaining optimal body function, including cognitive functions such as concentration, memory, and decision-making ability, as well as enhancing energy, muscle recovery, and stress reduction, all of which directly boost.

The results of this study provide a profound understanding of the importance of maintaining a balance between hard work and rest, as taught in the Qur'an. One verse that is particularly relevant to this topic is Q.S. Al-Baqarah/2:286, which states:

"Allah does not charge a soul except (with that within) its capacity.

This verse emphasizes that Allah, in His perfect wisdom, does not place a burden on a person greater than their capacity. This concept is crucial in understanding how we, as humans, should wisely manage our energy and time.

A stone breaker is a tangible representation of someone who works hard physically. In the context of their work, every action they take can be considered a form of worship, provided it is done with sincere intentions and in accordance with Islamic teachings. However, like all humans, the stone breaker has physical and mental limitations. When these limits are exceeded, the body signals fatigue as a protective mechanism.

From an Islamic perspective, fatigue is not only a sign that the body needs rest but also a reminder from Allah that we should not exceed the limits He has set. Islam teaches balance in all aspects of life, including in work and rest. The Prophet Muhammad in Al-Bukhari Hadith No. 5199 taught us to balance worship, work, and rest, as he said,

"*Your body has a right over you*."

By applying these principles, a stone breaker, or anyone engaged in strenuous work, can work more effectively while maintaining their health. Sufficient rest and taking care of one's health are part of worship to Allah, as the body is a trust that must be preserved. Furthermore, Islam emphasizes the importance of intention and purpose in every task. Working hard with the intention of earning a halal livelihood for one's family is a highly rewarded act of worship. However, working hard without considering health and life balance can be counterproductive and may even lead to sin if it results in self-harm.

Therefore, this study reminds us that maintaining a balance between work and rest is a reflection of practicing Islamic values. This principle not only aids in enhancing work productivity but also in preserving our physical and spiritual well-being as servants of Allah.

The limitations of this study include its focus solely on traditional stone breakers in the coastal areas of the Selayar Islands, which means the findings cannot be generalized to stone breaker populations in other regions with different working conditions. Additionally, traditional stone breaking involves extremely strenuous and hazardous working conditions, such as exposure to sunlight, dust, and vibrations. This study did not fully assess the impact of all these environmental factors on fatigue. Therefore, future research should aim to include the measurement of environmental factors in relation to work fatigue.

CONCLUSIONS

The results of this study prove that most traditional stone breakers in the coastal areas of the Selayar Islands experience very high levels of fatigue. Age and gender were shown to be the main causes of severe fatigue among these workers. However, other factors such as length of service, tenure, workload and total sleep time did not show a significant contribution to the level of occupational fatigue in traditional stone breakers. Given that stone-crushing work falls under the informal sector, it is imperative that workers take effective measures to reduce their fatigue levels. Some of the recommended measures include organizing work and rest time by implementing short breaks at regular intervals (every 30-45 minutes to rest), increasing water intake to maintain hydration, and performing light stretches regularly. For future research, it is recommended to consider work environment factors, such as exposure to dust, vibration, and extreme temperatures, as research variables. The influence of these environmental factors on work fatigue will provide a more comprehensive and in-depth understanding. In addition, future research could broaden the focus to include groups of workers from different regions and different job sectors to look at variations in fatigue caused by diverse working conditions. This more in-depth research will help in formulating more effective intervention strategies to improve the health and well-being of workers in the informal sector.

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AUTHORS' CONTRIBUTIONS
Rizky Maharja designed the study, wrote the manuscript, reviewed the manuscript. Tajuddin Tajuddin & Sitti F. Rahmansyah enrolled participants; collected data and analyzed the data. Andi T. F. Kessi, revised the manuscript performed the field work. Arni Juliani performed the field work. Riadnin Maharja revised the manuscript. All Authors read and approved the final manuscript.

