



# Ergonomic workstation reduces electrical activity of upper trapezius muscles, erector spinae muscles, and musculoskeletal complaints in agel fiber twisting process



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## ABSTRACT

**Background:** Humans' role in small industries as a source of labor is still dominant, mostly manual work. The research was conducted on manual workers in small agel fiber industries in Yogyakarta. Manual work is related to human strength and endurance. Ergonomic problems often arise in manual labor, including neck pain, back pain, and leg pain called musculoskeletal disorders. Non-ergonomic working conditions also increase the electrical activity of muscles. This study aims to reduce electrical muscle activity and musculoskeletal complaints by repairing an ergonomic workstation in the agel fiber twisting process.

**Methods:** This research is an experimental study with 15 female subjects. The electrical activity of muscles is measured when working under conventional conditions (Period 1) and repairing an ergonomic work station (Period 2). The electrical activity of the muscles was measured using surface electromyography. Musculoskeletal complaints were measured before and after intervention with conventional conditions (Period 1) and ergonomic work station repair (Period 2). Musculoskeletal complaints were measured using the Nordic Body Map Questionnaire. The measurement data between the two periods were analyzed by using the paired samples t-test and the Wilcoxon signed-rank test.

**Results:** The results showed a decrease in the upper trapezius muscles' electrical activity by 35.46% and the erector spinae muscles' electrical activity by 22.43%. The average of musculoskeletal complaints decreased by 23.77%, measured after working in period 1 and period 2.

**Conclusion:** Ergonomic work station can reduce the electrical activity of the upper trapezius muscles, electrical activity of the erector spinae muscles, and musculoskeletal complaints in workers twisting the agel fiber rope.

**Keywords:** work station ergonomics, the electrical activity of muscles, musculoskeletal disorder.

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## INTRODUCTION

Manual work is related to humans' strength and endurance in doing their work and can cause ergonomic problems. Ergonomic problems include back pain, neck pain, and pain in the legs, called musculoskeletal disorders.

Body posture while working is one of the factors that influence job performance. If the work posture is not well organized, it will cause discomfort and quickly tired, decrease concentration while working and lead to low productivity.

The application of ergonomics

needs to be done by designing a work station. Adjustment of work facilities for workers will support ease, comfort and work efficiency. Work station repair uses ergonomics that utilize information about human characteristics, abilities, and limitations to work effectively, safely, and comfortably.<sup>1</sup>

Workers in Sentolo Subdistrict, Kulonprogo Regency, Yogyakarta make ropes from agel fiber by twisting them. Twisting work is still done traditionally. Workers sit on the floor, bending over while making repetitive hand movements twisting the rope. As result workers have

ergonomic risks. The risk is a forced work attitude, an unnatural work posture. Work with your back bent forward without changing your sitting position for a long time. Repetitive twisting movements, back bending, neck bowing, and long working duration can experience work injury or musculoskeletal disorders. Workers work around the rope with their back bent forward without variation for a long time, exertion of muscle strength, rapid repetitive movements, long bowed neck stance. Long sitting posture, doing repetitive and monotonous work causes musculoskeletal complaints.<sup>2-6</sup>

Workers have the potential to experience injuries or musculoskeletal disorders related to their work. Musculoskeletal complaints are most often felt in the waist, back and neck. This shows that the muscles that play a role in twisting the rope are the upper trapezius and erector spinae muscles. An increase in the average work voltage of the muscles indicates that muscle tension is increasing. Increased muscle tension will interfere with blood circulation so that the accumulation of metabolic waste in the form of lactic acid is observed, which is associated with increased muscle tension, fatigue, and musculoskeletal complaints.<sup>7</sup>

This study aims to reduce the electrical activity of muscles and musculoskeletal complaints by improving an ergonomic workstation in the agel fiber twisting process.

## MATERIALS AND METHODS

### Study design and population

The sample in this study was 15 workers in Kulonprogo Regency, Yogyakarta Special Region. The tools and materials used were electrodes measuring 50cm x 50cm, surface electrode myography (SEMG) Neurotrac Myoplus pro 4 to measure the electrical activity of the upper trapezius muscles and erector spinae muscles, a Nordic Body Map questionnaire to measure musculoskeletal fatigue scores, anthropometers, writing books, pens, and digital cameras.

This research is an experimental study, and controlled variables consist of age, work experience, body mass index (BMI), work environment (air temperature, noise, humidity, lighting). Independent variables: work station design. The dependent variables were electrical muscle activity and musculoskeletal complaints. The intervention was given in the form of an ergonomic work station to avoid bending over the back and avoiding twisting the calves or thighs.

