

Integration of Ergonomic Intervention and Motor Control Exercises to Improve Work Posture and Reduce Musculoskeletal Complaints in Stone Crusher Workers

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ABSTRACT

Introduction: The incidence of musculoskeletal disorders in industrial workers who rely on manual material handling was found to be 100%. Uncontrolled exposure to risk factors in the workplace will cause the cumulative effect of repetitive strain injury so that musculoskeletal disorders become progressive and chronic and have the potential to cause disability, drug abuse, absenteeism, and cost expenditure. This study aimed to examine the effect of integrating ergonomic interventions and motor control exercises to improve work posture and reduce musculoskeletal disorders in stone crusher workers. **Methods:** This study was a randomized controlled trial design with two groups, a control group, and a treatment group. The study respondents were selected randomly, each group consisting of 21 respondents. The control group intervention consisted of conventional physiotherapy actions: Portable Transcutaneous Electrical Nerve Stimulation (TENS) treatment modalities, Portable Ultrasound (US), passive joint mobilization, and passive stretching. The treatment group intervention is called the ergo movement system which consists of the stages of risk assessment, risk control-task adaptation, and motor exercise. The data assessed included work posture assessment using the Rapid Entire Body Assessment (REBA) instrument and musculoskeletal complaints using the Nordic Body Map instrument. Data measurements were conducted before the intervention and 4 weeks after the intervention. **Results:** The control group intervention statistically only had a significant impact on reducing musculoskeletal complaints $0.01 < 0.05$ but had no impact on improving work posture $0.83 > 0.05$. Meanwhile, the treatment group intervention significantly affected improving work posture $0.01 < 0.05$ and reducing musculoskeletal complaints $0.01 < 0.05$. **Conclusion:** The ergo movement system intervention was significantly more effective than conventional physiotherapy intervention in overcoming problems related to occupational health.

Keywords: ergonomics, physiotherapy, occupational health, musculoskeletal complaints, work posture

INTRODUCTION

Stone-splitting businesses are usually found in rural areas in the form of household scale, unorganized, irregular, legal but not registered. Stone breaking is the main process in the production of split stones. Workers perform multiple manual material handling tasks, such as pulling stones, pushing stones, moving or lifting stones, and holding a sledgehammer with a mass of 8-10 kg. If done incorrectly, these tasks can

cause inflammation of the muscles and nerves which are at risk of causing or increasing musculoskeletal complaints. (Harari et al., 2020; Moradi & Barakat, 2020; Wicaksono et al., 2021, 2022)

The incidence of musculoskeletal complaints in industrial workers who rely on manual material handling was found to be 100%. The dominant body parts that had complaints included the upper extremities (64.3%), back

(59.5%), and upper and lower neck (57.1%)(Mallapiang & Muis, 2021). Work-related musculoskeletal disorders are a major concern in various industries and a serious threat to workers in today's world. Work-related musculoskeletal disorders are defined as disorders of body structures, such as joints, bones, ligaments, tendons, muscles, nerves, and blood vessels involved with these tissues caused by working conditions (Demissie et al., 2024). The complaints felt can be in the form of discomfort such as pain, tingling, numbness, stiffness, and loss of motor function and can lead to disability, drug abuse, absenteeism from work, and costly expenses. (Moradi & Barakat, 2020; Purba & Lestari, 2017).

Many studies have investigated physiotherapy interventions for musculoskeletal disorders experienced by workers. Typically, physiotherapists tend to provide exercise therapy, manual therapy, and some general advice to reduce symptoms due to work habits without specifically addressing risk factors in the workplace. (So et al., 2019; Van Eerd et al., 2016). This condition causes workers to experience repeated cases as much as 47% (Boschman et al., 2012) even though they have come to a physiotherapist. Exposure to risk factors in the workplace that are not controlled will cause an accumulated effect of repetitive strain injury so that the symptoms of musculoskeletal complaints that are felt become progressive and the complaints will be chronic (Wicaksono et al., 2021). If musculoskeletal complaints have become chronic, there will be an imbalance in muscle work which is the main pathology that causes pain and the level of complaints will worsen until it causes structural deformity. (Kim & Kwag, 2016; Tsang et al., 2018).

