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Enhancing Workspace Ergonomics to Mitigate Musculoskeletal Disorders in Stamped Batik Production (Case Study at PT.XYZ)

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Abstract— Batik is one of the works owned by the Indonesian Nation, which has noble values and is recognized by other nations. The rapid development of batik makes batik makers need to pay attention to the production process carried out, In carrying out the activities of making stamped batik, it has not been supported by a special work table. Still using an ordinary stamp table that is less comfortable to use for stamped batik. So that in doing their work craftsmen have low productivity and efficiency. This research was conducted at PT XYZ to evaluate and reduce the risk of musculoskeletal disorders in stamped batik makers through ergonomic work table redesign. The research method used is case study-based quantitative, with a population of PT XYZ employees who work as stamped batik makers. Primary data was collected through observation, questionnaires and interviews. Posture measurements were carried out using the NBM (Nordic Body Map) questionnaire, to determine musculoskeletal complaints including 28 muscle parts in the musculoskeletal system on both sides of the body right and left. Then posture measurements were taken using the REBA (Rapid Entire Body Assesment) method. The results of the NBM questionnaire showed that before the improvement of the stamp batik had a high chart of complaints of pain in the musculoskeletal muscles and also the results of the REBA score showed a high risk of musculoskeletal disorders, especially in the neck, shoulders, bronze, arms and legs. After the implementation of a more comfortable stamp work table design and stamp stove table (Adjustable) there was a significant decrease in the REBA score decreasing from 8 to 1. This shows a significant reduction in the risk of musculoskeletal disorders, so that ergonomic work table design can reduce the risk of musculoskeletal disorders at PT XYZ and increase worker comfort.

Keywords: Ergonomic cap table, Muskuloskeletal disorders, Nordic body map, Rapid entire body assesment

1. Introduction

Batik is one of the works owned by the Indonesian Nation, which has noble values and is recognized by the nation [1]. Batik can also be defined as a work made by humans with a variety of local wisdom, both from the motif and the manufacturing process [2]. The rapid development of batik makes batik makers need to pay attention to the production process carried out. In international trade, Batik is now an important commodity in Indonesia's income [3]. So, that batik makers become optimal, what needs to be considered is the work facilities in the batik process. Especially in Malang Regency, the use of stamped batik is increasingly widespread with the establishment of the Garudeya motif as the motif of Malang Regency. The Garudeya motif is derived from the reliefs of Kidal Temple [4]. The philosophical meaning of this relief is about freedom from slavery. It is expected that people will refer to Kidal Temple because they apply and teach the moral values contained in the Garudeya story.

Stamped batik making has not been supported with a special work table. Currently, craftsmen

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still use ordinary stamp tables that are less comfortable to use. Thus, craftsmen experience low productivity and efficiency. The factors causing this low productivity and efficiency are due to less ergonomic work facilities and layouts. The work of making stamped batik requires accuracy and accuracy which of course must be supported by tools, especially stamp tables and stamp stove tables that are comfortable for the job.

Causes of Musculoskeletal Disorders (MSDs) that need to be considered in the design of this workbench include ensuring an appropriate height, so that users do not need to bend or lift their arms excessively [5]. In addition, there should be enough space for easy maneuvering of technical equipment, such as lifting and moving the canting cap from the batik pan to the cloth sheet on the stamping table. The design should also accommodate a separate stamp stove table, which serves as a vital support tool, ensuring a clean and safe working environment. All these factors aim to increase comfort and productivity during the batik stamping process, ultimately contributing to increased sales and business growth in the batik industry.

One example of a company that focuses on stamped batik is PT XYZ. At PT XYZ, workers involved in stamped batik production use a stamp table for approximately 8 hours each day, with two 30-minute breaks. Work facilities provided by the company, such as work tables, are very important to support company operations and improve employee welfare [6]. The right facilities enable employees to perform their tasks effectively and safely, ensuring they can meet the company's production targets while minimizing the risk of occupational injuries. Well-designed work facilities, coupled with adequate rest periods and ergonomic considerations, not only encourage a healthier workforce but also help companies maintain consistent productivity [7] [8]. As a result, this can have a positive impact on the company's profitability, reputation and long-term sustainability.

The study conducted at PT.XYZ found that the work table design for stamped batik makers did not match the body dimensions because it caused musculoskeletal problems. This resulted in workers experiencing fatigue. One of the impacts of an unergonomic work environment and tools is the occurrence of Occupational Diseases (OBDs) related to Musculoskeletal problems (MSDs). This can result in decreased productivity, lost work time, lower levels of alertness, and increased risk of workplace accidents [9]. Musculoskeletal disorders (MSDs) are frequently reported by office workers globally, and these conditions can negatively impact both their health and productivity [10]. The risk factors for developing MSDs can be categorized into individual, ergonomic, and psychosocial factors [11], [12]. Workers who face heavy workloads, prolonged use of a mouse and keyboard, high levels of perceived muscle tension, and a history of neck and shoulder MSDs are at greater risk of developing these disorders.

