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Ergonomic Risk Mitigation in Batik Stamping: A Hierarchical Task Analysis and REBA Study at Batik Komar Bandung

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ABSTRACT

This research investigates postural risks faced by batik stamp workers at Batik Komar Bandung, employing Hierarchical Task Analysis (HTA) and Rapid Entire Body Assessment (REBA) to assess worker ergonomics. While batik holds immense cultural value, there is a lack of ergonomic research focusing on the well-being of workers in traditional batik production. The case study at Batik Komar Bandung involved 11 workers aged between 20 to 50 years, where work activities were documented through video and photographs, followed by HTA task analysis and REBA postural risk assessment. The findings reveal that the stamping stage, which constitutes 86.85% of the process, presents significant ergonomic risks, with a REBA score of 10 indicating high postural risk. Workers frequently use a ±1.1 kg stamp while maintaining bent postures for prolonged periods, contributing to potential musculoskeletal disorders. These findings underscore the urgent need for ergonomic interventions within the batik industry. The study proposes potential solutions, including workstation redesign, tool modification, and the implementation of regular rest periods to mitigate health risks. By addressing the ergonomic challenges in traditional batik production, this research highlights the importance of worker well-being and sustainability in the batik industry. Additionally, the study demonstrates the practical application of HTA and REBA in identifying postural risks and formulating effective interventions, contributing valuable insights to the growing field of ergonomic research in cultural industries.

KEYWORDS *Ergonomics, HTA, REBA, Postural Risks, Batik Stamp Workers*

INTRODUCTION

UNESCO acknowledges batik as an intangible cultural asset, drawing attention to its cultural relevance and the essential preservation efforts required in Indonesia. As of 2021, *Balai Besar Kerajinan dan Batik* reported 3,159 batik enterprises, including 208 large to medium-scale businesses and 2,951 micro to small-scale enterprises, employing approximately 37,093 workers nationwide (Ahdiat, 2022; Siregar et al., 2020). Batik production methods are classified into three techniques: hand-drawn (batik tulis), stamped (batik cap), and a combination of both (Trixie, 2020). Stamped batik, introduced to enhance production efficiency, utilizes the canting cap, which enables faster production compared to hand-drawn techniques (Anugraha et al., 2015; Artiwi & Widyastuti, 2021). Made from copper for its durability and flexibility, the canting cap facilitates precise application throughout the production process (Suharto et al., 2014). However, the use of the canting cap involves continuous human-tool interaction, requiring significant physical activity. Musculoskeletal complaints are prevalent among workers in various cultural settings, with significant impacts on occupational health. Studies have shown high prevalence rates among Indonesian batik workers (Prabarukmi & Widajati, 2020). This results in potential health risks for workers, particularly musculoskeletal issues due to prolonged exposure to non-ergonomic postures. This study aims to identify and analyze the postural risks faced by batik cap workers, with a focus on implementing relevant ergonomic interventions to mitigate health risks.

Physical activities in this context involve musculoskeletal movements that result in significant energy expenditure (Gellman & Turner, 2013). However, repetitive motions increase the risk of repetitive strain injury (RSI), a common condition among workers in physically demanding tasks (Błaszczyk & Ogurkowska, 2022). RSI often arises from workstations that fail to meet ergonomic standards, leading to long-term health consequences (McDermott, 1986). Batik stamping workers are particularly vulnerable to RSI due to the repetitive use of the canting cap, which typically weighs between 1–2 kilograms. In addition to musculoskeletal disorders, informal workers, including those in the batik industry, face a range of other health risks. Meher (2024) highlights that respiratory diseases, dermatitis, eye strain, and fatigue are among the primary health problems experienced by informal workers in their workplaces (Meher & Panda, 2024). Cumulative trauma disorders (CTDs) and repetitive motion injuries (RMIs) are particularly prevalent due to the sustained, repetitive nature of tasks such as batik stamping. Furthermore, mental health issues like anxiety and depression are also common, exacerbated by the physical strain and poor working conditions.

These health issues not only affect workers' well-being but also lead to significant economic consequences. The costs of treating these conditions, the impact on productivity, and workers' compensation claims can place a substantial financial burden on both workers and the industry. Musculoskeletal disorders (MSDs) have a significant economic impact on industries across Europe, potentially costing up to 2% of GDP due to lost productivity. These health issues are the foremost causes of disability at work, absence due to sickness, and diminished productivity (Bevan, 2015). Studies have shown that ergonomic-related injuries account for 33-40% of total worker compensation spending (Shamsuddin, et al., 2014). Given the cultural and economic importance of the batik sector in Indonesia, it is crucial to address these health risks to ensure the sustainability of the industry and improve the quality of life for workers.

