
REDUCING CTS COMPLAINTS AND THE FATIGUE OF ROCK BREAKER THROUGH ERGONOMICS APPROACH BY EXERCISING NERVE-TENDON MOBILIZATION AND SHORT BREAK

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ARTICLE INFO ABSTRACT

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The ergonomics problem related to the casual laborers which here focus on rock breakers as their job, covers some aspects such as their muscle usage, working hours, postures, tools and environments. The ergonomics problem created health problems where the workers are having Carpal Tunnel Syndrome (CTS) and fatigue. This study intends to prove that exercising nerve-tendon mobilization and short break through ergonomics approach will be able to reduce the volume CTS complaints and the fatigue of the rock breakers. This study involves 7 samples from the controlling group and 7 samples from the intervention group. The CTS complaints are measured by using Symptom Severity Scale (SSS) from Boston Carpal Tunnel Questionnaire (BCTQ) and the fatigue was surveyed through 30 questionnaires from Item of Rating Scale of Industrial Fatigue Research Committee (IFRC). The Data were analyzed by applying Statistical Package for the Social Science (SPSS) software. The goals of this study is to give nerve-tendon mobilization exercise and short break through ergonomics approach related to the problem of muscle usage, working hours, postures, tools and environments would lessen the CTS complaints about 12,71% while the fatigue level in the amount of 5,69% that has been experienced by the rock breakers.

KEYWORDS

Carpal Tunnel Syndrome, Ergonomics, Fatigue, Nerve-Tendon Mobilization, Short Break



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INTRODUCTION

West Bangkal Awang Village which located in Karang Intan District, Banjar Regency, South Kalimantan Province is a village close to the hills known as Bukit Tahura. This village has many residents who sell crushed stones. The production of the crushed stones includes processes such as rock collection, rock breaking and moving the rock itself to the main storage. Breaking the rocks is the main process to produce crushed stones so it would be ready to be sold to the customers. However, this process has high risks for the workers. That is because the process is done manually and solely relying on physical strength. The tools used consist of a sledgehammer. It has been modified by a rattan handle in order to reduce the vibration caused by the impact between the sledgehammer and the rock. The diameter and length of the handle are adjusted subjectively to suit the user's necessity. The weight of the sledgehammer varies between 8kg – 10kg. Another tool used in the process is a crowbar with a weight that varies between 4kg – 6kg.

Working with the sledgehammer makes the workers perform repetitive movements that create a force whenever the sledgehammer strikes against the rock. When a sledgehammer collides with a rock, it produces vibrations that propagate to the workers' arms. Furthermore, the workers will also perform awkward postures, which tend to bend their wrists for a long time. According to [Ibrahim \(2012\)](#) this condition is the most significant factor in the incidence of CTS. The combination of repetitive movements of force, exposure, and vibration from awkward wrist postures increases pressure within the carpal tunnel tissue. Increased pressure causes tissue compression which will trigger repeated small injuries, in a long term it can cause inflammation of the tendon which further increases compression and causes poor circulation to the tissue and afterwards, causing tissue ischemia resulting in musculoskeletal. If the compression condition is ignored until a chronic stage, it will cause adhesions between the nerves and tendons in the carpal tunnel which causes gradual tissue damage and will reduce the functional ability of the workers ([Duncan & Kakinoki, 2017](#); [Ibrahim et al., 2012](#); [Salawati & Syahrul, 2014](#); [Wardana, Wijayanti, & Ekawati, 2018](#)).