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COMPETING INTERESTS

The author(s) declare no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

Aagaard, P., Suetta, C., Caserotti, P., Magnusson, S. P., & Kjær, M. (2010). Role of the nervous system in sarcopenia and muscle atrophy with aging: Strength training as a countermeasure. Scandinavian *Journal of Medicine and Science in Sports*, *20*(1), 49–64. https://doi.org/10.1111/j.1600-0838.2009.01084.x

Agostini, A., Lushington, K., & Dorrian, J. (2019). The relationships between bullying, sleep, and health in a large adolescent sample. *Sleep and Biological Rhythms*, *17*, 172–182. https://psycnet.apa.org/doi/10.1007/s41105-018-0197-z

Allison, P., Tiesman, H. M., Wong, I. S., Bernzweig, D., James, L., James, S. M., & Patterson, P. D. (2022). Working hours, sleep, and fatigue in the public safety sector: A scoping review of the research. *American journal of industrial medicine*, *65*(11), 878-897. https://doi.org/10.1002/ajim.23407

Amalianah, R., Sutangi, & Rahmawati, Ad. (2022). Faktor-Faktor Yang Mempengaruhi Terhadap Kelelahan Kerja Pada Pekerja Pengisian Air Minum Dalam Kemasan Di PT Bharata Sakti Persada Indramayu Tahun 2021. *Afiasi : Jurnal Kesehatan Masyarakat*, *7*(2), 288–292. https://doi.org/10.31943/afiasi.v7i2.220

Antika, R., & Prameswari, G. N. (2023). Hubungan Masa Kerja, Usia, Status Gizi, Kecukupan Energi, Kebiasaan Merokok dengan Kelelahan Kerja pada PEtani Padi. *Indonesia Journal of Public Health and Nutrition*, *3*(1), 127–136. https://doi.org/10.15294/ijphn.v3i1.53917

Antoni, F., & Widanarko, B. (2023). Durasi Kerja Harian sebagai Determinan Utama Kelelahan Pekerja House Keeping. *Jurnal Penelitian Kesehatan Suara Forikes*, *14*(3). http://dx.doi.org/10.33846/sf14303

Anwer, S., Li, H., Antwi-Afari, M. F., Umer, W., & Wong, A. Y. L. (2021). Evaluation of physiological metrics as real-time measurement of physical fatigue in construction workers: state-of-the-art review. *Journal of Construction Engineering and Management*, *147*(5), 03121001. https://doi.org/10.1061/(ASCE)CO.1943-7862.0002038

Argyle, E. M., Marinescu, A., Wilson, M. L., Lawson, G., & Sharples, S. (2021). Physiological indicators of task demand, fatigue, and cognition in future digital manufacturing environments. *International Journal of Human-Computer Studies*, *145*, 102522. https://doi.org/10.1016/j.ijhcs.2020.102522

Ávila-Gutiérrez, M. J., Suarez-Fernandez de Miranda, S., & Aguayo-González, F. (2022). Occupational safety and health 5.0—A model for multilevel strategic deployment aligned with the sustainable development goals of agenda 2030. *Sustainability*, *14*(11), 6741. https://doi.org/10.3390/su14116741

Baraniuk, J. N. (2022). Review of the midbrain ascending arousal network nuclei and implications for myalgic encephalomyelitis/chronic fatigue syndrome (ME/CFS), Gulf War Illness (GWI) and Postexertional Malaise (PEM). *Brain Sciences*, *12*(2), 132. https://doi.org/10.3390/brainsci12020132

Behm, D. G., Alizadeh, S., Hadjizedah Anvar, S., Hanlon, C., Ramsay, E., Mahmoud, M. M. I., & Steele, J. (2021). Non-local muscle fatigue effects on muscle strength, power, and endurance in healthy individuals: A systematic review with meta-analysis. *Sports Medicine*, *51*, 1893-1907. https://doi.org/10.1007/s40279-021-01456-3

Behrens, M., Gube, M., Chaabene, H., Prieske, O., Zenon, A., Broscheid, K. C., & Weippert, M. (2023). Fatigue and human performance: an updated framework. *Sports medicine*, *53*(1), 7-31. https://doi.org/10.1007/s40279-022-01748-2

Bendak, S., & Rashid, H. S. (2020). Fatigue in aviation: A systematic review of the literature. *International Journal of Industrial Ergonomics*, *76*, 102928. https://doi.org/10.1016/j.ergon.2020.102928

Bláfoss, R., Sundstrup, E., Jakobsen, M. D., Brandt, M., Bay, H., & Andersen, L. L. (2019). Physical workload and bodily fatigue after work: Cross-sectional study among 5000 workers. *European Journal of Public Health*, *29*(5), 837–842. https://doi.org/10.1093/eurpub/ckz055