Based on previous research conducted on the population of stone crusher workers, providing muscle stretching interventions during work, regulating rest periods, and adding work equipment in the form of wrist bandages can only significantly reduce the workload by 11% but do not affect reducing musculoskeletal complaints. The failure of previous research is that

researchers have not taken a multi-component approach to addressing the problems found. Other aspects that are not considered to address the problems found include non-ergonomic work equipment in the form of sledgehammers that are not adjusted to the characteristics of individual workers and jobs, forcing workers to adopt inefficient work postures. (Wicaksono et al., 2022).

Work-related musculoskeletal disorders are a priority for many countries around the world to be resolved and prevented. Ergonomic intervention is one of the main ways to prevent or control these problems, the approach of which is multi-component including individual and work factors so that the chances of success are greater (Bazazan et al., 2019; Karimi et al., 2020; Tsang et al., 2018). Ergonomic interventions can be divided into interventions for individuals or workers (eg physical exercise, education, and training), interventions for the physical environment (eg modification of work tools and workstations), and interventions for organizations (eg optimization of work time and rest time)(Karimi et al., 2020; Tsang et al., 2019).

Ergonomic interventions in the form of redesigning or modifying work tools, improving work posture, arranging rest periods, and stretching during work time are good solutions and have been proven to have a strong impact on reducing musculoskeletal complaints. The effects of ergonomic interventions can prevent the accumulation of fatigue and repetitive strain injury in musculoskeletal tissue, prevent muscle spasms, improve work posture, and make muscle work efficient (Damantalm et al., 2018; Daryono et al., 2016; Ferdyastari et al., 2018). An important thing that is also considered is optimizing effective muscle activity patterns when workers carry out their daily work tasks by providing motor control training programs. Several recent studies have reported significant effects of motor control resistance training in reducing musculoskeletal pain complaints among workers. Motor control training affects improving body posture through deep muscle activation and correcting muscle imbalances that can cause pain complaints (Kim & Kwag, 2016; Tsang et al.,



2018, 2019; Van Eerd et al., 2016). Based on the description above, this study aims to test the effect of integrating ergonomic interventions and motor control training to improve work posture and reduce musculoskeletal complaints in stone crusher workers.

METHODS

This study was a randomized controlled trial design with two groups, a control group, and a treatment group. The samples involved were selected by a simple random drawing method. The number of samples involved was 42 respondents, each group consisting of 21 respondents. The number of samples in this study has met the minimum sample requirements, and an adequate number of samples for experimental research ranges from 8-20 respondents (Alwi, 2015). Inclusion criteria: 1) being a stone crusher worker for ≥ 2 years at the current workplace; 2) age range between 21-50 years; 3) history of having musculoskeletal complaints for the past 1 month with a numeric rating score of 1-10; and 4) having a body mass index between 18.5-24.9 kg/m². Exclusion criteria: 1) experiencing pain in the limbs due to a history of trauma; 2) deformity or abnormalities of the limbs; 3) consuming nonsteroidal anti-inflammatory drugs; and 4) having undergone surgery. This research has received a Certificate of Research Ethics Suitability from the STIKES Suaka Insan Research Ethics Committee with Number: 155/KEPK-SI/VII/2024.

Both groups received intervention for 4 weeks consisting of 2 sessions/week so the number in each group was 8 sessions. Each intervention session lasted for 45-60 minutes.

Control group program: Conventional physiotherapy intervention, in the form of Portable Transcutaneous Electrical Nerve Stimulation (TENS) treatment modalities: normal mode, 50-100Hz, intensity according to tolerance; Portable Ultrasound (US): frequency 1 MHz, 2-4 W/cm². Passive joint mobilization; and passive stretching exercises.

