

The Effectiveness of Chair-Based Stretching Exercises in Reducing Musculoskeletal Disorder (MSD) Complaints Among Tofu Industry Workers in Bandungan

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Abstract. The production process of soybean tofu involves several stages, including soaking, grinding, cooking, filtering, coagulating, molding, and packaging. The workers' activities are monotonous and typically performed in a prolonged sitting posture that lacks ergonomic support. Such non-ergonomic working postures combined with repetitive tasks can lead to musculoskeletal disorder (MSD) complaints among workers. This study aims to analyze the effectiveness of chair-based stretching exercises on MSD complaints among tofu factory workers in Bandungan. This study employed a quasi-experimental approach with a non-equivalent control group design. The study sample consisted of 25 respondents in the treatment group and 25 respondents in the control group, selected through purposive sampling based on inclusion criteria. The instrument used to measure MSD complaints was the numerical rating scale (NRS). Data were analyzed using the Mann-Whitney statistical test. The results showed that prior to the intervention, the level of MSD pain was categorized as moderate and after the implementation of chair-based stretching exercises, the pain level decreased to a mild category. Statistical analysis revealed a p-value of 0.000 (<0.05), indicating a significant difference in MSD complaints between the treatment and control groups. Therefore, chair-based stretching exercises are significantly effective in reducing MSD complaints among tofu industry workers.

1 Introduction

The informal sector is currently experiencing more rapid growth compared to the formal sector, making it a significant component of the people-centered economy that plays an important role in community development and national progress in Indonesia. As of February 2020, the labor force reached 137.91 million people with 131.03 million individuals employed, an increase of 1.67 million from February 2019. Among them, 74.04 million people (56.50%) were engaged in informal employment [1]. According to data from the Central Bureau of Statistics of Central Java Province (No. 35/05/33/Th.XIV), in February 2019, approximately 10.74 million people (60.24%) of the workforce were employed in the informal sector. This figure slightly decreased to 10.52 million people (58.49%) in February 2020 [2]. Despite its economic contribution, the informal sector is characterized by substandard levels of welfare. Informal workers often face excessive workloads and long

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working hours, while occupational safety and health principles are frequently neglected by employers in this sector.

A study conducted in an informal brass handicraft industry in Pati Regency, Central Java, reported that the work was carried out in an uncomfortable environment, with workers typically maintaining prolonged sitting postures. This working condition presents various occupational risks and hazards, one of which is the development of musculoskeletal complaints. Musculoskeletal complaints in the study were assessed using a scoring scale, where a score of 1 indicated no complaint, 2 indicated mild pain, 3 indicated pain, and 4 indicated severe pain. The results showed that workers experienced pain in several body regions, including the upper neck, right shoulder, lower neck, back, and buttocks. The most common pain experienced by workers occurred in the lower back, with a prevalence of 59.6% [3].

Occupational diseases can be prevented through engineering controls and management interventions by improving workplace ergonomics [4]. One of the preventive efforts that can be implemented is the provision of non-pharmacological therapy in the form of chair-based stretching exercises. This intervention was carried out for 10 minutes over the course of one week using a chair as the main equipment.

Stretching for 5–10 minutes has been proven to reduce muscle pain [5]. According to the American College of Sports Medicine (ACSM), effective stretching and flexibility exercises should be performed 3–5 times per week [6]. Through stretching, the muscles undergo contractions that help reduce the risk of lower back injuries. Simultaneous muscle contractions also improve stabilization and reduce muscle imbalances.

Respiratory endurance or maximum oxygen uptake is an important component of physical fitness. A high level of physical fitness can enhance athletic performance, improve physical abilities, and reduce the risk of injury during competition [7]. The factors that influence physical fitness are divided into two categories, internal and external. Internal factors include genetics, age, and sex. External factors include physical activity, health status, lifestyle habits, nutritional status, and temperature.

Based on the results of a preliminary study involving initial interviews with several workers at the tofu industry in Bandung, it was found that the interviewed workers reported experiencing pain in the back, lower back, shoulders, and legs. Several factors were identified as contributing to the subjective musculoskeletal complaints among the workers, including a forward-leaning sitting posture that imposes additional pressure on the spine, legs that remain bent due to non-ergonomic chairs, and the performance of tasks in a monotonous posture over extended periods of time.

Flexibility is the ability of the body to move individual parts or the entire body to the maximum range of motion without causing injury to muscles or joints. Flexibility is also referred to as suppleness or joint mobility. It is considered one of the key components of physical fitness. Flexibility training can be achieved through stretching exercises targeting the neck, shoulders, arms, back, hips, and legs. The benefits of chair-based stretching exercises include preventing joint and muscle injuries, improving joint mobility for smoother and freer movement, reducing the risk of sprains or strains, decreasing the likelihood of muscle cramps, and enhancing overall posture.

Based on these considerations, the researchers observed that studies on ergonomic working posture among tofu workers in Bandung remain limited. Therefore, this study aims to examine the effectiveness of chair-based stretching exercises in increasing flexibility and reducing MSD complaints among tofu workers in Bandung.