As the presence of musculoskeletal and the high demand of work, it is no wonder that psychological and physical fatigue of the worker would be affected ([Adiputra, 2003](#); [Hedge, 2017](#); [Kroemer & Grandjean, 2009](#)). Fatigue experienced by rock breakers also occurs as the result of improper work time management applied by workers ([Bridger, 2003](#); [Hedge, 2017](#); [Kroemer & Grandjean, 2009](#)). The working time set by the employer begins at 08.00 a.m – 03.00 p.m of Indonesia Central Standard Time (UTC+08:00) for six working days, as they are Monday to Saturday. Practically speaking, the working hours and the rest hours that are provided to the workers depend on the ability of the worker individually. The current habits create a stigma in which most workers choose to force themselves to work continuously preferring to accumulate their rest time in the middle of the day and because of that many workers are not able to continue working due to wrist pain and fatigue throughout their body. Overworking can cause the body tends to spend more energy than it actually targeted. In the process of producing energy, it is necessary to break down glycogen which also produces lactic acid, so the more energy produced, the more lactic acid is created and it will causes vasoconstriction of blood vessels, resulting in obstruction of blood flow and the disposal of the body metabolic wastes. The accumulation of lactic acid that occurs causes fatigue throughout the body in workers ([Hedge, 2017](#); [Kroemer & Grandjean, 2009](#); [Maharja, 2015](#)). Musculoskeletal disorders and fatigue are the factors that can reduce worker productivity ([Damantalm et al., 2018](#);

Rusni, Tirtayasa, & Muliarta, 2017). This is supported by the testimony from the workers who after having the related health complaints only able to work effectively until lunch time meanwhile some of them went home and stopped their work. Which retards the production and the income that should have been able to be earned by the workers for about 3 – 4 days.

In order to fix the mentioned problems, it is necessary to have a comprehensive study that totally focuses on the ergonomics approach. A total focus on ergonomics approach will help encourage all parties to take part in identifying the root cause of the problems, therefore will be able to apply a proper solution with appropriate technology. It is meant to solve the problem by using the SHIP approach (Systemic, Holistic, Interdisciplinary, Participatory) so that a beneficial mechanism would be created and the aimed products quality can be obtained according to the demands of the current era (Manuaba, 2003, 2005). The ergonomics approach is based on eight aspects, known as muscle usage, work posture, nutrition, interactions between human and machine and also situation and condition of time, environment, information and socio-cultural (Oesman & Adiatmika, 2008). The ergonomics approach tries to conduct simple ergonomics improvements based on the existing resource in small industries. In this case, every improvement method applied is intended to be simple yet logical so it can be accepted and applied easily. As the results, the ergonomics problems that will be solved are the aspect of muscle use and work posture by adjusting the jobs to the worker by providing nerve-tendon mobilization exercises after they perform the repetitive movements with strength and make a awkward postures on their wrist; as well as to prevent the health problems where the workers should use their provided rest time instead of constantly working and accumulating their rest hours later.

The application of nerve-tendon mobilization exercises is an option since work-related diseases experienced by workers can be lessened or prevented before it gets worse and affects the workers. According to Atya & Mansour (2011) the reason nerve-tendon mobilization exercises recommended because it provide opportunities for the tissues to relax thereby reducing its tension, smoothing the circulation of nutrients to tissues, improving venous blood flow, preventing or reducing tissue tension, edema, and also the pressure so that the tissue adhesion in the carpal tunnel does not occur. If it successfully applied, complaints about CTS because of tissue ischemia can be solved and finally the workers can carry out their work comfortably without health problems. Several other research claims that the main outcome obtained from applying nerve-tendon mobilization exercises is an increase in vascular reactivity. It can also give an effect on increasing axonal transport and nerve conduction, resulting in improvements of functional state and perceived fatigue (Coppieters & Butler, 2008; Puspawati, Adiatmika, & Sutarja, 2018).

In addition, short breaks can also be considered as a preventive effort since it can help to minimize exposure to risk factors and change the bad habits of the workers who force themselves to work continuously, accumulating breaks and consequently create a system that is not ergonomically friendly. If the latter is not followed, it can actually increase work demands that cause musculoskeletal disorders and build up fatigue of the workers. Having short breaks regularly will further reduce or prevent repetitive strain injuries that can trigger musculoskeletal disorders and other disorders such as fatigue

(Chakrabarty et al., 2016). Short breaks can also reduce the workload, provide an opportunity for the body to recover through valodilation of blood vessels and help the heart's function to be as good as its original condition (Sutapa, Sudiarsa, & Susila, 2017), making its cells able to relax and reduce musculoskeletal disorders (Puspawati et al., 2018), and prevent the accumulation of fatigue (Dewi et al., 2018).