Hierarchical Task Analysis (HTA) is a structured method for breaking down complex tasks into smaller components to better understand physical demands and ergonomic risks (Sheperd, 1998; Stanton, 2006). By providing a systematic framework for task description, HTA facilitates the identification of ergonomic issues and potential solutions. It can be used in conjunction with other evaluation methods, such as usability testing, to offer a more comprehensive assessment of user interfaces and workflows (Promann & Zhang, 2015). Although widely applied in industrial settings, its use in traditional crafts like batik—particularly in Micro, Small, and Medium Enterprises (MSMEs)—remains limited. Given the repetitive and physically intensive nature of batik cap production, this study applies HTA to identify high-risk tasks and postural challenges associated with using the heavy *canting cap*. The goal is to generate ergonomic insights and practical recommendations to reduce musculoskeletal injury risks among batik workers.

In both hand-drawn and stamped batik techniques, workers often adopt positions that are ergonomically unfavorable, leading to discomfort, especially in the neck, back, and upper limbs. Studies show high incidences of musculoskeletal complaints among batik workers, with 90% reporting pain in areas such as the neck and waist and 57.7% experiencing low back pain (Widyaningtyas Savitri et al., 2015). In batik cap production, the squatting posture exacerbates these risks, with workers in Sragen also reporting significant musculoskeletal discomfort. A recent investigation involving batik cap workers revealed multiple factors linked to musculoskeletal issues, such as working posture ($p=0.000$), duration of work ($p=0.043$), length of employment (p=0.000), workload (p=0.019), and age (p=0.000). Conversely, no significant associations were observed between musculoskeletal complaints and variables like gender, physical activity routines, or body mass index (BMI) (Fitrianingrum, 2023). Despite growing awareness of these risks, there is limited research on ergonomic interventions tailored to the batik industry. While studies identify musculoskeletal complaints, few propose specific ergonomic solutions like workstation or tool redesigns emphasizing the need for ergonomic improvements in traditional industries to reduce fatigue and health issues (Sumardiyono et al., 2023).

Studies from the informal and industrial sectors such as tailoring, garment production, and automotive manufacturing highlight a consistent pattern of musculoskeletal disorder (MSD) risks due to repetitive motions and prolonged static postures (Das & Natarajan, 2022; Ncube et al., 2019). Similar ergonomic risks are evident in the batik cap production process, where workers engage in repetitive stamping movements and sustained upper-body positions. Like workers in the automotive industry (Spallek et al., 2010), batik artisans often report discomfort in the neck, shoulders, and upper limbs. This study confirms that batik workers face comparable physical strain, underscoring the need for ergonomic interventions in traditional craft settings, an area often overlooked in mainstream ergonomic research (Chang et al., 1987).

This research aims to: (1) systematically document and analyze the batik stamping process using Hierarchical Task Analysis to identify time-intensive and physically demanding stages; (2) assess postural risks among batik cap workers using the Rapid Entire Body Assessment method; and (3) propose evidence-based ergonomic interventions to mitigate musculoskeletal disorder risks in traditional batik production. The significance of this research lies in addressing a critical gap in ergonomic literature concerning traditional cultural industries, particularly small-scale batik enterprises. By demonstrating the applicability of HTA and REBA methodologies in informal work settings, this research contributes practical knowledge for improving worker health and safety while preserving cultural heritage practices. The findings will benefit batik industry stakeholders, occupational health practitioners, and policymakers in developing ergonomic standards for traditional crafts, ultimately supporting both worker well-being and industry sustainability.

METHOD

This research employed a descriptive observational study design with an ergonomic assessment approach. It focused on Batik Komar Bandung, located in Bandung, West Java, Indonesia, a prominent and well-organized *batik* industry employing 11 stamping workers aged 20–50 years, with 8-hour daily shifts. The population consisted of all 11 *batik* stamping workers at Batik Komar Bandung, and a total sampling technique was used, whereby all workers who met the inclusion criteria (active workers with a minimum of 6 months of experience in stamping tasks) were included as research subjects. The structured workflow at Batik Komar, with clearly defined divisions for each production stage, including stamping, enabled a comprehensive analysis of its processes. The findings of this research contributed to ergonomics by highlighting RSI risks in *batik* production and providing a foundation for further assessment. These insights could guide the development of preventive measures to enhance workplace ergonomics, ultimately improving worker productivity in the *batik* industry.

