The Effect of Ergonomic Batik Chairs on Musculoskeletal Disorders Among Traditional Batik Makers

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Abstracts: In the traditional batik industry, batik makers typically use a small chair known as a "dingklik," which is not ergonomically designed. This often leads to poor posture and discomfort during work. The objective of this study was to develop a chair specifically tailored to the anthropometric measurements of batik makers, ensuring an ergonomic working position. The benefits of this ergonomic chair were assessed by evaluating musculoskeletal disorder scores. This research is categorized as quasi-experimental and involves 60 participants, comprising 30 individuals in the experimental group (using the newly designed chairs) and 30 in the control group (using traditional chairs). Statistical analyses included Paired Samples T-Test, Independent Samples T-Test, and Analysis of Covariance, with a significance level of (α) = 0.05. There were significant differences in musculoskeletal disorders before and after using the customized chair design (p = 0.000). Confounding variables such as age (p = 0.689), years of service (p = 0.407), and body mass index (p = 0.187) did not significantly impact the observed differences in musculoskeletal disorders. In conclusion, ergonomic chairs prove beneficial in reducing musculoskeletal disorders among traditional batik industry workers.

Keywords: Ergonomic Chair, Musculoskeletal Disorders.

1. INTRODUCTION

During and after work, complaints of pain often arise. Pain is a sensory sensation resulting from tissue damage that occurs through the processes of transduction, transmission, and perception modulation. The most prevalent work-related pain is typically localized in the lower back, followed by the elbows, wrists, and neck to shoulders[1]. In 2019, data from the WHO revealed that musculoskeletal disorders ranked second among diseases causing disability worldwide, as measured by productive years lost due to disability. The total number of productive years lost due to musculoskeletal disorders worldwide increased from 77,377,709.4 in 2010 to 103,817,908.4 in 2015. The prevalence of musculoskeletal disorders in Indonesia among individuals aged 15 years and older reached 24.7%[2]. Traditional batik industry workers use a seat known as a "dingklik," which is of small stature. This short seating arrangement causes batik makers to adopt a slouched posture while working, resulting in an ergonomic deficiency in their working position. Working in the traditional manner with a hunched posture for extended periods leads to discomfort related to joint angles. The adoption of an ergonomic chair by batik makers during work can help mitigate this non-ergonomic sitting position[3]. Traditional batik makers in Sragen Regency, Central Java Province, Indonesia, utilize a basic seat known as a "dingklik," which forces them into a continuous bent posture during their work. The aim of this study was to create a chair tailored to the anthropometric dimensions of batik makers, enabling them to work in an ergonomic position. The benefits of this ergonomic chair were evaluated by assessing the musculoskeletal disorder scores.

2. MATERIALS AND METHODS

2.1. Types of Research

This study employs a quasi-experimental research design with a preventive intervention approach. Preventive intervention research aims to investigate the relationship between risk factors and the onset of a disease by administering treatments to reduce exposure to these risk factors among the study subjects[4].

The study population consisted of female traditional batik makers in the Sragen district, Central Java, Indonesia. The sampling method employed the rule of thumb, resulting in an experimental group (Ergonomic Chairs) comprising 30 individuals and a control group ("Dingklik") consisting of 30 individuals. The research design utilized an experiment with the Two Group Pre-Test-Post Test Design method, as illustrated in Table 1.

Table 1. Two Group Pre-Test-Post-Test Design Method

Group	Pretest	treatment	Posttest
Experiment	O_1	X_1	O_2
Control	O_1	X_0	O_2

Table Description: O_1 = Pretest; O_2 = Posttest; X_1 = Treated; X_0 = Untreated

The Control Group consists of traditional batik makers who use a seat called a "dingklik." The "Dingklik" measures 12.5 cm in height, 31.0 cm in length, and 23.7 cm in width. It lacks a backrest and armrests. Figure 1(a) illustrates the description of the "dingklik." The experimental group comprises traditional batik makers who use a chair developed based on anthropometric data specific to traditional batik makers. The dimensions of this batik chair resulting from the research design are as follows: height = 36.3 cm, length = 37.8 cm, width = 33.7 cm, and backrest height = 42.5 cm, as depicted in Figure 1(b).

(a) (b)

Figure 1. (a) "Dingklik", (b) The research design results of the batik chair (ergonomic chair)

2.3. Research variable

The independent variables in this study consist of two groups: the "dingklik" group and the Ergonomic Chair group. The dependent variable under investigation is musculoskeletal disorders, while the control variables encompass age, years of service, and body mass index.