RESEARCH METHOD

This research is an experiment with a randomized pre-post test control group design involving 14 research samples with technique of purposive sampling. The sample in this study was divided into two groups, which are 7 workers in the control group who worked without any intervention and 7 workers in the treatment group who worked with the intervention. The interventions meant through an ergonomic approach include: nerve-tendon mobilization exercises following the Alexander protocol (2017) with a dose of 1 session carried out every 2 hours after work, thus designing 3 sessions in a day, each session consists 1 series of nerve mobilization exercises and 1 series of tendon mobilization exercises, each series was repeated 5 times, it performed in working days for 2 weeks; and a 5 minute short break after undergoing 55 minutes of work activity for 2 weeks. CTS cases first proposed by Chang (2008) when the workers confirm to feel the following: numbness or tingling in the median nerve area, tingling at night, wrist pain radiating to the shoulder, occurrence of Phalen's and Tinel sign. CTS complaints were measured using the Symptom Severity Scale (SSS) from the Boston Carpal Tunnel Questionnaire (BCTQ) and fatigue was measured using a 30 Item of Rating Scale questionnaire from the Industrial Fatigue Research Committee (IFRC). Data analysis used Independent-Samples T Test for data that gave normal results while Mann-Whitney Test for data with abnormal results with a significance level of 5% ($\alpha = 0.05$).

RESULT AND DISCUSSION

1. Respondent Characteristics

Table 1. Respondents Characteristics

Variable	n	%	Average	SD	Range
Age (yrs)	14	100	45,50	2,10	42 – 48
Weight (kg)	14	100	59	2,72	54 – 63
Height (cm)	14	100	163,14	3,01	158 – 168
Working Period (yrs)	14	100	14,86	2,66	12 – 19
IMT (kg/m ²)	14	100	22,17	0,97	20,58 – 23,83
CTS Hand					
Right	14	100	-	-	-
Left			-	-	-

The respondent age involved in this study is considered a productive age. Research from Nurjana (Nurjana, 2015) shows that productive age ranges from 15 to 49 years. Furthermore, the age of workers is classified by the risk of the CTS incidence, according to a study by Cazares-Manríquez (2020) those over the age of 40 years have 1.92 of risk to experience CTS complaints compared to those under 40 years. Body mass index (BMI) of rock breaker workers in Awang village, West Bangkal is considered ideal. Excessive BMI will inflict CTS complaints and fatigue (Purnawijaya & Adiatmika, 2016). According to the Cazares-Manríquez (Cazares-Manríquez et al., 2020) study, a BMI that exceeds its ideal has 2.90 of risk to develop CTS. The average working hours of the workers in this study have a high risk of getting CTS. Lazuardi (2016) research states that ≥ 4 years of working period is one of the reasons for the occurrence of high complaints of CTS, also Atiqoh (2014) states that a long working period can cause high levels of boredom and fatigue for the workers. Another study states that workers who have a working period of 4 years have 11.71 greater risk of experiencing musculoskeletal disorders compared to workers with a working period who < 4 years (Riningrum & Widowati, 2016). The arms of workers affected by CTS all occurred on their right hand. This event can happen seeing that every worker has a dominant arm on the right hand (Rambe, 2004).

2. Working Environment Conditions

Table 2. Working Environment Conditions

Variable	Control		Treatment		p-Value
	Average	SD	Average	SD	
Lighting (lx)	4341,33	0,88	4341,17	1,86	0,85*
Humidity (%)	68,7	0,21	68,72	0,15	0,64*
Temperatures (°C)	28,97	0,18	28,95	0,23	0,89*
Noises (dB)	68,85	0,15	68,82	0,12	0,68*

*Independent-Sample s T Test, **Mann-Whitney Test

As explained in the research by Putra and Madyono (2017), the intensity of lighting in the work environment of the control groups already has an ideal level of lighting. Work that is carried out routinely should have an intensity level of lighting at least 300lx. Meanwhile, the humidity level in the control and treatment groups has met the worker standard comfort. Rezalti and Susetyo (2020) state, the humidity that meets the standards of the industrial work environment is 65% – 95%. The results of measuring the temperature of the industrial work environment in both the control group and the treatment group can be concluded that they have met its quality standard. The research of Lady and Wiyanto (2019) discuss that the temperature condition of the industrial work environment should be at 18°C – 30°C. Next, the noise level in the work environment of both groups is considered to be quite good. According to Permenkes No. 70 concerning Standards and Requirements for Health in the Industrial Work Environment (Menteri Kesehatan Republik Indonesia, 2016), the noise level for 8 hours of work in a day is supposed to be < 85 dB. Thereupon, statistical analysis of lighting conditions, humidity, temperature, and noises in the work environment of both groups were not significantly different (p -value > 0.05). Thus, all aspects of environmental conditions during the study

can be controlled and did not give impact to the activity of the workers.