Cheng, Q. S., Liu, T., Huang, H. B., Peng, Y. F., Jiang, S. C., & Mei, X. B. (2017). Association between personal basic information, sleep quality, mental disorders and erectile function: a cross-sectional study among 334 Chinese outpatients. *Andrologia*, *49*(3). https://doi.org/https://doi.org/10.1111/and.12631

Cunningham, C., O'Sullivan, R., Caserotti, P., & Tully, M. A. (2020). Consequences of physical inactivity in older adults: A systematic review of reviews and meta-analyses. *Scandinavian journal of medicine & science in sports*, *30*(5), 816-827. https://doi.org/10.1111/sms.13616

Darchia, N., Oniani, N., Sakhelashvili, I., Supatashvili, M., Basishvili, T., Eliozishvili, M., Maisuradze, L., & Cervena, K. (2018). Relationship between sleep disorders and health related quality of life—results from the georgia SOMNUS study. *International Journal of Environmental Research and Public Health*, *15*(8), 1–15. https://doi.org/10.3390/ijerph15081588

Guduru, R. K. R., Domeika, A., & Domeikienė, A. (2022). Effect of rounded and hunched shoulder postures on myotonometric measurements of upper body muscles in sedentary workers. *Applied Sciences*, *12*(7), 3333. https://doi.org/10.3390/app12073333

Guglielmi, O., Magnavita, N., & Garbarino, S. (2018). Sleep quality, obstructive sleep apnea, and psychological distress in truck drivers: a cross-sectional study. *Social*

Psychiatry and Psychiatric Epidemiology, 53(5), 531–536. https://doi.org/0.1007/s00127-017-1474-x

Harknett, K., Schneider, D., & Wolfe, R. (2020). Losing sleep over work scheduling? The relationship between work schedules and sleep quality for service sector workers. *SSM-Population Health*, *12*, 100681. https://doi.org/10.1016/j.ssmph.2020.100681

Ibáñez, S. J., Perez-Goye, E., García-Rubio, J., & Courel-Ibáñez, J. (2020). Effects of task constraints on training workload in elite women's soccer. *International Journal of Sports Science & Coaching*, *15*(1), 99-107. https://doi.org/10.1177/1747954119891158

International Labour Organization. (2016). *Workplace Stress: a collective challenge*. In Workplace Stress: A collective challenge World (Issue April 2016). International Labour Organization. https://www.ilo.org/global/topics/safety-and-health-at-work/resources-library/publications/WCMS_466547/lang--en/index.htm%0Ahttp://www.ilo.org/africa/media-centre/news/WCMS_477712/lang--en/index.htm

Jean-louis, G., Turner, A. D., Seixas, A., Jin, P., Rosenthal, D. M., Liu, M., & Avirappattu, G. (2020). Epidemiologic Methods to Estimate Insu ffi cient Sleep in the US Population. *International Journal of Environmental Research and Public Health*, *17*(24). https://doi.org/10.3390/ijerph17249337

Jones, M. D., Wewege, M. A., Hackett, D. A., Keogh, J. W., & Hagstrom, A. D. (2021). Sex differences in adaptations in muscle strength and size following resistance training in older adults: A systematic review and meta-analysis. *Sports Medicine*, *51*, 503-517. https://doi.org/10.1007/s40279-020-01388-4

Joshi, C. K., Ranga, M. M., & Ranga, S. (2021). Silicosis: An Occupational Health Crisis Among Stone Grinders. In *Multidimensional Approaches to Impacts of Changing Environment on Human Health* (pp. 169-181). CRC Press. https://doi.org/10.1201/9781003095422-9

Juliana, M., Camelia, A., & Rahmiwati, A. (2018). Analisis Faktor Risiko Kelelahan Kerja pada Karyawan Bagian Produksi PT. Arwana aAnugrah Keramik, Tbk. *Jurnal Ilmu Kesehatan Masyarakat*, *9*(1), 53–63. https://doi.org/10.26553/jikm.2018.9.1.53-63

Kar, G., & Hedge, A. (2020). Effects of a sit-stand-walk intervention on musculoskeletal discomfort, productivity, and perceived physical and mental fatigue, for computer-based work. *International Journal of Industrial Ergonomics*, *78*, 102983. https://doi.org/10.1016/j.ergon.2020.102983