2.4. Research instrument

The instruments utilized in this study included data entry sheets for determining the research sample's identities, ergonomic batik chairs designed for the intervention, and the Nordic Body Map for assessing musculoskeletal complaints among the research subjects. The Nordic Body Map represents a straightforward method for evaluating musculoskeletal issues. This tool employs a body map worksheet that is exceptionally simple, easy to comprehend, cost-effective, and requires only a minimal amount of time (approximately 5 minutes) per individual. Observers can conduct direct interviews or inquire with respondents to identify specific areas of skeletal muscle experiencing pain or discomfort, or they can use the Nordic Body Map questionnaire worksheet to pinpoint these areas directly.

The Nordic Body Map comprises 28 sections representing skeletal muscles on both the right and left sides of the body. These sections range from the upper limbs, including the neck muscles, to the lower extremities, encompassing the leg muscles. The Nordic Body Map questionnaire enables the identification of muscle areas experiencing pain or discomfort, with a scale that spans from low-level complaints (no complaints/injury) to high-level complaints (severe discomfort)[5].

The assessment involves the use of the Nordic Body Map questionnaire with a Likert scale scoring system consisting of four levels, as follows: Score 1: Workers do not experience any complaints or pain in their skeletal muscles (no pain); Score 2: Workers have minimal complaints or slight pain in their skeletal muscles (slight pain); Score 3: Respondents report experiencing complaints or pain in their skeletal muscles (pain); Score 4: Respondents report experiencing significant discomfort or severe pain (very painful). The next step involves calculating the total individual score for all observed skeletal muscles, which encompass 28 muscle sections. In this 4-point Likert scale design, the lowest possible individual score is 28, while the highest score achievable is 112.

The final step in the Nordic Body Map method involves taking measures to enhance working conditions and posture if the results indicate a high level of severity in the skeletal muscles. The corrective actions to be implemented naturally depend on the risk associated with any skeletal muscles experiencing disruption or discomfort. Table 2 presents straightforward guidelines that can be used to assess the subjective qualifications for the risk level of skeletal muscles.

Table 2. Subjectivity Classification of Skeletal Muscle Risk Levels Based on Individual Total Scores

Action Level	Total Individual score	Risk Levels	Corrective action
1	28 – 49	Low	No need for improvement action at the moment.
2	50 – 70	Medium	Improvement action may be necessary in the future.
3	71–91	High	Immediate action is required.
4	92 - 112	Very High	Comprehensive action is needed as soon as possible.

2.5. Statistic analysis

Statistical analysis employed the following methods: The Paired Samples T-Test was utilized to assess differences in musculoskeletal disorders before and after traditional batik workers used seats according to their respective groups for three-weeks intervals. The Independent Samples T-Test was conducted to examine differences in musculoskeletal disorders between the control and experimental groups before and after the intervention. Analysis of Covariance (ANCOVA) was employed to investigate differences in musculoskeletal disorders between the control and experimental groups after three-weeks intervals of intervention while controlling for confounding variables. The significance level utilized was $\alpha = 0.05$.

2.6. Ethical Clearance

The ethical clearance for this study was granted by the Health Research Ethics Committee at Dr. Moewardi, as indicated in the Ethical Clearance Letter with the reference number 691/V/HREC/2022, dated May 27, 2022.

3. RESULTS AND DISCUSSIONS

Ergonomic chairs are designed based on the anthropometric dimensions of workers related to design, including sitting knee height, distance from the bend of the knee to the backline, hip width, and back height. The basis for determining the dimensions of an ergonomic chair is using sitting knee height (5th percentile), distance from the bend of the knee to the backline (5th percentile), hip width (95th percentile), and back height (5th percentile), as well as calculations regarding allowances. Using the Nordic Body Map, interviews were conducted with 30 subjects in the "Dingklik" group and 30 subjects in the "Ergonomic Chair" group to assess musculoskeletal disorder scores. Interviews were conducted before and after traditional batik makers worked over a three-week interval.

3.1. Description of the position of traditional batik makers

The working positions of the control group's traditional batik makers are depicted in Figure 2(a) workers using "Dingklik", while the working positions of the experimental group's traditional batik makers are illustrated in Figure 2(b) workers using ergonomic chairs.