Measurement of the tension in the upper trapezius and erector spinae muscles is done by determining the maximal voluntary isometric contraction (MVIC) and muscle tension during the activity of twisting the agel cord. The MVIC measurement of the trapezius pars descendens muscle was measured in

an upright sitting position with the arm hanging vertically. The electrodes are placed mid-line between the acromion and the vertebral body C7.<sup>8,9</sup> The reference electrodes are placed on the spinous process C7 or around the wrist. Clinical trials are carried out by lifting the acromion, extension and rotation of the head towards the raised shoulder with the face rotated in the opposite direction. The pressure is exerted against the shoulder downward and against the head in an anterolateral flexion direction. The MVIC measurement of the erector spinae muscle is carried out in a pronated sleeping position on a bench then the surface electrode is placed 1 finger medial from the posterior line of the superior iliac spine downward under the ribs as high as the second lumbar in the direction of the line between the posterior superior iliac spine and under the lower rib. The reference electrode is placed in the spinous process C7.<sup>8,9</sup> Clinical trials are carried out by lifting the body from the pronation position. Score musculoskeletal complaints by filling in the Nordic Body Map (NBM) questionnaire.<sup>10,11</sup> Filling the questionnaire based on questions about musculoskeletal complaints that are felt in body muscles. The Nordic Body Map questionnaire consists of 28 questions, which have been modified to the Likert scale.<sup>12</sup>

### Statistical analysis

Analysis in this study used SPSS version 25.0 (IBM Corporation, Armonk, USA) for windows. Numeric data are displayed as mean and standard deviation, while categorical data are shown in frequency and percentage. Paired t test and Wilcoxon test were used to assess changes in the electrical activity of the upper trapezius and erector spinae muscles as well as changes in musculoskeletal complaints. All values are considered significant if  $p < 0.05$ .

## RESULTS

A good work environment is a work environment that is safe, healthy, comfortable, and enjoyable for workers. Microclimate air temperature measurements in the rope maker between period 1 of  $28.587 \pm 0.729^\circ\text{C}$  and period 2 of  $28.595 \pm 0.733^\circ\text{C}$  did not cause health



**Figure 1.** Work attitude when twisting ropes before workstation repair



**Figure 2.** Work attitude when twisting ropes after work station repair

problems. The average air humidity in period 1 was  $79.283 \pm 2.547\%$  and period 2 was  $79.717 \pm 2.637\%$ . Indonesians can generally acclimatize well at air temperatures between  $29^\circ\text{C}$ - $30^\circ\text{C}$  with a humidity of 85-95%. The average light intensity in period 1 was  $398.333 \pm 49.638$  Lux and in period 2 was  $400.00 \pm 46.894$  Lux. The light intensity level in manual labor is at least 300 Lux. Light intensity is good in both periods. Noise in period 1 is  $53.583 \pm 2.25$  dB and in period 2 is  $54.272 \pm 2.631$  dB. The noise level is still below the 85 dB threshold. The work environment air temperature, humidity, noise, and lighting in Period 1 and Period 2 did not have statistically different meanings ( $p > 0.05$ ). Thus, the working environment conditions do not influence the improvements to the

applied work stations' improvements.

### Ergonomic workstation design

The implementation stage of this research consisted of period 1 and period 2. In period 1 the subject did work as usual (conventional), without any workstation repair, as shown in Figure 1. In period 1, the microclimate was measured (air temperature, humidity, noise, and lighting), muscle electrical activity, and musculoskeletal complaints. Period 2, the subject works with the new work station, namely sitting on a chair and using a table when twisting (Figure 2). In period 2, a measurement is performed such as period 1.

Work stations are designed using personalize anthropometric data on workers. Table height is 56.94 cm, table length 44.68 cm, table width 50 cm. Seat height 48.30 cm, chair length 31.07 cm, seat width is 48.63 cm, back seat height is 37.36 cm. Anthropometric measurements on research subjects are related to workstation design that is made and adjusted to ergonomic principles. Ergonomic work stations can increase comfort, convenience, and work efficiency. This study used a sample of 15 female workers. The mean age was  $50.67 \pm 4.32$  years, and the range was 40-55 years. Worker age  $50.67 \pm 4.32$  years. Worker average weight  $50.27 \pm 1.91$  kg. Height  $152.30 \pm 0.05$  cm. Body Mass Index (BMI)  $21.71 \pm 0.94$  kg/m<sup>2</sup>.

### The electrical activity of the upper trapezius and erector spinae muscles

The normality test of upper trapezius muscle tension data in period 1 and period 2 with the Shapiro-Wilk Test shows abnormal data. Wilcoxon signed-rank test was used to evaluate difference test for upper trapezius muscle tension. There was a significant difference between the upper trapezius muscle tension in period 1 and period 2 ( $p < 0.05$ ). The normality test results of erector spinae electrical activity in period 1 and period 2 with the Shapiro-Wilk Test are normally distributed. A Paired-samples t-test was used to evaluate the erector spinae muscles' electrical activity between period 1 and period 2, and there was a significant difference in electrical activity in erector spinae muscle

**Table 1. Statistical analysis of mean result of electrical activity of upper trapezius muscles and erector spinae muscles (n=15)**