Treatment group program: The treatment group received intervention with the term ergo movement system consisting of the risk

assessment stage, risk control-task adaptation, and motor exercise. In the risk assessment stage, the Chief Researcher conducted by observing the work demands of workers to assess work-related risks. The aspects analyzed were the nature of the work, working hours, main tasks of the work, equipment, and tools used, frequency and intensity of work postures, and work environment conditions. In the risk control-task adaptation stage, respondents will be given ergonomic education on how to improve the arrangement of workstations, work environments, work equipment, and work organizations. For example, workers are given education on adjusting body position and posture during the process of breaking rocks and moving rocks into trucks, so that the position and posture of the workers are more effective and efficient. Respondents should not accumulate rest time until they feel tired, what should be done is to take a short 10-minute break after working for 30 minutes, and do muscle group stretching exercises after working for 2 hours. Each respondent's work equipment in the form of a sledgehammer was modified within practical limits depending on the available resources, namely the sledgehammer lever arm was replaced using rattan with the length and diameter of the sledgehammer lever adjusted to the characteristics of the worker's body and worker comfort. Participants were also trained to apply appropriate work postures and work techniques to reduce the possibility of further injury. In the motor exercise stage, the treatment group received intervention in the form of motor control training as many as 2 sessions/week with a total of 8 sessions for 4 weeks. The general approach is to improve muscle imbalance problems when respondents perform their work tasks. Specific exercises were taught to respondents to be done at home and at work to increase the activation of inactive muscles while chronically overactive muscles were not trained. Specifically, these exercises focused on training head control, scapular control, and lumbar control to produce optimal posture while performing work tasks. Respondents in the treatment group were given simulation sessions for 1-2 weeks to learn the correct motor control exercises.



The main data of this study were work posture assessment using the Rapid Entire Body Assessment (REBA) instrument and musculoskeletal complaints assessment (feeling pain, tingling, numbness, or stiffness in the limbs) using the Nordic Body Map instrument. Data measurements were taken before the intervention and 4 weeks after the intervention. Changes in intervention results were compared between the two groups and the data measurement intervals.

Data analysis in this study used IBM SPSS Statistics software (version 29): 1) Comparing the initial conditions of work posture and musculoskeletal complaints in the same or different conditions between the control and treatment groups was tested using the Independent-Samples T-Test for normally distributed data and the Mann-Whitney Test for non-normally distributed data with a significance level of 5% ($\alpha = 0.05$); 2) Comparing the conditions of work posture and musculoskeletal

complaints before and after the intervention in each control and treatment group was tested using the Paired-Samples T-Test for normally distributed data and the Wilcoxon Signed Ranks Test for non-normally distributed data with a significance level of 5% ($\alpha = 0.05$); 3) Comparing the effects of better interventions on work posture conditions and musculoskeletal complaints between the control and treatment groups was tested using the Independent Samples T-Test for normally distributed data and the Mann-Whitney Test for non-normally distributed data with a significance level of 5% ($\alpha = 0.05$).

RESULTS

The number of respondents involved in this study until completion was 42 respondents who were divided into a control group and a treatment group (ergo movement system), each consisting of 21 respondents recruited randomly. Each group underwent a program for 4 weeks.

Table 1. Respondent Characteristics

	Control Group		Treatment Group	
	n(%)/ $\bar{x} \pm \sigma$	Min-Max	n(%)/ $\bar{x} \pm \sigma$	Min-Max
Gender				
Male	21 (100%)	-	21 (100%)	-
Female	0 (0%)	-	0 (0%)	-
Age (Years)	42,6 $\pm$ 2,8	36-46	42,3 $\pm$ 4,2	32-47
Work Period (Years)	3,9 $\pm$ 1,1	2,9-6,4	3,8 $\pm$ 1,1	2,6-6,4

Data from Table 1 can be explained that men are the dominant gender in this type of work with all respondents being male in each group. Breaking rocks is a job that involves physical or technical work, so men will be more dominant than women (Blau & Kahn, 2017). The average age of respondents in the control group was 42.6 years and the treatment group was 42.3 years, both of which were workers in the productive age category (Republic of Indonesia, 2003). The length of service of respondents in the control group was 3.9 years and the treatment group was 3.8 years, who were workers with intermediate level experience, meaning that workers already had more in-depth experience and skills in their field of work (Judge & Robbins, 2017).

The results of the treatment effect test based on Table 2, conventional physiotherapy intervention in the control group did not have a significant effect on work posture (p-value > 0.05) based on the results of the Wilcoxon Signed Ranks Test (non-normal data distribution). However, conventional physiotherapy intervention can have a significant effect on reducing musculoskeletal complaints (p-value < 0.05) based on the Paired-Samples T-Test (normal data distribution). The ergo movement system intervention in the treatment group had a significant effect on improving work posture (p-value < 0.05) based on the Wilcoxon Signed Ranks Test (non-normal data distribution) and reducing musculoskeletal



complaints (p-value <0.05) based on the Paired-Samples T-Test (normal data distribution).