3. CTS Complaints

Table 3. CTS Complaints

Variable	Control		Treatment		p-Value
	Average	SD	Average	SD	
Pre-CTS Complaints	26,71	0,76	27	1	0,37**
Post-CTS Complaints	32,57	0,53	28,43	0,98	0,00**

*Independent-Sample s T Test, **Mann-Whitney Test

There was no significant difference in the initial conditions (pre) of CTS complaints between the control group and the treatment group (p-value > 0.05). This shows that the initial conditions in both groups are similar. The statistical test for the final condition (post) of CTS complaints in the control group and treatment group obtained a p-value (0.00) <0.05, which means that CTS complaints in the treatment group prove it has a significantly smaller value than the control group. Thus, complaints of CTS in the treatment group decreased remarkably with a percentage decrease of 12.71%. Some effects of CTS complaints that the workers encounter are pain level during the day from severe to moderate, the frequency of pain during the day from 3 – 5 times to 1 – 2 times, the tingling that is felt in moderate to mild, whilst at night it feels moderate to mild. These events occurred because of the intervention of nerve-tendon mobilization exercises through an ergonomic approach on the between working period. According to Ibrahim (Ibrahim et al., 2012) high complaints of CTS that experienced by workers related to occupational factors, such as long work postures to perform extreme wrist flexion or extension, repetitive use of flexor muscles, and exposure to vibrations is said to cause stress on the tissue and lesions in the carpal tunnel tissue which if left unchecked can lead to inflammation and adhesions between the tissues and will develop into a serious problem like CTS.

Performing mobilization exercises can serve as an opportunity for the carpal tunnel tissue to stretch so that it can reduce the tension, give an ease for the nutrients tissue circulates, prevent or reduce edema from pressure so that there is no adhesion between tissues in the carpal tunnel. Therefore, CTS complaints about tissue ischemia can be solved, workers can finish their work comfortably and healthily (Atya & Mansour, 2011; Muliarta, Adiputra, Dinata, Adiputra, & Tunas, 2020). This study is consistently follow previous studies that have analyzed about nerve-tendon mobilization exercises proven to be able to provide: a significant improvement in the severity of the complaints, functional ability, perceived pain, and quality of life of CTS patients (Horng et al., 2011); a significant effect on the improvement of CTS symptoms, which are the subside of silent pain by 7.85% and motion pain by 11.80% (Zuhri, Miharjanto, & Trisnowiyanto, 2012); it also recovers some symptoms like the reduction in pain, paresthesias, tingling, nocturnal symptoms and trouble of sleeping (Marryam, Yasmeen, Malik, Malik, & Amjad, 2018); and another significant improvement in complaints of tingling sensation, pain, hypesthesia, impaired touch sensation, vanishing of positive Phalen sign, increased grip strength, decreased symptom severity, and increased functional ability (Bartkowiak, Eliks, Zgorzalewicz-Stachowiak, & Romanowski, 2019).

The lesser complaint of CTS also occurred because of the intervention in the form of a short 5 minute break after undergoing 55 minutes of work activity. In the control group who was not given the intervention, the workers were only able to work for a shorter time, which is ± 4 hours from 08.00 – 12.00 of Indonesia Central Standard Time (UTC+08:00) meanwhile in the intervention group workers were able to work longer and that is about ± 7 hours from 08.00 – 15.00 of Indonesia Central Standard Time. The reason the control group did a shorter working time is because the occurrence of CTS complaints and fatigue felt by workers is faster, and as a consequence they should stop working. Giving short breaks passively or actively will reduce repetitive workloads which can prevent repetitive strain injuries in the tissues involved in performing risky work (Chakrabarty et al., 2016; Luger, Maher, Rieger, & Steinhilber, 2017). The results of this study are in line with research conducted by Wood (2017), the application of short breaks significantly reduces neuromusculoskeletal complaints from its effects, which can restore posture, soft tissue mobility, and reduce stress due to work processes. Nooryana (2020) also found similar findings, that providing short breaks can significantly reduce musculoskeletal disorders by 7.72% because by doing it the workers will get the opportunity to recover their energy even after doing awkward postures and relaxing the soft tissues involved in the work process.