This study conducted an initial survey of respondents (batik stampers) using the Nordic Body Map (NBM) to determine musculoskeletal complaints. The Nordic Body Map questionnaire covers 28 muscle parts in the musculoskeletal system on both the right and left sides of the body, starting from the upper limbs, namely the neck muscles to the lowest part, namely the leg muscles. Through the Nordic Body Map questionnaire, it will be known which parts of the muscles experience discomfort or complaints from low levels or no complaints or injuries to high level complaints or complaints of severe pain [13]. Furthermore, to reduce musculoskeletal risks, this study redesigned the workbench using the Rapid Entire Body Assesmet (REBA) method to strengthen the results of measuring complaints using the NBM questionnaire, then analyzed the risk of work posture hazards using the Rapid Entire body Assesment (REBA) method and Anthropometric.

Researchers conducted a survey of pain complaints. The results showed that there were complaints of pain in 10 employees who would become research respondents who complained of pain in the neck, pain in the body, pain in both legs, pain in the upper arm, pain in the forearm, pain in the wrist. In order to confirm the complaints, researchers used the Nordic Body Map questionnaire which includes 28 muscle parts in the masculosceletal system on both sides of the right and left body parts. The results can be known the kinds of MSDs complaints felt by employees/stamp batik workers.

Complaints regarding, muscle disorders of the right shoulder, back, right upper arm, right leg and left leg are complaints that score the highest. It is necessary to immediately make improvements so that the complaints that are felt can decrease.

The existence of complaints from workers as described above which is a problem in this study is MSDs on the right shoulder, left leg, right leg, back and upper right arm. This study uses the Nordic body map (NBM) method and the REBA method to identify the risk of batik work posture. Then a redesign of the batik work table is carried out to reduce MSDs complaints.

2. Method

This research was conducted at PT XYZ during June to July 2024. The method used in this research is case study-based quantitative, chosen because it is able to provide numerical data that can clearly measure research needs and provide results that can be analyzed statistically [14]. This is especially useful in understanding the problems and solutions of the work system of batik making with the stamp technique that causes musculoskeletal disorders in employees at PT.XYZ. The proposed improvement of this system is the design of an ergonomic stamp batik work table that does not slouch and is equipped with a stamp stove table with an upright standing position so that fatigue in the work process can be minimized, thus making workers more comfortable, safe effective and efficient.

The population of this study were employees of PT XYZ who worked as stamped batik makers. The technique used was purposive sampling [15], with 10 respondents of PT XYZ employees who often experience fatigue at work and often complain in the neck, shoulders, waist and legs. Primary data in this study were taken through observation, questionnaires, and interviews. Furthermore, posture measurements using the REBA (Rapid Entire Body Asessment) method were analyzed to identify high-risk work postures, formulate and recommend the design of an ergonomic stamp batik table in the workplace.

3. Result and Discussion

The level of employee complaints when doing batik stamping using a table that is less ergonomic can be known based on the results of Nordic Body maps (NBM) in Figure 1.

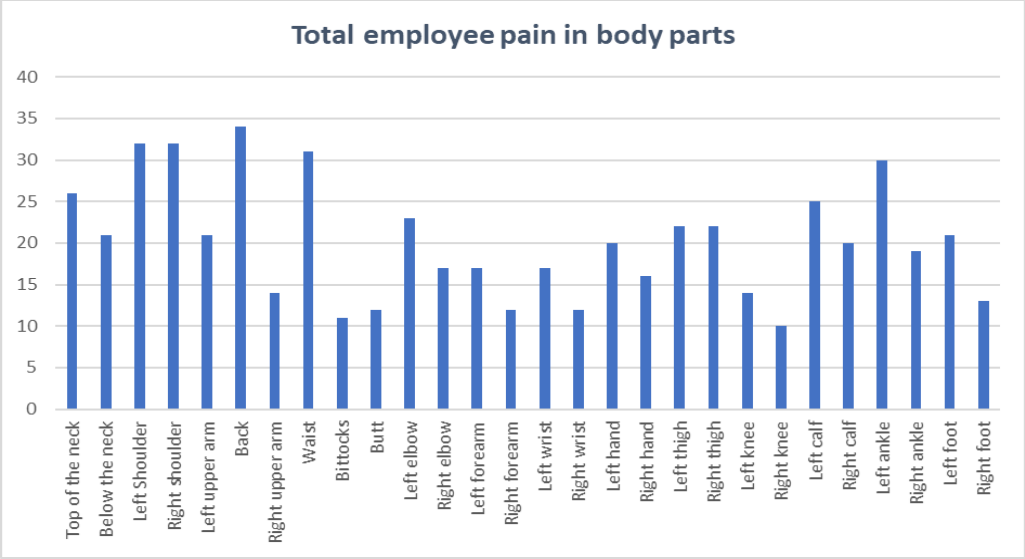

Figure 1. Nordic Body Map Questionnaire Results

Based on observations using the Nordic Body Map (NBM) of musculoskeletal complaints (MSDs) to 10 workers, it can be concluded that in general, the average worker experiences complaints