Table 2. Analysis of Pre-Post-Treatment Effects

	Pre $\bar{x} \pm \sigma$	Post $\bar{x} \pm \sigma$	P-Value	95% CI
Control Group				
Work Posture	11,81±0,40	11,95±0,22	0,83 ^{††}	-
Musculoskeletal Complaints	65,19±5,08	61,48±5,24	0,01 [‡]	1,76-5,67
Treatment Group				
Work Posture	11,80±0,40	9,43±0,51	0,01 ^{††}	-
Musculoskeletal Complaints	65,05±5,63	55,38±6,62	0,01 [‡]	7,82-11,52

[‡]: Paired-Samples T-Test; ^{††}: Wilcoxon Signed Ranks Test

Conventional physiotherapy intervention in the control group did not have a significant effect on work posture (p-value > 0.05) based on the results of the Wilcoxon Signed Ranks Test (data distribution is not normal). However, conventional physiotherapy intervention can have a significant effect on reducing musculoskeletal complaints (p-value < 0.05) based on the statistical test *Paired-Samples T-*

Test (normal data distribution). Ergo movement system intervention in the treatment group had a significant effect on improving work posture (p-value <0.05) based on the Wilcoxon Signed Ranks Test (non-normal data distribution) and reducing musculoskeletal complaints (p-value <0.05) based on the Paired-Samples T-Test (normal data distribution).

Table 3. Analysis of Treatment Effects of Control Group-Treatment Group

	Control Group $\bar{x} \pm \sigma$	Treatment Group $\bar{x} \pm \sigma$	P-Value	95% CI
Work Posture	11,95±0,22	9,43±0,51	0,01 ^{††}	-
Musculoskeletal Complaints	61,48±5,24	55,38±6,62	0,01 [‡]	2,37-9,82

[‡]: Independent Samples T-Test; ^{††}: Mann-Whitney Test

Table 3, overall explains that the ergo movement system intervention in the treatment group has a significantly better effect compared to conventional physiotherapy intervention in the control group on improving work posture with an impact of 20.08% (p-value <0.05) based on the Mann-Whitney Test statistical test (non-normal data distribution) and reducing musculoskeletal complaints with an impact of 14.87% (p-value <0.05) based on the Independent Samples T-Test statistical test (normal data distribution).

DISCUSSION

Eight complaints dominate stone crusher workers, including the waist, hands, wrists, forearms, shoulders, lower neck, upper legs, and feet. These complaints can occur according to the characteristics of the work done by the workers. Workers do manual material handling to break rocks using a sledgehammer. Such demands require workers to perform repetitive movements and bear the load from the sledgehammer which is done with a standing work posture. In addition, the workers' work objects are in situational places that sometimes make workers do uncertain work postures. If the work object is lower, the worker's posture will be more bent and the worker often



steps on the rock surface so that the worker is on an unstable surface.

This home industry has unorganized and irregular work management. Working hours and rest times vary greatly between workers. The habit of workers to take a break is to accumulate fatigue until the body feels very tired, then the worker stops work activities for a moment or even ends work for the day. Such conditions will hurt the pathophysiology of the body, namely triggering micro-injuries and increasing the rate of progression of disorders due to repetitive strain injuries (Wicaksono, 2021). Micro injuries in the acute phase are very difficult to detect and will start to cause significant complaints when they are in the chronic phase. Thus, a physiotherapy treatment program to overcome musculoskeletal complaints felt by workers must consider the personal aspects and work environment which are risk factors for these problems.

Ergo movement system intervention is a multimodal physiotherapy treatment approach that can accommodate occupational health needs. This approach is participatory, so it emphasizes respondents or workers who are actively involved in carrying out occupational health programs. The intervention was developed considering that musculoskeletal complaints in the worker population are disorders of body structures, such as joints, bones, ligaments, tendons, muscles, nerves, and blood vessels caused by working conditions (Demissie et al., 2024). This intervention consists of the stages of risk assessment, risk control-task adaptation, and motor exercise.