4. Fatigue

Table 4. Fatigue

Variable	Control		Treatment		p-Value
	Average	SD	Average	SD	
Pre-Fatigue	1,11	48	1,63	0,36*	0,36*
Post-Fatigue	72,71	1,80	68,57	1,90	0,00**

*Independent-Sample s T Test, **Mann-Whitney Test

There was no significant difference in the initial conditions (pre) of fatigue between the control group and the treatment group (p-value > 0.05). This shows that the initial conditions in both groups are similar. The final condition (post) of fatigue in the control group and treatment group based on statistical tests obtained p-value (0.00) <0.05, which means that the fatigue in the treatment group shows that it is significantly smaller than the control group. It reveals that fatigue in the treatment group experienced a significant decrease with a percentage decrease of 5.69%. Of the three types of fatigue associated with weakened activity, weakened motivation, physical fatigue, it was found that the intervention of nerve-tendon mobilization exercise and short break through an ergonomic approach had the most effect on the type of physical fatigue felt by workers with a decreasing effect of 11.16%. By applying the intervention of mobilization exercises to the tissues involved in the work process, it will provide opportunities for the tissues to stretch so as to reduce tissue tension, vascular reactivity, facilitate venous return, facilitate circulation of nutrients to the tissues, and result in increased blood flow to the tissues (Atya & Mansour, 2011; Coppieters & Butler, 2008; Muliarta et al., 2020; Puspawati et al., 2018). Due to the success of this intervention in reducing musculoskeletal disorders, the workers felt less tired. The results of this study are in the same understanding with research by Lacaze (2010) that states exercise at work has a significant effect on reducing musculoskeletal disorders, physical and mental fatigue

rather than just resting passively. Another study that supports the results of this study concluded that doing exercises on the body parts involved after performing work tasks had a significant effect on reducing fatigue at the end of work by 29.22% (Wahyu et al., 2020).

Not only providing training between working hours, the treatment group also practically got a short 5 minute break after undergoing 55 minutes of work activity. The intervention is purposely done in order to make the workers have their work done in an ergonomic way. The workers should avoid working nonstop of their full working hours because they should have a rest for the sake of their own health and also to ensure they can they optimized their job. Short break will help the body to recover through vasodilation of blood vessels so that the heart's burden is reduced and even regain its original condition (Sutapa et al., 2017), providing an opportunity for muscles to relax so the cells can recover muscles that can reduce musculoskeletal disorders (Damantalm et al., 2018; Puspadewi et al., 2018), and prevent the accumulation of fatigue (Dewi et al., 2018; Dhari, Muliarta, & Adiputra, 2017). Research by Sarker (2021) bears similar results to this study, the impact of short breaks to the workers who perform monotonous work or tasks can crucially reduce the cause of fatigue by preventing muscle discomfort. Further research from (Damantalm et al., 2018) states that short breaks have a significant effect in reducing fatigue by 23.75% so that the urge to work remains high and utilizes time at work effectively.

In this study, the score of CTS complaints and fatigue in the treatment group was shown to decrease more compared to the control group, but the intervention provided was not able to reduce the degree of complaints and fatigue felt by workers, which fortunately is still at a moderate degree. This is because there are several factors that play a major role in the incidence of CTS and uncontrolled fatigue such as prolonged awkward work postures, repetitive movements, and exposure to vibration (Ibrahim et al., 2012). In addition, researchers find it difficult to control working time since it is diverse to each person. There are differences in the working time, the control group has a shorter working time whereas the treatment group has a longer working time. This is the answer why the intervention provided was only able to reduce the value of CTS complaints and fatigue but yet to reduce the degree of perceived complaints subjectively (Sani & Widajati, 2021; Wahyu et al., 2020).

