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Improving Ergonomic Work Attitudes Reducing of Musculoskeletal Disorders, Workload and Increasing Work Productivity of *Pande Besi* in Gubug Village Tabanan, Bali-Indonesia

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ABSTRACT

One of the processes in the making household tools such as small knives, large knives, sickles, and machetes is a tool in the form of a gerida that weighs approximately 1.5 kg. Working on the floor with the base can cause several musculoskeletal disorders such as pain in the back, waist, neck, shoulders, buttocks, legs, and knees. The purpose of this study was to determine the effect of Ergonomic Work Attitudes in Reducing of Musculoskeletal Disorders (MSDs), Workload, and Increasing Work Productivity of Pande Besi in the Gubug Village of Tabanan. This study is an experimental study with treatment by subject design. The population is 40 people from 10 industries. Selection of sample using random sampling with a table of random numbers. The minimum sample size is calculated using the Colton formula so that the sample size is 16 people. Data processing and analysis: descriptive test for data on the subject's condition includes age, weight, height, and body mass index. The difference test for data work productivity was analyzed using a Wilcoxon test with $\alpha = 0.05$, and the data MSDs and workload were analyzed using a paired samples t-test with $\alpha = 0.05$) in Period I and Period II. The mean age of the subjects was 49.19 ± 12.24 years, body weight was 67,25 ± 7,10 kg, body height was 162,3 ± 0,07 cm, and the subject's body mass index was 25,48 ± 1,64 kg / m2. There was a decrease in musculoskeletal disorders by 18,37%, a decrease in workload by 34,6%, an increase in productivity by 47.06%. There is a significant decrease between musculoskeletal disorders, workload before and after the redesign ($p < 0.05$), and a significant increase in work productivity before and after work attitude improvement

1. Introduction

One of the occupational diseases that often arise from the incompatibility of workers with work is musculoskeletal disorders. Musculoskeletal disorders are complaints on the skeletal muscles that are felt by a person ranging from very mild to severe complaints. If the muscles receive static loads repeatedly and for a long time, it can cause complaints in damage to joints, ligaments, and tendons (Tarwaka, 2010).

Pande Besi is a small industry that develops in the village of Gubug, Tabanan Regency. These blacksmith craftsmen have been doing their job for a long time and are hereditary from their ancestors. They receive an inheritance as it is and carry out this work as the responsibility of their ancestors. One of the manufacturing processes is a small knife, a large knife, a sickle, and a machete. One of the processes in making household tools is small knives, large knives, sickles, and machetes are confronted with a tool in the form of a grinder to smooth and sharpen the knife. In this process, the worker holds a vibrating grinder, weighing more than 1.5 kg using one hand, and the other hand holds the knife to be smoothed. They work on the floor with the seats as they are. The attitude of sitting with a seat and a work platform that is not ergonomic will cause musculoskeletal disorders. The habit of working with a bowed position causes a forced attitude at work. This forced attitude will cause pain in the body if done continuously for a long time, such as pain in the back, waist, neck, shoulders, and buttocks.

Improving work facilities by changing work attitudes can reduce musculoskeletal disorders, work fatigue, and increase work productivity (Siswiyanti & Luthfiyanto, 2011). The best posture when working is to keep the body in a neutral position, namely; the spine is in a natural position, forming an S letter, the elbows are close to the body, and the shoulders are relaxed, and the wrists are in a neutral position (Nurhikmah, 2011).

A preliminary survey with ten blacksmiths in the grinding department stated that after working, they experienced pain in the back, waist, neck, shoulders, buttocks, knees, legs, chest pain due to bending and bowing work. In addition to reducing productivity, this situation will also impact decreasing the health of workers. Musculoskeletal Disorders (MSDs) are a group of symptoms related to muscle tissue, tendons, ligaments, cartilage, nervous system, bone structure, and blood vessels. Musculoskeletal disorders are complaints of the skeletal muscles that are felt by a person ranging from mild to fatal complaints. Initially, MSDS complaints were pain, pain, numbness, tingling, swelling, stiffness, shaking, sleep disturbances, and burning, resulting in a person's inability to move and coordinate movement of limbs or extremities, thereby reducing work efficiency and losing time. Work so that work productivity decreases (Tarwaka, 2010).
Based on this background, the researchers made improvements to working attitudes by designing Pande Besi work tables and chairs to reduce fatigue and workload and increase worker productivity