Karyati, E., Junus, S., & Hasanuddin, H. (2021). Hubungan Antara Kelelahan dan Keluhan Fisik Berdasarkan Jenis Kelamin Pada Pekerja Pengalengan Ikan. *Jamura Industrial Review*, *1*(1), 7–14. https://doi.org/10.37905/jirev.v1i1.7772

Kenny, G. P., Yardley, J. E., Martineau, L., & Jay, O. (2008). Physical work capacity in older adults: Implications for the aging worker. *American Journal of Industrial Medicine, 51*(8), 610–625. https://doi.org/10.1002/ajim.20600

Koohsari, M. J., Nakaya, T., McCormack, G. R., Shibata, A., Ishii, K., & Oka, K. (2021). Changes in workers' sedentary and physical activity behaviors in response to the COVID-19 pandemic and their relationships with fatigue: longitudinal online study. *JMIR public health and surveillance*, *7*(3), e26293. https://doi.org/10.2196/26293

Krasin, E., Schermann, H., Snir, N., Tudor, A., & Behrbalk, E. (2022). A quick and comprehensive guide to differential diagnosis of neck and back pain: a narrative review. *SN Comprehensive Clinical Medicine*, *4*(1), 232. https://doi.org/10.1007/s42399-022-01321-y

Krishnan, K. S., Raju, G., & Shawkataly, O. (2021). Prevalence of work-related musculoskeletal disorders: Psychological and physical risk factors. *International journal of environmental research and public health*, *18*(17), 9361. https://doi.org/10.3390/ijerph18179361

Leivas, E. G., Corrêa, L. A., & Nogueira, L. A. C. (2022). The relationship between low back pain and the basic lumbar posture at work: a retrospective cross-sectional study. *International Archives of Occupational and Environmental Health*, 1-9. https://doi.org/10.1007/s00420-021-01778-9

Lestari, A. D., Batara, A. S., & Mytthalib, N. U. (2021). Faktor yang Berhubungan dengan Kelelahan Kerja pada Karyawan di PT Sumber Graha Sejahtera Luwu. *Window of Public Health*, *2*(6), 1145–1156. https://doi.org/10.33096/woph.v2i6.321

López-Núñez, M. I., Rubio-Valdehita, S., Diaz-Ramiro, E. M., & Aparicio-García, M. E. (2020). Psychological capital, workload, and burnout: what's new? the impact of personal accomplishment to promote sustainable working conditions. *Sustainability*, *12*(19), 8124. https://doi.org/10.3390/su12198124

Njaka, S., Yusoff, D. M., Anua, S. M., Kueh, Y. C., & Edeogu, C. O. (2021). Musculoskeletal disorders (MSDs) and their associated factors among quarry workers in Nigeria: A cross-sectional study. *Heliyon*, *7*(2). https://doi.org/10.1016/j.heliyon.2021.e06130

Prakoso, D. I., Setyaningsih, Y., & Kurniawan, B. (2018). Hubungan Karakteristik Individu, Beban Kerja, dan Kualitas Tidur dengan Kelelahan Kerja apda Tenaga Kerja Kependidikan di Institusi Pendidikan X. *Jurnal Kesehatan Masyarakat*, *6*(April), 88–93. https://doi.org/10.14710/jkm.v6i2.20803

Pratiwi, A. P., & Diah, T. (2023). Hubungan Faktor Internal Dengan Kelelahan Kerja Pada Tenaga Kerja Bongkar Muat. *Jurnal Keolahragaan JUARA*, *3*(1), 31–37. https://doi.org/10.37304/juara.v3i1.9355

Rahmawati, R., & Afandi, S. (2019). Faktor yang Berhubungan dengan Kelelahan Kerja pada PErawat di RSUD Bangkinang Tahun 2019. PREPOTI: *Jurnal Kesehatan Masyarakat*, *3*(2), 41–45. https://doi.org/10.31004/prepotif.v3i2.478

Rezaie, A., Godio, M., & Beyer, K. (2021). Investigating the cracking of plastered stone masonry walls under shear–compression loading. *Construction and Building Materials*, *306*, 124831. https://doi.org/10.1016/j.conbuildmat.2021.124831