Variable	Period 1	Period 2	Mean differences (%)	p
	Mean $\pm$ SD (% MVIC)	Mean $\pm$ SD (% MVIC)		
Electrical activity of Upper trapezius muscles	$71.36 \pm 7.02$	$46.03 \pm 6.37$	35.46	0.001
Electrical activity of erector spinae muscles	$24.21 \pm 1.69$	$18.78 \pm 2.93$	22.43	<0.001

**Table 2. Differences of musculoskeletal complaint scores after work between period 1 and period 2**

Variable	Period 1	Period 2	Change (%)	p
	Mean $\pm$ SD	Mean $\pm$ SD		
Musculoskeletal disorders	$40.67 \pm 0.52$	$31.00 \pm 0.29$	23.77	<0.001

before and after workstation intervention (Table 1).

### Musculoskeletal complaints

The measurement of musculoskeletal complaints used a Nordic Body Map questionnaire with a likert scale. The results of normality testing with the Saphiro-Wilk test, scores of musculoskeletal complaints in period 1 and period 2, showed that the data were normally distributed ( $p > 0.05$ ). A paired sample t-test was used to evaluate the difference in musculoskeletal complaints between periods 1 and 2. There was a significant difference in musculoskeletal complaints scores between period 1 and period 2 ( $p < 0.05$ ) (Table 2).

## DISCUSSION

The age range of the subject is the productive age. The subject's age range still has optimal workability and can carry out everyday activities, marked by good health status. Body mass index (BMI) is determined from height and weight. Excessive BMI and obesity tend to be more prone to musculoskeletal disorders.<sup>13-15</sup> Obesity will complicate the measurement of muscle activity with SEMG because fat inhibits the measurement of electrical activity.<sup>16-19</sup>

The decrease in the upper trapezius muscles' electrical activity was 35.46% and the erector spinae muscles by 22.43% after the application of the new work station. Before repairing the work station, the

muscles do not get the opportunity to relax, as a result the muscles receive continuous loads, excessive muscle tension because the exertion exceeds the optimum muscle strength. If muscle tension is allowed to continue, it will cause muscle injury. Adopting a new, ergonomic work station with a better working attitude and working way can reduce muscle load and minimize muscle tension.<sup>20</sup> A non-ergonomic work attitude will increase muscle tension.<sup>21</sup>

The less ergonomic attitude and work methods are characterized by a forced and slouching posture, which causes a heavy load on the spine. Bending posture will increase the electrical activity of muscles, especially in the erector spinae muscles. The increase in the electrical activity of the muscles indicates the heavier the muscle tension. Increased muscle tension will interfere with blood circulation, resulting in the accumulation of metabolic waste. The proliferation of metabolic waste in lactic acid is associated with increased muscle tension, musculoskeletal complaints, and the appearance of fatigue. Workstations that use worker anthropometry give workers the ability to work with a more natural posture, thus preventing early musculoskeletal complaints of muscle tension.<sup>22</sup>

A bent work attitude, static position, repetitive work activities and a less ergonomic manner often cause musculoskeletal complaints. Musculoskeletal complaints can include complaints or discomfort in the muscles,

aches, to pain. Complaints can range from complaints so mild to severe that they cannot work in a few days.

Before the intervention, musculoskeletal complaints were 40.667, compared to work attitudes with a new work station, which was a score of 31.00. Musculoskeletal complaints on bending over and sitting on the floor were found in the upper neck, lower neck, back, waist, legs and buttocks. After using the new workstation, musculoskeletal complaints were reduced. Work stations that comply with ergonomic principles can reduce musculoskeletal complaints.<sup>23-25</sup> The statistical analysis results are shown in Table 2, that there is a significant difference in musculoskeletal complaints, a decrease in musculoskeletal complaints by 23.77%.

## CONCLUSION

Ergonomic workstations can reduce the electrical activity of the upper trapezius muscles, erector spinae muscles and reduce workers' musculoskeletal complaints in the process of twisting agel fibers. The decrease in the upper trapezius muscles' electrical activity was 35.46%, and the erector spinae muscles were 22.43%. The decrease in musculoskeletal complaints was 23.77%.

## CONFLICT OF INTEREST

The author declares there is no conflict of interest regarding the publication of this article.

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This study doesn't receive any specific grant from the government or any private sector.

## ETHICAL STATEMENT

This study has been approved by Ethical Committee Faculty of Medicine, Universitas Udayana/Sanglah General Hospital 1730/UN 14.2.2.VII.14/LT/2020. All study protocol in accordance with the Helsinki declaration of human right.

## AUTHOR CONTRIBUTION

Chandra Dewi Kurnianingtyas responsible for project administration, main idea, and writing the original draft. I Putu Gede

Adiatmika, Ketut Tirtayasa, and I Wayan Surata responsible for supervision and methodology guidance.

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