(a) (b)

Figure 2. (a) The working position of the control group's traditional batik makers, (b) The working position of the experimental group's traditional batik makers

3.2. Ergonomic Chair Description

In the design of an ergonomic traditional batik chair, anthropometric data related to traditional batik makers are utilized. This data comprises sitting knee height, distance from the bend of the knee to the backline, hip width, and back height. A description of the body dimension data obtained from anthropometric measurements is presented in Table 3.

Table 3. Anthropometric Measurements Data of Traditional Batik Makers

Description of Statistics	Sitting Knee Height (cm)	Distance from Knee Bend to Back Projection (cm)	Hip Width (cm)	Back Height(cm)
Average	36.1	41.4	33.9	39.1
5% percentile	36.3	37.8	29.9	35.3
95% percentile	38.8	45.5	33.7	42.5

Based on the data from Table 3, an ergonomic work chair is designed with the dimensions presented in Table 4.

Table 4. Dimensions of Designed Work Chairs

No.	Seat Size	Percentile	Size(cm)
1	Seat height	5%	36.3
2	Seat length	5%	37.8
3	Seat width	95%	33.7
4	Seat back height	95%	42.5

3.3. Description Comparison of Chairs with Chairs of the Design Results

A comparison of the chair sizes from the design results is presented in Table 5.

Table 5. Comparison of the Size of the Designed Chair and Traditional Chair

No.	Dimension size	Chair (cm)	Work chair(cm)	Difference (cm)
1	Seat height	12.5	36.3	+23.8
2	Seat length	31.0	37.8	+6.8
3	Seat width	23,7	33.7	+10.0
4	Backrest	There is no	42.5	+42.5

Comparison of Sitting Position Descriptions Before and After Using the Ergonomic Chair Design. The results of the design are presented in Table 6.

Table 6. The sitting position of workers before and after using the designed chair design

No.	See Figure 2(a)	See Figure 2(b)
1	The chairs are too short, and the legs cannot relax	The seat height corresponds to the height of the knee bend, ensuring a more relaxed leg position.
2	The chair is too short in length, which results in the upper leg (thigh) being compressed and, consequently, hampers blood circulation.	The chair's length corresponds to the length of the upper leg, and the seat is cushioned to prevent compression of the thighs.
3	The seat width is too narrow, which prevents the buttocks from fitting comfortably on the chair.	The width of the seat matches the width of the hips, providing greater comfort.
4	Chairs without backrests are exhausting.	Chairs with backrests allow the back to rest, reducing fatigue.
5	The seat cushion is made of hard material, causing pressure on the blood flow to the thighs.	The seat cushion is covered with foam, thereby reducing pressure on the blood flow to the thighs.

3.4. Statistical Test Results for Musculoskeletal Complaints Before and After Treatment

The results of the statistical tests to determine the mean differences in musculoskeletal complaint scores before and after using the designed ergonomic chair were conducted using the Paired Samples T-Test (Table 7). The statistical test results to ascertain the mean differences in musculoskeletal complaint scores between the "Dingklik" group and the "Ergonomic Chair" group after three-week intervals while controlling for the control variables (Age, Years of Service, and Body Mass Index) were conducted using Analysis of Covariance (Table 8).

Table 7. Results of Paired Samples T-Test analysis

Means		n	BMI ±SD mean	Difference	CI95%	t	df	p value
				BMI ±SD mean				
“Dingklik”	before	30	71.60±4.515	-0.333±2.845	-1.396 to 0.792	-0.642	29	0.526
	After	30	71.83±4.849					
Ergonomic Chair	before	30	69.37±7.509	24,667±8,260	21,582 to 27,751	16,356	29	0.000
	After	30	44.70±4.170					

Table 8. Results of Analysis of Covariance

		n	Mean±SD	Mean Difference (CI95%)	F(p)	t	df	p value
MSDs Before	"Dingklik"	30	71.60±4.515	0.333 (-2.755 to 2.088)	0.386 (0.537)	-0.276	58	0.784
	Ergonomic Chair	30	71.93±4.849					
MSDs After	"Dingklik"	30	72.07±4.934	27,367 (25,006 to 29,728)	0.960 (0.331)	23,204	58	0.000
	Ergonomic Chair	30	44.70±4.170					
Age	"Dingklik"	30	48.17±4.871	-0.467 (-2.789 to 1.856)	1.983 (0.164)	-0.402	58	0.689
	Ergonomic Chair	30	48.63±4.081					
Years of service	"Dingklik"	30	20.37±4.335	-0.933 (-3.169 to 1.302)	0.343 (0.561)	-0.836	58	0.407
	Ergonomic Chair	30	21.30±4.316					
BMI	"Dingklik"	30	25.78±2.410	0.727 (-0.363 to 1.816)	2.479 (0.121)	1,335	58	0.187
	Ergonomic Chair	30	25.053±1.755					