in various parts of the body such as the neck, shoulders, back and legs. This pain can be attributed to the working positions that workers complain of, including bending the neck, at an angle of about 200°, the body position forming an angle of 460°, and the feet that support the body for a relatively long time. The average score obtained from the 10 samples is 8, reflecting a high level of risk, therefore corrective action needs to be taken immediately to reduce the risk.

3.1 Rapid Entire Body Asessment

According to Valentine and Wisudawati [8], the Rapid Enter body Assesment (REBA) method in ergonomics is an approach that is used quickly to evaluate the posture of workers, especially in the neck, back, arms, wrists, and feet REBA is an evaluation method in the ergonomics domain that focuses on assessing the operator's work position, including aspects of the posture of the neck, back, arms, wrists and feet.

Score Group A

Group A in the REBA method consists of scoring the neck, body, legs. The neck measurement gets a score of 3 because the neck forms an angle of 200°, the scoring for the body gets a score of 4, because the body forms an angle of 200-600°, and the foot score gets a value of 1 because the foot has a balanced position. Furthermore, the total score of group A is determined based on the REBA guidelines which can be seen in Table 1. The results show that the value of group A (neck, body, and legs). Got a total score of 5.

Table 1. REBA Group A Analysis Assessment

Neck Posture Score	**Trunk**											
	1		**2**		**3**		**4**		**5**		**6**	
	Foot		**Foot**		**Foot**		**Foot**		**Foot**		**Foot**	
	1	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Score Group B.

Group B in the REBA method consists of scoring the upper arm, forearm and wrist, the upper arm scores 3, because the upper arm forms an angle of 200-450°, the forearm scores 1, because the forearm forms an angle of 600-1000°. The wrist gets a score of 3, because the wrist bends to the center line forming an angle of 1800°, because the wrist rotates in the middle range. Furthermore, the total score of group B is determined based on REBA guidelines which can be seen in table 2. The results show that the total score of B (upper arm, forearm, and wrist) gets a total score of 5.

Table 2. REBA Group B Analysis Assessment

Table B		Lower Arm					
		1			2		
	Wrist	1	2	3	1	2	3
	1	1	2	2	1	2	3

Upper arm	2	1	2	3	2	3	4
	3	3	4	5	4	5	5
	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
	6	7	8	8	8	9	9

Score final REBA.

The next step, enter the final score of table A and the final score of table B, The final score of REBA is the result of the work posture.

1. Score A is obtained with 5 plus 5 kg weights and repetitive activities, so the total score of table A is 5 + 0 + 1 = 6 Then in the score table A circled number 6.

2. Score B is obtained with 5 plus weights < 5 kg and repetitive activities, so that the total score of group B is 5 + 0 + 1 = 6 then in the score table B circled number 7.

The final REBA score can be seen in Table 3 where it is found that the REBA score of workers before the implementation of improvements is 8. This score indicates that the employee's posture before improvement has a high level of ergonomic risk and needs to be done immediately. Make improvements to workers' posture to reduce the risk of injury or discomfort at work.

Table 3. Score Final REBA

Table Score A	Tabel C											
	Table Score B											
	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

3.2 Anthropometry Data Processing

Anthropometric data serves as a guide in determining the dimensions for designing tables to improve the working position of employees during work. From the results of data uniformity testing, all anthropometric values measured are within the control limits, indicating that the data is homogeneous. The results of data sufficiency testing state that all anthropometric data meet the N>N' requirement, confirming that the amount of data collected is more than sufficient. Furthermore, the percentile calculation of anthropometric data is then used as the basis for dimensions in the design of the stamp table and stamp stove table, the results of which can be seen in Table 6.

Table 4. Recapitulation of Percentile Calculations

Percentil	**Body Dimensions (cm/kg)**							
	Tbt	**Tmt**	**Tbb**	**Tsb**	**Tpb**	**Jka**	**Plb**	**Tlb**
Mean	160.60	150.10	133.60	106.10	99.30	198.40	44.70	48.00
SD	4.45	7.98	5.80	7.37	6.20	11.95	2.36	2.26
P5	155	138.9	126.9	96.7	90.9	182.9	40.9	44
P95	166.1	158	141.1	116.2	106.55	211.3	47	50

The anthropometric data processing process aims to obtain table dimensions that are in accordance with ergonomic principles, as an effort to adjust the position and work environment to reduce the potential risk of musculoskeletal disorders in workers. Based on the fixed measurements, it can be expected that improvements in ergonomics can be implemented by ensuring more automated functionality in order to adapt to the body conditions of workers and minimize adverse effects on the musculoskeletal health of workers.