CONCLUSION

The nerve-tendon mobilization exercises and short break using an ergonomic approach was able to reduce the level of CTS complaints by 12.71% and the level of fatigue by 5.69%. It is expected the future research would be able to conduct similar study by focuses on work-related factors that have an impact on the occurrence of carpal tunnel syndrome (CTS), for instance are work duration, working period, work posture, working tools, repetitive movements like grab on something, and the exposure to vibration during the process of working.

REFERENCES

- Adiputra, I. N. (2003). Kapasitas kerja fisik orang bali. *Majalah Kedokteran Udayana (Udayana Medical Journal)*, 108–110.
- Alexander, A. (2017). Hand & plastics physiotherapy department: carpal tunnel syndrome-information for patients. *Oxford University Hospitals NHS Trust*, 1–12.

- Atiqoh, J., Wahyuni, I., & Lestantyo, D. (2014). Faktor-faktor yang berhubungan dengan kelelahan kerja pada pekerja konveksi bagian penjahitan di cv. aneka garment gunungpati semarang. *Jurnal Kesehatan Masyarakat*, 2(2), 119–126.
- Atya, A. M., & Mansour, W. T. (2011). Laser versus nerve and tendon gliding exercise in treating carpal tunnel syndrome. *Life Science Journal*, 8(2), 413–420.
- Bartkowiak, Z., Eliks, M., Zgorzalewicz-Stachowiak, M., & Romanowski, L. (2019). The effects of nerve and tendon gliding exercises combined with low-level laser or ultrasound therapy in carpal tunnel syndrome. *Indian Journal of Orthopaedics*, 53(2), 347–352.
- Bridger, R. (2003). *Introduction to ergonomics*. London: Taylor & Francis.
- Cazares-Manríquez, M. A., Wilson, C. C., Vardasca, R., García-Alcaraz, J. L., Olguín-Tiznado, J. E., López-Barreras, J. A., & García-Rivera, B. R. (2020). A review of carpal tunnel syndrome and its association with age, body mass index, cardiovascular risk factors, hand dominance, and sex. *Applied Sciences*, 10(10), 1–30.
- Chakrabarty, S., Sarkar, K., Dev, S., Das, T., Mitra, K., Sahu, S., & Gangopadhyay, S. (2016). Impact of rest breaks on musculoskeletal discomfort of chicken embroiderers of west bengal, india: a follow up field study. *Journal of Occupational Health*, 58, 365–372.
- Chang, W. D., Wu, J. H., Jiang, J. A., Yeh, C. Y., & Tsai, C. T. (2008). Carpal tunnel syndrome treated with a diode laser: a controlled treatment of the transverse carpal ligament. *Photomed Laser Surg*, 26(6), 551–557.
- Coppieters, M. W., & Butler, D. S. (2008). Do ‘sliders’ slide and ‘tensioners’ tension? an analysis of neurodynamic techniques and considerations regarding their application. *Manual Therapy*, 13(3), 213–221.
- Damantalm, Y., Tirtayasa, K., Adiatmika, I. P. G., Manuaba, I. B. A., Sutjana, I. D. P., & Sudijang, L. (2018). Pemberian buah pisang, istirahat pendek dan peregangan menurunkan keluhan muskuloskeletal, kelelahan dan meningkatkan produktivitas pemanen pengguna alat egrek perkebunan kelapa sawit pt. ssd kalimantan timur. *Jurnal Ergonomi Indonesia*, 4(1), 47–56.
- Dewi, K. L. P., Adiputra, I. N., Muliarta, I. M., Tirtayasa, K., Adiatmika, I. P. G., & Adnyana, I. W. B. (2018). Pemberian workplace stretching exercise dan modifikasi kondisi kerja dapat menurunkan keluhan muskuloskeletal dan kelelahan pada pekerja pembuat dodol tradisional di desa tamblang-kabupaten buleleng. *Jurnal Ergonomi Indonesia*, 4(1), 11–17.
- Dhari, I. F. W., Muliarta, I. M., & Adiputra, L. M. I. S. H. (2017). Pemberian pilates exercise dan modifikasi kondisi kerja menurunkan keluhan subjektif dan meningkatkan produktivitas kerja pada pembatik cap di industri batik. *Jurnal Ergonomi Indonesia*, 3(1), 19–28. <https://doi.org/10.24843/JEI.2017.v03.i01.p03>
- Duncan, S. F., & Kakinoki, R. (2017). *Carpal tunnel syndrome and related median neuropathies: challenges and complications*. Switzerland: Springer.
- Hedge, A. (2017). *Ergonomic workplace design for health, wellness, and productivity*/editor, Alan Hedge. Boca Raton: CRC Press; Taylor & Francis Group.
- Horng, Y. S., Hsieh, S. F., Tu, Y. K., Lin, M. C., Horng, Y. S., & Wang, J. D. (2011). The comparative effectiveness of tendon and nerve gliding exercises in patients with carpal tunnel syndrome. *American Journal of Physical Medicine & Rehabilitation*, 90, 435–442.
- Ibrahim, I., Khan, W. S., Goddard, N., & Smitham, P. (2012). Carpal tunnel syndrome: a review of the recent literature. *The Open Othopaedics Journal*, 6(1), 69–76.