At the risk assessment stage, physiotherapists observe the work demands of workers to assess work-related risks. Based on observations, risk factors are obtained, including work posture, rest time, repetitive movements, and work tools that do not comply with ergonomic principles. The risk control-task adaptation stage is an effort with a participatory approach. Respondents will be given education on ergonomic principles on how to perform work movements and adjust effective and efficient work positions and postures. Increase worker

awareness that they should not accumulate rest time until they feel tired, what should be done is to take a short 10-minute break after working for 30 minutes, and do muscle group stretching exercises after working for 2 hours. The sledgehammer work tool is modified by replacing the sledgehammer lever arm using rattan with a length and diameter adjusted to the safety and comfort of the worker. The motor exercise stage is a restorative program to restore the balance of the body's motor control function. This exercise consists of a series of deep core muscle activation exercises of 2 sessions/week with a total of 8 sessions over 4 weeks.

Based on the results of this study, the intervention in the treatment group was better than the intervention in the control group significantly improving work posture and reducing musculoskeletal complaints. Work posture is a variable that contributes to musculoskeletal complaints. By providing education on ergonomic principles related to work position and posture and modifying work tools, the REBA value can be reduced compared to the control group, which experienced a slight increase in the REBA value, so that the effect of the intervention on musculoskeletal complaints was not optimal. This is in line with Dayono's research (Daryono et al., 2016), reducing postures that are too bent and redesigning or modifying work tools can reduce musculoskeletal complaints. A bent posture causes muscles to be more tense, so workers will need great muscle endurance, this condition will cause excessive muscle loading and strain which can cause musculoskeletal complaints and increase the workload that triggers muscle spasms (Vitalistyawati & Sari, 2024).

The decrease in musculoskeletal complaints in the treatment group was due to the effects of short breaks and active stretching performed by workers in between work hours. Short breaks and active stretching provide an opportunity for tissue to stretch, thereby preventing tissue tension, facilitating tissue nutrient circulation, preventing or reducing oedema, and preventing or reducing pressure so that adhesions between tissues do not



occur, and tissue is protected from ischemia which causes workers to experience musculoskeletal complaints (Atya & Mansour, 2011; Muliarta et al., 2020; Wicaksono et al., 2022). Other studies that explain the main effects of stretching in between work are increased blood flow to the muscles, thereby increasing the supply of nutrients and oxygen to the muscles and vertebral discs, which then increases the production of synovial fluid in the joints, reduces the occurrence of trigger points, maintains the range of motion of the joints, can cause a relaxed response in the central nervous system, warms up the muscles before starting work, and can prevent micro-injuries. Ideally, stretching between work is done for 15-30 seconds on one muscle group, slowly to reduce muscle tension and prevent musculoskeletal complaints (Nooryana et al., 2020).

Providing deep core muscle activation training to workers who predominantly experience low back pain is very effective in improving musculoskeletal complaints through the effect of increasing muscle endurance which results in internal posture correction (Shah et al., 2020). Deep core muscles are very important for maintaining the integrity of the kinetic chain and distributing power to the legs and arms (Nandlall et al., 2020). Increasing the strength of deep core muscles can help stabilize waist posture, relieve musculoskeletal complaints, and improve the ability of daily living activities (Ekstrom et al., 2007). The results of other studies state that exercises that target deep core muscles are more effective than conventional exercises in reducing low back pain complaints. Deep core muscle training can improve neuromuscular control, spinal stability, endurance, and muscle strength. Optimal deep core muscle conditions function to withstand loads and move the body more efficiently due to the integration and balance between deep muscles and global muscles (Putri et al., 2021).

CONCLUSION

This study has compared the effects of the ergo movement system intervention program consisting of stages consisting of risk assessment, risk control-task adaptation, and motor exercise. Intervention in the treatment group provided a significantly more effective effect compared to conventional physiotherapy to improve work posture with an impact of 20.08% and a decrease in musculoskeletal complaints with an impact of 14.87%. This study is an effort to develop a model or concept of physiotherapy in dealing with occupational health problems, especially musculoskeletal complaints. With the presence of this study, it is hoped that there will be more physiotherapy research that focuses on solving problems related to ergonomics and occupational health, most of which still focus on aetiology or risk factors.

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