3.5. Discussion

Common musculoskeletal complaints occur because workers sit for extended periods, and the chair size does not match the worker's body size, leading to injuries in the form of aches, pains, and discomfort in various body parts. Muscles frequently affected by musculoskeletal disorders include those in the neck, shoulders, arms, hands, waist, fingers, back, and other lower body areas. Muscle pain can also result from repetitive strain during prolonged periods of poor posture or continuous engagement in ergonomically unfavorable work positions with excessive loads[5]. This condition leads to excessive stress on the myofascial tissue, both intermittently and chronically, thus stimulating fibroblasts in the fascia to increase collagen production. The accumulation of collagen in the muscle tissue results in the formation of fibrous tissue known as a myofascial trigger point, which subsequently becomes a sensory stimulus for muscle pain[6]. This type of muscle pain is referred to as a musculoskeletal disorder[7].

Musculoskeletal Disorders (MSDs) constitute a group of health issues that are more prevalent among workers compared to the general population. These disorders are not typically caused by acute trauma or any systemic disease[8]. MSDs are conditions that result in discomfort in the striated muscles, as well as in the joints where two bones meet, and other soft tissues such as tendons and ligaments. These discomforts can range from mild to severe complaints and typically occur due to repetitive loading in a stationary position over the course of extended working periods[9]. This musculoskeletal disorder can manifest as muscular fatigue, which may result from the accumulation of lactic acid production in fast-twitch muscles or the depletion of glycogen in muscle fibers[10].

Ergonomic chairs can be utilized to effectively reduce MSDs, particularly long-term back pain. Long-term back pain is not only physically uncomfortable but also has the potential to induce psychological stress. Furthermore, ergonomic chairs significantly alleviate bodily stress by offering proper support and enhancing overall comfort. Additionally, ergonomic work chairs provide various health benefits, such as improved blood circulation, enhanced work productivity, reduced pressure on the hips, prevention of neck pain, and alleviation of back pain[11].

The results of this study showed that the musculoskeletal complaints of workers who previously worked using a chair called "dingklik" (pre-test) showed that both groups had the High-Risk category and were not statistically significant ($p = 0.526$; "Dingklik" group = 71.60-point and Ergonomic Chair group = 71.93-point) with the risk criteria "Immediate action is required". After work (post-test). within three-weeks intervals, the score for musculoskeletal disorders in the "Dingklik" group increased to 72.07-points which was not statistically significant ($p = 0.784$) so it was still in the High-Risk category, while the Ergonomic Chairs group decreased to 44.70-points which was statistically significant ($p = 0.000$) so that it becomes a Low-Risk Category. The confounding variable has no effect on the statistical test results for the mean difference between the "Stool" group and the Ergonomic Chair group after three-weeks intervals of doing work, respectively Age ($p = 0.689$), Years of Service ($p = 0.407$), and Body Mass Index ($p = 0.187$).

The statistical tests indicated a reduction in musculoskeletal disorders among workers before and after using ergonomic chairs. The provision of ergonomic work chairs, which are equipped with foam on the chair base as an improvement in workplace facilities, can reduce the risk of musculoskeletal disorders by directly addressing soft muscle tissues. Additionally, using chairs tailored to anthropometric measurements can promote a natural working posture, thereby reducing complaints related to skeletal muscles.

Research similar to this study was conducted by Buckle stated that ergonomics is associated with musculoskeletal disorders[12]. It is also noted that musculoskeletal disorders encompass conditions such as low back pain and knee pain. Another similar study was conducted by Trevelyan & Legg, who stated that there is a relationship between work chairs and the onset of low back pain complaints[13]. The results of this study also corroborate previous research conducted by González-Muñoz & Chaurand regarding the ergonomic effects of workstations on complaints related to skeletal muscles[14].

CONCLUSIONS

The conclusion of the research demonstrates that for traditional batik workers, the utilization of ergonomic chairs can significantly reduce musculoskeletal disorders.

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