Rini, N. W. E., & Lanita, U. (2023). Analysis of The Risk Factors of Work Fatigue in Formal dan Informal Workers. *JMJ Special Issues*, *1*(3), 257–266. https://doi.org/10.22437/jmj.v11i3.24936

Rini, W. N. E., Halim, R., & Sarah, U. (2023). Factors related to work fatigue among traffic police. *Poltekita: Jurnal Ilmu Kesehatan*, *16*(4), 429-435. https://doi.org/10.33860/jik.v16i4.1740

Rino Komalig, M., & Mamusung, N. (2020). Hubungan Antara Umur Dan Shift Kerja Dengan Kelelahan Kerja Pada Petugas Karcis Parkir Kawasan Megamas Kota Manado. *Media Publikasi Promosi Kesehatan Indonesia (MPPKI)*, *3*(1), 26–30. https://doi.org/10.56338/mppki.v3i1.1015

Santriyana, N., Dwimawati, E., & Listyandini, R. (2023). Faktor-Faktor yang Berhubungan dengan Kelelahan Kerja pada Pekerja Pembuat Bolu Talas Kujang di Home Industry Kelurahan Bubulak Tahun 2022. *Promotor: Jurnal Mahasiswa Kesehatan Masyarakat*, *6*(4), 2–9. https://doi.org/10.32832/pro.v6i4.273

Shur, N. F., Creedon, L., Skirrow, S., Atherton, P. J., MacDonald, I. A., Lund, J., & Greenhaff, P. L. (2021). Age-related changes in muscle architecture and metabolism in humans: the likely contribution of physical inactivity to age-related functional decline. *Ageing Research Reviews*, *68*, 101344. https://doi.org/10.1016/j.arr.2021.101344

Song, Z., Yang, Z., Song, F., Wu, Y., & Konietzky, H. (2022). Mechanical responses of freeze–thaw treated natural stone masonry subject to compressive variable amplitude fatigue loading: Insights from stiffness loss and constitutive characterization. *Construction and Building Materials*, *350*, 128908. https://doi.org/10.1016/j.conbuildmat.2022.128908

Souchet, A. D., Lourdeaux, D., Pagani, A., & Rebenitsch, L. (2023). A narrative review of immersive virtual reality's ergonomics and risks at the workplace: cybersickness, visual fatigue, muscular fatigue, acute stress, and mental overload. *Virtual Reality*, *27*(1), 19-50. https://doi.org/10.1007/s10055-022-00672-0

Völker, J., Koch, T. J., Wiegelmann, M., & Sonnentag, S. (2024). Mind the misalignment: The moderating role of daily social sleep lag in employees' recovery processes. *Journal of Organizational Behavior*. https://doi.org/10.1002/job.2777

Widiyanti, E., Karimuna, S. R., & Saptaputra, S. K. (2021). Faktor Yang Berhubungan Dengan Kelelahan Kerja Pada Operator Alat Angkat Angkut Di Pt Pelindo Iv Cabang Kendari. *Jurnal Kesehatan Dan Keselamatan Kerja Universitas Halu Oleo, 1*(2), 48–53. https://doi.org/10.37887/jk3-uho.v1i2.16585

Wilkinson, D., Piasecki, M., & Atherton, P. (2018). The age-related loss of skeletal muscle mass and function: Measurement and physiology of muscle fibre atrophy and muscle fibre loss in humans. *Ageing Research Reviews, 47*, 123–132. https://doi.org/10.1016/j.arr.2018.07.005

Xia, Q., Guo, C., Li, Y., Liu, T., & Liu, J. (2023). Fatigue characteristics of ancient brick masonry under cyclic load. *Construction and Building Materials*, *400*, 132653. https://doi.org/10.1016/j.conbuildmat.2023.132653

Xing, X., Zhong, B., Luo, H., Rose, T., Li, J., & Antwi-Afari, M. F. (2020). Effects of physical fatigue on the induction of mental fatigue of construction workers: A pilot study based on a neurophysiological approach. *Automation in Construction*, *120*, 103381. https://doi.org/10.1016/j.autcon.2020.103381

Zhen, G., Fu, Y., Zhang, C., Ford, N. C., Wu, X., Wu, Q., & Guan, Y. (2022). Mechanisms of bone pain: Progress in research from bench to bedside. *Bone Research*, *10*(1), 44. https://doi.org/10.1038/s41413-022-00217-w