2. Literature Review

2.1 Subjective complaints

Subjective complaints in the form of a musculoskeletal system disorder is often found in workers who work manually in a sitting position with their legs extended due to one of the body's reactions caused by work (task). In carrying out activities or jobs in a sitting position, the legs are extended, the muscles of the hands, fingers and back to the buttocks play a major role. Among the many types of muscles, it is the skeletal muscles that receive the most attention. The function of the skeletal muscle is to contract the bones, where wrinkles occur when the muscle gets an impulse from the central nerve (Guyton & Hall, 2014).
Complaints in the musculoskeletal system are influenced by the work of muscles that work abnormally as a result of an unnatural work attitude, the impact of which can cause muscle fatigue and discomfort. Discomfort can lead to an urge to move (unnecessary movement) to change positions caused by physiological and psychological factors. Discomfort can occur because the pressure on the soft tissue can cause blood flow to the tissue to block. The result is reduced oxygen and carbon dioxide build-up and produce lactic acid waste. Meanwhile, one of the factors causing muscle fatigue is the result of obstruction of the metabolic process. Loss of muscle function due to fatigue can increase the risk of injury to the musculoskeletal system. Subjective complaints are the subject's experience of a combination of physiological and psychological processes and include muscle fatigue. Muscle fatigue is a physiological phenomenon that can be directly measured by electromyography (EMG) and is often used by ergonom to detect workspaces and task factors that cause muscle fatigue. Meanwhile, subjective measurement techniques for workers by questioning and showing body diagrams or questionnaires to determine the location of complaints of the musculoskeletal system are known as the Nordic Body Map.

2.2 Workload

Workload is a number of processes or activities that must be completed by a worker within a certain period of time. If a worker is able to complete the assigned task, then this does not become a workload. However, if the worker is unsuccessful, the task becomes a workload. Workload can be divided into two groups (Vanchapo, 2020).

a. External workload (stressor) is the workload that comes from the work that is being done. External burdens include tasks, organization and environment.
b. Internal workload is work load that is generated by individual worker factors which are somatic in nature (gender, age, body size, health condition and nutritional status) and which are psychological in nature (motivation, perception, desire, etc.)

2.3 Work productivity

Work productivity is the ability of a person/group of people to produce products, both in the form of goods and services, which increase from time to time. Productivity can be obtained by comparing output with input per unit time. What gives a role in the output are human, material, energy and information resources. Included in the input are land, material, machinery and human resources and technology. Human resources are a determining factor for both output and input. Basically, productivity is closely related to the production process in which factors of labor, capital, work equipment, raw materials and others are managed effectively and efficiently. The measure of the success of a production process is usually expressed in terms of work productivity or the amount of the ratio of output per input produced multiplied by the time to get the output. In this case, human performance is the main factor determining efforts to increase work productivity (Mahawati, et al., 2021).
The factors that affect work productivity are:

a. Workforce: age, nutrition, physical condition, skills and psychology of workers.
b. Work equipment: tools used or machines and so on.
c. Work environment: heat, dust, equipment conditions, safety, noise and so on.
d. How to work: work attitude, work position, work system and so on.
e. Work organization: work administration, shifts, length of work, rest periods and so on.

3. Methodology

This research is an experimental study with treatment by subject design (Sarmanu, 2017). The research was conducted in Gubug Tabanan Village in 2020, with 40 people from 10 small industries. Based on the sample size calculation formula, the total sample size is 16 people. The sample inclusion criteria included: *Pande Besi* workers living in Batu Sangiang Village, Tabanan aged 22-60 years, physically fit with a doctor's examination, at least one year of work experience, and willing to be research subjects. Meanwhile, the drop-out criteria were not being present during the study, suffering from illness during the study, for some reason resigning as a sample. Samples that meet the inclusion criteria are then randomly selected using random numbers.

The data collected included: 1) the condition of the subject through interviews (for age data) and measuring body weight and height; 2) MSDs complaint by using Nordic Body Map, the workload is measured by Pulse Oximeter, and work productivity is obtained by comparing output (number of plates produced) with input (work pulse) x time. To analysis the effect of treatment, the Paired Sample t-Test analysis was performed with $\alpha = 0.05$ for normally distributed data and the Wilcoxon difference test, $\alpha = 0.05$ for abnormally distributed data

4. Results and Discussion

4.1 Subject's condition

The research subjects were 16 *Pande Besi* workers living in the village of Gubug, Tabanan Regency. The subjects' conditions recorded in this study were age, weight, height, and body mass index (BMI). Descriptive analysis of the subject's condition is presented in Table 4.1.