2 Methods

This study employed an experimental approach with a pretest–posttest control group design. Participants were divided into two groups, a treatment group and a control group, with group assignments determined through random selection. The intervention consisted of a 10-minute chair-based stretching exercise administered to the treatment group, while the control group did not receive any intervention. During the preliminary study, the intervention was tested by measuring participants' body flexibility before and after the exercise to determine the appropriate duration (dosage) of the stretching session.

The intervention was carried out over 12 sessions within a one-week period. Flexibility measurements were conducted twice, once one day before the intervention and again on the final day after the intervention. MSD complaints were also assessed to determine the baseline level of discomfort before the intervention.

The study population comprised all tofu industry workers in Bandungan, with participants between 35 and 55 years of age. The sample size was calculated using a paired categorical analytic formula, resulting in a total of 50 participants. These participants were divided into two groups: the chair-based stretching group ($n = 25$) and the control group ($n = 25$). Inclusion criteria included tofu industry workers aged 30–59 years, in good physical health, with no physical disabilities, employed as permanent workers, and willing to participate by providing informed consent.

The independent variable in this study was the implementation of chair-based stretching exercises, while the dependent variable was physical fitness (flexibility). Confounding variables included age, gender, and length of service. For paired data with a normal distribution, a paired t-test was used. If data were not normally distributed, the Wilcoxon signed-rank test was applied. For unpaired data, the independent t-test was used for normally distributed data and the Mann–Whitney U test was used for non-normally distributed data.

This study received ethical approval from the Health Research Ethics Committee of the Faculty of Public Health, Diponegoro University, with a certificate number 98/EA/KEPK-FKM/2024.

3 Results and Discussion

3.1 Overview of Work Activities

Workers at the tofu production center in Bandungan Village carry out all tasks manually and adopt non-ergonomic working postures. Their work is performed for approximately eight hours per day, from 06:00 to 14:00 Western Indonesian Time (WIB), or until the tofu materials are fully processed, with a one-hour break from 12:00 to 13:00 WIB. These activities are conducted almost daily, covering six working days: Monday, Tuesday, Wednesday, Thursday, Saturday, and Sunday.

In addition, the workers are subjected to prolonged working hours and perform repetitive tasks in static positions without changing workstations. These conditions contribute to the occurrence of MSDs among the workers. They have never engaged in stretching exercises or any physical activities aimed at reducing MSD complaints. Furthermore, the Bandungan Community Health Center (*puskesmas*) does not conduct specific physical health assessments for workers at this tofu production center. Employers have also not provided any guidance or implemented physical activity or stretching programs for the workers at the tofu industry in Bandungan.

3.2 Univariate Analysis

The univariate analysis was conducted to describe the characteristics of respondents in both the treatment and control groups at the tofu industry in Bandungan. The combined results of the respondent characteristics based on age, gender, and length of service are presented in Table 1.

Table 1. Respondent Characteristics Based on Age, Gender, and Length of Service in the Treatment and Control Groups

Variables	Treatment Group		Control Group	
	N = 25	%	N = 25	%
Age				
35–40 years	16	64	13	52
41–45 years	6	24	8	32
46–50 years	2	8	3	12
51–55 years	1	4	1	4
Sex				
Male	1	4	1	4
Female	24	96	24	96
Length of Service				
<3 years	2	8	1	4
>3 years	23	92	24	96

The analysis revealed that the majority of respondents in both groups were 35–40 years of age (64%), while the smallest proportion belonged to the 51–55 years age group (4%). In terms of gender, most respondents were female, accounting for 96% of each group. Regarding length of service, the majority had been employed for more than three years (92%), and a small proportion had less than three years of service (8%).

As age advances, degenerative processes such as tissue damage, replacement of normal tissue with scar tissue, and a reduction in body fluid content occur, leading to decreased elasticity and stability of bones and muscles. According to Tarwaka, MSD complaints are commonly experienced between the ages of 35 and 65 years and tend to increase with age [8]. Many of the participants in this study were over 45 years old, which falls within the World Health Organization's (WHO) definition of middle age. This age group is characterized by a decline in nerve conduction velocity, decreased muscle strength, coordination, reflexes, balance, and changes in posture. These conditions increase the risk of MSDs [9].

Sex is one of the variables affecting the risk of MSDs, with women typically being at higher risk than men. Only around 60–66% of men's muscle strength is possessed by women, especially in the arms, back, and legs [10]. Up to the age of 60, men and women have a relatively similar risk; however, hormonal factors such as menstruation and menopause may increase the risk in women. The decline in estrogen levels associated with these hormonal changes can lead to reduced bone density and contribute to the occurrence of musculoskeletal pain [8].

Longer work duration is also associated with an increased risk of MSDs. Jobs that require high physical exertion and involve monotonous, repetitive tasks over extended periods can further increase the risk of MSDs. Chronic muscle fatigue may eventually result from prolonged exposure to repetitive motions, non-ergonomic working postures, and ongoing physical strain [11]. Due to the accumulation of physical stress and the lack of movement variation, the tofu workers in Bandungan has a higher risk of MSD complaints because their work activities are performed virtually every day, with long working hours and no changes in workstation.