- Kroemer, K. H. E., & Grandjean, E. (2009). *Fitting the task to the human a textbook of occupational ergonomics* (Fifth Edit). Philadelphia: UK Taylor & Francis Ltd.
- Lady, L., & Wiyanto, A. S. (2019). Tingkat kelelahan kerja pada pekerja luar ruangan dan pengaruh lingkungan fisik terhadap peningkatan kelelahan. *Journal Industrial Servicess*, 5(1), 58–64.
- Lazuardi, A. I., Ma'rufi, I., & Hartanti, R. I. (2016). *Determinan gejala carpal tunnel syndrome (cts) pada pekerja pemecah batu (studi pada pekerja pemecah batu di kecamatan sumbersari dan sukowono kabupaten jember)*. Universitas Jember.
- Luger, T., Maher, C. G., Rieger, M. A., & Steinhilber, B. (2017). Work-break schedules for preventing musculoskeletal ndisorders in workers. *John Wiley & Sons, Ltd*, 1–11.
- Maharja, R. (2015). Analisis tingkat kelelahan kerja berdasarkan beban kerja fisik perawat di instalasi rawat inap rsu haji surabaya. *The Indonesian Journal of Occupational Safety and Health*, 4(1), 93–102.
- Manuaba, I. B. A. (2003). Organisasi kerja, ergonomi dan produktivitas. *Seminar Nasional Ergonomi*. Jakarta.
- Manuaba, I. B. A. (2005). Total ergonomic enhancing productivity. product quality and customers satisfaction. *Seminar Nasional Ke II Untuk Peningkatan Kualitas Sistem Manufaktur Dan Jasa*. Yogyakarta.
- Marryam, M., Yasmeen, R., Malik, T. M., Malik, A. N., & Amjad, I. (2018). A comparision of the effectiveness of neurodynamics versus nerve and tendon gliding exercises alone for carpal tunnel syndrome. *Pak Armed Forces Med J*, 68(4), 924–929.
- Menteri Kesehatan Republik Indonesia. *Peraturan menteri kesehatan republik indonesia tentang standar dan persyaratan kesehatan lingkungan kerja industri.* , Pub. L. No. 70 (2016).
- Muliarta, I. M., Adiputra, I. N., Dinata, I. M. K., Adiputra, L. M. I. S. H., & Tunas, I. K. (2020). Active stretching and working posture correction to improve psycho-physiological response among computer operators for high school students. *Journal of Human Ergology*, 49(1), 9–16.
- Nooryana, S., Adiatmika, I. P. G., & Purnawati, S. (2020). Latihan peregangan dinamis dan istirahat aktif menurunkan keluhan muskuloskeletal pada pekerja di industri garmen. *Jurnal Ergonomi Indonesia*, 6(1), 61–67.
- Nurjana, M. A. (2015). Faktor risiko terjadinya tuberculosis paru usia produktif (15-49 tahun) di indonesia. *Media Litbangkes*, 25(3), 165–170.
- Oesman, T. I., & Adiatmika, I. P. G. (2008). Aplikasi model total ergonomic approach pada industri kecil-suatu pendekatan praktis. *Seminar Nasional Aplikasi Sains Dan Teknologi*, 222–225.
- Purnawijaya, M. A., & Adiatmika, I. P. G. (2016). Hubungan indeks massa tubuh dengan gangguan muskuloskeletal dan distribusinya menggunakan nbm (nordic body map) pada anggota senam satria nusantara di lapangan nitimandala renon. *E-Jurnal Medika Udayana*, 5(2), 1–8.
- Puspadewi, M. A., Adiatmika, I. P. G., & Sutarja, I. N. (2018). Penerapan istirahat aktif meningkatkan kapasitas kerja dan produktivitas pekerja bagian pembentukan keramik di btikk bppt bali. *Jurnal Ergonomi Indonesia*, 4(2), 19–28.
- Putra, B. G. A., & Madyono, G. (2017). Analisis intensitas cahaya pada area produksi terhadap keselamatan dan kenyamanan kerja sesuai dengan standar pencahayaan (studi kasus di pt. Lendis cipta media jaya). *Jurnal Optimasi Sistem Industri*, 10(2), 115–124.