Table 1 Descriptive Analysis of Subject Conditions

No.	Subject Conditions	Average±SD	Min	Maks
1.	Age (years)	49,19±12,24	22	60
2.	Height (cm)	2±0,07	150	172
3.	Weight (kg)	67,25±7,10	56	74
4.	Body Mass Index (MBI (kg/m^2)	25,50±1,70	22,55	29,14

The total number of subjects who participated in the study was 16 people, and all of them were in good health based on a physical examination from a doctor. The subjects' age was between 22-60 years by the limits set in determining the sample. This grinding metalwork to make sharp knives is a craft passed down from generation to generation so that workers will always work even though they are classified as elderly, as long as they are still able to do this work. The subject's body weight was in the range of 56-74 kg with a height of 150-172 cm. After calculating the body mass index (BMI) to determine the subject's nutritional status, the average BMI of the subjects was 25.50 ± 1.70 kg / m2 with a range of 23.83-27.24 kg / m2. After being compared with WHO standards, the subjects' mean BMI was classified as overweight (Almatsier, 2009). This BMI reflects the balance of a person's nutritional intake. The imbalance condition can be caused by excessive consumption of nutrients, especially carbohydrates and fats, for a long time, so this situation needs to be corrected and considered so that the journey to obesity does not occur in the subject. A good nutritional status will increase immunity and improve health to carry out daily activities better, thus improving the quality of life.

4.2 Musculoskeletal disorders

Complaints data were obtained using a Nordic Body Map questionnaire with direct interviews with workers. The first-period measurements are before and after work, and in the second period before and after work. Descriptive analysis, normality test, and different test data for musculoskeletal disorders are shown in Table 4.2.

Table 2 Descriptive Analysis, Normality Test, and Difference Test for Musculoskeletal Disorders Data

No	Complaints	Period I		Period II		t	p
		Average±SD	p*	Average±SD	p*		
1.	Before work	35,68±2,54	1,001	35,31±2,24	1,001	0,953	0,357

2.	After work	50,56±7,90	0,328	37,81±2,90	0,463	7,568	0,001

* normally distributed if p>0,05

Table 4.2 shows the average Musculoskeletal disorders in Period I before and after work increased by 41.68%, from 35.68 ± 2.54 to 50.56 ± 7.90. Whereas in Period II, before and after work experienced a minor increase of 7.08%, from 35.31 ± 2.24 to 37.81 ± 2.90. There was a decrease in Musculoskeletal disorders in Period I and Period II by 34.6%. Data normality test with the Shapiro-Wilk test at the level of confidence α = 0.05 shows all data are normally distributed (p> 0.05) to continue with the Paired Sample-t-Test difference test at the confidence level α = 0.05. Analysis of the Paired Sample-t-Test difference test in Period I and Period II before working found no significant difference (p> 0.05), indicating that Period I and Period II's initial conditions were the same. While the data analysis after work found a significant difference (p <0.05). Thus, the improvement of work attitudes at *Pande Besi* affects Musculoskeletal disorders.

Musculoskeletal disorders are disorders or injuries to soft tissues such as muscles, tendons, joints, ligaments, and the nervous system, most commonly in the arms and back. Musculoskeletal disorders are complaints that occur in skeletal muscles experienced by a person ranging from minor complaints to severe complaints (Kemenkes, 2016). The reduction in complaints after improving work attitudes by providing work desks and chairs impacts reducing work stress. This study's results are in line with other studies that state that improving ergonomics-based work systems can reduce worker complaints.

A person's work attitude can be affected due to unfavorable workstation conditions. Many respondents work at workstations that are not ergonomic. If the workstation is not ergonomic, it can cause the work position to also be at risk of experiencing musculoskeletal disorders. Therefore, it is necessary to repair the workstation. The relationship between work attitude and musculoskeletal disorders in the study of work attitude correlates with musculoskeletal disorders. The research states that work attitude has a relationship with musculoskeletal disorders (Sihombing, 2015). Research shows that work attitude has a relationship with musculoskeletal disorders (Larono, et al., 2017).). Other research also states that there is a significant relationship with musculoskeletal (Suwanto, 2016).

4.3 *Workload*

The workload is assessed by measuring the pulse before and after working in Period I and Period II. Descriptive analysis, normality test, and workload data difference test are presented in Table 4.3.