3.3 Design of stamp table.

After considering the initial conditions, it is known that the standing position when the batik maker performs activities in the stamp batik process with an uncomfortable work table with a long duration of time of about 1-4 hours. So the next step is to utilize Anthropomeri data to design a stamp table:

1. The length of the stamp table is taken from TMT (Upright eye height) with a percentile value (95) = 158 cm.
2. The width of the stamp table is taken from TSB data (standing elbow height) with a percentile value (95) = 116.2 cm.
3. The height of the stamp table can be adjusted according to the height of the batik maker, so the data used is Anthropometric data TPM (Standing waist height) with a percentile value (95) = 106.55 cm.

For the stamp stove table design:

1. The length of the stamp stove table is taken from PLB data (forearm length) with a percentile value (95) = 47 cm.
2. The width of the stamp stove table is taken from PLB (forearm length) data with a percentile value of (95) = 50 cm.
3. The height of the stamp stove table is taken from TLB (Standing Knee Height) data with a percentile value (95) = 47 cm.

Figure 2. Cap Table And Stamp Stove After Repair

Figure 3. Working Position After Improvement

Cap table and stamp stove after repair as shown in Figure 2. After making improvements to the working position as shown in Figure 3, the next step involves calculating the employee's body angle to determine the improvement score. This process aims to quantitatively measure and evaluate the extent to which the adjustments affect the working posture. By obtaining an improvement score, a more detailed understanding of the positive impact of the change in work position on ergonomics and the potential risk reduction of musculoskeletal disorders can be obtained. This calculation process is a critical step in assessing the effectiveness and efficiency of improvements that have been implemented in the work environment.

3.4 Data Processing Results.

Based on data analysis using the REBA method, it was found that the REBA score of workers before the implementation of improvements was 8. This score indicates that the posture of employees before improvement has a high level of ergonomic risk. Therefore, the necessary step is to make improvements to the worker's posture while working to reduce these risks.

Nordic Body Map

Based on observations using the Nordic body map there are complaints of musculoskeletal disorders in 10 workers, it can be concluded that in general, the average worker experiences

complaints in various parts of the body such as the neck, shoulders, back and legs. These pains can be attributed to the working positions adopted by the workers, including neck bending at an angle of about 20°, torso position forming a 45° angle, and legs supporting the body for a relatively long time. The average score obtained from the 10 samples was 8, reflecting a high level of risk. Therefore, corrective action needs to be taken immediately to reduce the risk.

Anthropometric Data

Anthropometric data serves as a guide in determining dimensions for designing tables to improve the working position of employees during work. From the results of data uniformity testing, all anthropometric values measured are within the control limits, indicating that the data is homogeneous. The results of data sufficiency testing stated that all anthropometric data met the N>N' requirement, confirming that the amount of data collected was more than sufficient. Furthermore, the calculation of percentiles from anthropometric data is then used as the basis for dimensions in table design.

After calculating the initial REBA score and anthropometric calculations are carried out, the appropriate work table size is obtained for improvement. The repair workbench is applied then the final score measurement for REBA is carried out. Comparison of the initial and final REBA scores is shown in Table 5.

Table 5. Comparison of REBA Scores

Description	Before Improvement	After Improvement
Body score table A	6	1
Body score table B	6	1
Total score	8	1
Risk level	High	Small
Action	Needs immediate repair	Can be ignored and does not need repair

The REBA score for posture after the improvement obtained is in the actual situation, the final REBA score is 8. This means that employees have a high risk of musculosceletal disorders, so efforts are needed to improve posture now. After improving posture while working by making stamp tables and stamp stove tables based on the results of anthropometric calculations of workers, the final REBA score is 1. This means that workers tend not to be at risk of musculosceletal disorders and other skeletal muscle disorders 5, comparison of REBA scores before and after improvement.

4. Conclusion

The redesigned work tables have effectively reduced the risk of musculoskeletal disorders (MSDs) among stamped batik makers at PT. XYZ. An evaluation using the REBA method revealed a significant decrease in the initial high-risk posture score from 8 to 1. The improved table design, including features like adjustable height and ergonomic positioning, has positively impacted workers' postures and minimized the potential for MSDs. The researchers suggest that the company needs to prioritize ergonomic aspects during work activities in order to reduce the potential risk of musculoskeletal disorders in the future. Long periods of work with static postures need to be accompanied by periodic breaks to reduce muscle stiffness during the work process. Improvements to work facilities are implemented by ensuring more automated functionality to adapt to the user's body, which is expected to provide comfort in reducing adverse effects on workers' musculoskeletal health.

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