- Rambe, A. S. (2004). *Sindrom terowongan karpal (carpal tunnel syndrome)*. Medan: Bagian Neurologi FK USU.
- Rezalti, D. T., & E., Susetyo A. (2020). Kadar suhu dan kelembaban di ruang produksi wedang uwuh universitas sarjanawiyata tamansiswa. *Industrial Engineering Journal of The University of Sarjanawiyata Tamansiswa*, 4(2), 70–78.
- Riningrum, H., & Widowati, E. (2016). Pengaruh sikap kerja, usia, dan masa kerja terhadap keluhan low back pain. *Jurnal Pena Medika*, 6, 91–102.
- Rusni, N. W., Tirtayasa, K., & Muliarta, I. M. (2017). Workplace stretching exercise and giving sweet tea improve physiological response and increase the productivity among tailors in pt. fussion hawai. *Jurnal Ergonomi Indonesia*, 3(1).
- Salawati, L., & Syahrul. (2014). Carpal tunnel syndrome. *Jurnal Kedokteran Syiah Kuala*, 14(1), 29–37.
- Sani, N. T., & Widajati, N. (2021). The correlation of work duration and physical workload with the complaints of musculoskeletal disorders in informal workers. *The Indonesian Journal of Occupational Safety and Health*, 10(1), 79–87.
- Sarker, P., Norasi, H., Koenig, J., Hallbeck, M. S., & Mirka, G. (2021). Effects of break scheduling strategies on subjective and objective measures of neck and shoulder muscle fatigue in asymptomatic adults performing a standing task requiring static neck flexion. *Applied Ergonomics*, 92.
- Sutapa, I. K., Sudiarsa, I. M., & Susila, I. N. D. (2017). Penerapan istirahat pendek menurunkan beban kerja dan keluhan muskuloskeletal petugas parkir di hardy's sesetan denpasar. *Logic: Jurnal Rancang Bangun Dan Teknologi*, 17(1), 26–30.
- Wahyu, A., Stang, S., Russeng, S., Salmah, A. U., Dahlan, N. A., Mallongi, A., & Restu, M. (2020). Workplace stretching exercise toward reduction job burnout among workers pt. x international, indonesia. *Open Access Macedonian Journal of Medical Sciences*, 8(T2), 7–11.
- Wardana, E. R., Wijayanti, S., & Ekawati, E. (2018). Faktor-faktor yang berhubungan dengan kejadian carpal tunnel syndrome (cts) pada pekerja unit assembling pt x kota semarang tahun 2018. *Jurnal Kesehatan Masyarakat*, 6(5), 502–509.
- Wood, K. A. C., Lowndesb, B. R., Buusd, R. J., & Hallbeckb, M. S. (2017). Evidence-based intraoperative microbreak activities for reducing musculoskeletal injuries in the operating room. *IOS Press*, 649–659.
- Zuhri, S., Miharjanto, H., & Trisnowiyanto, B. (2012). Latihan neural stretching dan penurunan nyeri penderita carpal tunnel syndrome. *Jurnal Terpadu Ilmu Kesehatan*, 1(1), 61–66.