Table 2. Pre-Test and Post-Test Results of Musculoskeletal Disorder (MSD) Pain Scale Measurement Using the Numeric Rating Scale (NRS) in the Treatment and Control Groups

Pain Scale	Treatment Group				Control Group			
	Pre-Test		Post-Test		Pre-Test		Post-Test	
	N = 25	%	N = 25	%	N = 25	%	N = 25	%
Mild Pain	5	20	23	92	3	12	2	8
Moderate Pain	18	72	2	8	21	84	20	80
Severe Pain	2	8	0	0	1	4	3	12

Table 2 illustrates how the pain levels associated with MSDs changed in the treatment and control groups before and after the intervention. Following the chair-based stretching intervention, the percentage of respondents reporting mild pain in the treatment group increased from 20% to 92%, indicating an improvement in pain levels. Meanwhile, the percentage of respondents who reported moderate pain dropped from 72% to 8%. In the post-test assessment, none of the participants reported experiencing extreme pain.

In contrast, the control group showed no meaningful improvement. Moderate pain remained high, decreasing slightly from 84% to 80%, while severe pain increased from 4% to 12%, indicating a worsening trend in the absence of intervention. The increase in pain is attributed to the absence of stretching activities, which leads to muscle stiffness, reduced flexibility, and a higher risk of disorders affecting the joints, muscles, ligaments, and other bodily structures [12]. The control group served as a comparison to the treatment group, which received chair-based stretching interventions for one week.

The high prevalence of musculoskeletal pain in the control group is presumed to be associated with static and repetitive work activities performed in a seated, forward-bending posture without back support for eight hours a day, six days a week. Such non-ergonomic working postures, when not accompanied by stretching exercises, significantly increase the risk of MSDs among workers at the tofu industry in Bandungan.

3.3 Bivariate Analysis

The bivariate analysis was conducted to examine the difference in MSD pain complaints between the treatment and control groups, both before and after the intervention. The results of the Mann–Whitney U test for pre-test and post-test pain scale measurements are presented in Table 3.

Table 1. Mann–Whitney U Test Results of Pre-Test and Post-Test Musculoskeletal Disorders (MSDs) Pain Scale Between Treatment and Control Groups

Test Phase	N	Mean	SD	p-Value
Pre-Test				
Treatment Group	25	2.88	0.526	0,727
Control Group	25	2.92	0.400	
Post-Test				
Treatment Group	25	2.08	0.277	0.000
Control Group	25	3.04	0.455	

The Mann–Whitney U test conducted on the pre-test results yielded a p-value of 0.727 ($p > 0.05$), indicating no statistically significant differences in MSD pain scale between the treatment and control groups prior to the intervention. The average MSD pain score in the

treatment group was 2.88 (SD = 0.526), while in the control group it was 2.92 (SD = 0.400), with both falling into the moderate pain category.

In the post-test assessment, there was a significant difference between the two groups with a p-value of 0.000 ($p < 0.05$). The treatment group experienced a decrease in pain scores to an average of 2.08 (SD = 0.277), which falls into the mild pain category, while the control group remained in the moderate pain category with a higher average score. Based on these results, the chair-based exercise intervention was effective in reducing musculoskeletal pain in the treatment group.

Most respondents in the treatment group reported a reduction in MSD pain after one week of chair-based stretching intervention. The workers included in the treatment group were tofu industry workers in Bandung who had reported MSDs. The stages of assessing the effectiveness of the chair-based exercise intervention were carried out through a pre-test, followed by the chair-based stretching exercises, and then a post-test.

The chair-based stretching exercises used in this study are a non-pharmacological strategy aimed at improving blood circulation, reducing stress, and strengthening muscles. This stretching helps improve blood flow, thus preventing oxygen deficiency in the cells which can cause pain and lactic acid buildup. Regular stretching has been proven beneficial in reducing MSD complaints by relieving muscle tension caused by prolonged sitting and non-ergonomic working postures [12]. The increased understanding and skills of employees in performing chair-based stretching for musculoskeletal pain management also contributed to pain reduction in the treatment group. Respondents reported that chair-based stretching improved physical fitness, reduced muscle tension, and prevented cramps, particularly in body parts frequently used during work.

The results of this study indicate an alignment between field findings and existing theory. The decrease in NRS scores after the intervention demonstrates that chair-based stretching has a significant effect in reducing MSD complaints in the treatment group. This is consistent with previous research, which showed no significant difference in muscle pain levels between the intervention and control groups during the pre-test phase [13]. After the intervention, the treatment group experienced a reduction in MSD complaints, while the control group showed an increase in pain levels [14].

4 Conclusion

It can be concluded that tofu workers in Bandung who were in the control group experienced a significant reduction in pain following the chair-based stretching intervention. After one week of chair-based stretching, the majority of respondents reported a decrease in pain to the mild category, reaching 92% from the initial 72% who experienced moderate pain. Statistically, there was a significant difference between the intervention and control groups with a p-value of 0.000 ($p < 0.05$). Therefore, chair-based stretching exercises are effective in reducing MSD complaints.

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