Table 3 Descriptive Analysis, Normality Test, and Different Test for Workload Data

No	Workload	Period I		Period II		t	P
		Average±SD	p*	Average±SD	p*		
1.	Before work	79,56±5,44	0,363	79,18±7,74	0,490	1.861	0,83
2.	After work	109,50±4,61	0,520	94,43±3,72	0,157	11.113	0,000

* normally distributed if p>0,05

Table 4.3 shows the average workload in Period I before and after work has increased by 37.63%, from 79.56 ± 5.44 to 109.50 ± 4.61. Whereas in the second period before and after work, there was a minor increase of 19.26%, from 79.18 ± 7.74 to 94.43 ± 3.72. Data normality test with the Shapiro-Wilk test at the level of confidence α = 0.05 shows all data are normally distributed (p> 0.05) to continue with the Paired Sample-t-Test difference test at the confidence level α = 0.05. Analysis of the Paired Sample-t-Test difference test workload data in Period I and Period II before working found no significant difference (p> 0.05). The data shows no difference between the initial conditions in Period I and Period II, or it can be interpreted that the initial conditions for the two periods are the same or comparable. Analysis in Period I and Period II after work found a significant difference (p <0.05).

The decrease in Period I and Period II workload is predicted to be due to a decrease in external stress due to dust exposure in the work environment. One of the impacts of external stress conditions is an increase in pulse rate. In this study, external stress can be overcome by improving work attitudes to provide tables and chairs to reduce musculoskeletal disorders. There is an efficient use of energy to reduce the workload as measured by the work pulse. Several similar research results also found a decrease in workload by 21.43% in the modification of Tri Hita Karana ergonomics-based working conditions for rice mill workers (Ruliati, et al., 2017), a decrease in workload by 15.3% in dodol industrial workers in Bali (Santosa, & Yusuf, 2017), and a decrease in workload by 3.41% for the Kukus Bread industry workers in Denpasar (Dinata, 2018).

4.4 *Productivity*

Productivity is the ratio of the output to the input per unit time. In this study, productivity was assessed by comparing the plates that were successfully hammered (output) with the work pulse (input) in one working hour (time). Descriptive analysis, normality test, and different test of productivity data are presented in Table 4.4.

Table 4 Descriptive Analysis, Normality Test, and Different Test for Productivity Data

No	Productivity	Period I		Period II		Z	P
		Average±SD	p*	Average±SD	p*		
1	Productivity (1 hour)	0,024±0,05	0,001	0,035±0,05	0,005	-3,477	0,001

* normally distributed if p>0,05

Table 4.4 shows that Period I and Period II's average productivity has increased by 0.011%, from 0.023 ± 0.05 to 0.035 ± 0.01. After the data normality test was carried out in Period I and Period II using the Shapiro-Wilk Test at the confidence level α = 0.05, all data were not normally distributed (p <0.05), so it was continued with the Wilcoxon difference test at the confidence level α = 0.05. Wilcoxon test analysis of productivity data in one hour in Period I and Period II found a significant difference (p <0.05).

Increased productivity impacts increasing the number of knives produced by workers so that it will increase their income. In addition to increasing income, this improvement will reduce the risk of workers getting respiratory diseases because exposure to dust in the workplace has been reduced to below the established threshold (Kemenkes, 2016).

Several similar research results also found that improvements with an ergonomic approach can increase productivity. The increase in productivity obtained is due to improved physiological responses, faster processing times, and increased production. Intervention by stretching and giving sweet tea to tailors was also reported to increase worker productivity by 66.67% (Rusni, Tirtayasa, & Muliarta, 2017), an increase in 54.95% in the use of solar dryers with a Techno-Ergonomic approach to manufacturing. dodol in Singaraja (Santosa & Sutarna, 2018), and a 121% increase in productivity in the steamed bread manufacturing industry with the intervention of a total ergonomics-based pouring tool application (Dinata, 2018).

5. Conclusion

From the results of this study, it can be concluded that after improving work attitudes by providing chairs and desks, it was found that there was a significant decrease in Musculoskeletal disorders and workload, and there was a significant increase in work productivity. It is recommended that the Pande Besi in the grinding section always apply and pay attention to ergonomic principles because improvements in the form of improved work attitudes are proven to reduce dust levels in the air, fatigue, and workload and can increase work productivity

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Conflict of Interest

Author has no conflict of interest regarding all elements in this study

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