Data were collected through multiple sources: (1) primary data obtained through direct observation, video documentation, and photographic recording of work activities; (2) secondary data gathered from company records regarding worker demographics and work schedules. Participants' work activities were documented sequentially through photos and videos. Each workstation measures 2 x 2 meters, ensuring complete documentation of all activities. The instruments used include an iPhone 12, tripod, pen, and notebook to record micro-activities during the batik stamping process. Further analysis was conducted by identifying tasks and work stages to evaluate potential ergonomic risks. The assessment is using hierarchical task análisis, a versatile method for analyzing complex tasks and informing design decisions (Shepherd, 1985). The method involves breaking down tasks into hierarchies of operations and plans. HTA has proven valuable in evaluating and improving designs (Hodgkinson & Crawshaw, 1985; Promann & Zhang, 2015).

The data collection procedure was carried out in the following steps:

a) Participants signed a consent form to document their work activities;
b) Cameras were positioned to avoid interfering with the workers' physiological movements;
c) Video recordings were performed sequentially for each fabric stamping process, from start to finish;
d) The duration of each micro-task was recorded to calculate the average time required to complete it;
e) Hierarchical Task Analysis (HTA) was conducted in two categories: HTA 1 analyzed the main tasks in the stamping process, while HTA 2 focused on micro-tasks and potential injury risks;
f) Micro-tasks requiring extended work durations were analyzed further;
g) Specific observations were conducted on prolonged-duration tasks to evaluate their execution time and assess potential postural risks faced by workers.

Following the task analysis, postural risk urgency is implementing the Rapid Entire Body Assessment (REBA)'s protocol which categorizes risks on a 1–10 scale. The Rapid Entire Body Assessment (REBA) evaluates ergonomic risks associated with work postures. It involves observing tasks, selecting and scoring postures, and calculating a final REBA score to determine action levels (McAtamney & Hignett, 2004). The scoring process involves four systemic steps;

1. Step 1: Neck Posture Scoring. Neck posture is catagorized into two positions; flexion between 0°–20° and flexion or extension >20°. Scoring criteria for neck posture are outlined in Table 1.

Table 1 – Neck posture scoring

Score	Posture description
+1	Neck flexion at 0°–20°
+2	Neck flexion >20° or extension
+1	Neck rotation
+1	Neck lateral flexion

Source: McAtamney & Hignett (2004)

2. Step 2: Trunk Posture Scoring. Trunk posture is scored based on alignment and angular deviation; upright posture (0°) receives the lowest score, flexion/extension angles increase the score incrementally. Detailed scoring is provided in Table 2.

Table 2 – Trunk posture scoring

Score	Posture description
+1	Upright trunk (0°)
+2	Flexion/extension 0°–20°
+3	Flexion/extension 20°–60°
+4	Flexion >60°
+1	Add if trunk is twisted
+1	Add if trunk is bent sideways

Source: McAtamney & Hignett (2004)

3. Step 3: Leg Posture Scoring. Leg posture scoring emphasizes knee flexion angles; higher scores apply to unilateral or bilateral knee flexion. Scoring criteria are detailed in Table 3.

Table 3 – Neck posture scoring

Score	Posture description
+1	Legs straight
+2	One knee flexed
+1	Add if knee flexion 30°– 60°
+2	Add if knee flexion > 60°

Source: McAtamney & Hignett (2004)

Composite Posture Scoring (Table A). Final REBA scores are derived by cross-referencing neck, trunk, and leg scores in Table A (see Figure 1).

Table A		Neck											
		1				2				3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk Posture Score	1	1	2	3	4	1	2	3	4	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

Figure 1. Table A scoring
Source: McAtamney & Hignett (2004)

4. Step 5: Load/Force Scoring. The load carried during tasks is scored as follows;

Table 4 – Load/force scoring

Score	Posture description
+0	Load <11 kg
+1	Load 11-22 kg
+2	Load >22 kg
+1	Additional score for shock impact or repetitive lifting

Source: McAtamney & Hignett (2004)

Posture Score A (Table C). Combine the posture score from Step 4 (neck, trunk, legs) with the load score from Step 5. Cross-reference these values in Table C (Figue 2) to derive Score A, which reflects the combined risk of posture and load.

Score A	Table C											
	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

Figure 2. Table C scoring

Source: McAtamney & Hignett (2004)

5. Step 5: Upper Arm Posture Scoring. Upper arm posture is scored based on angular deviation from the body.

Table 5 – Upper arm posture scoring

Score	Posture description
+1	Arm swings ±20° from the body (neutral position)
+2	Arm extended > 20° backward or flexed 20°- 45° forward
+3	Arm flexed 45°– 90° forward
+4	Arm flexed >90° forward
+1	Add if shoulder is elevated
+1	Add if arm is abducted (lifted sideways)
+1	Add if arm is supported or worker is lean

Source: McAtamney & Hignett (2004)

6. Step 6: Forearm posture scoring is scored as follows;

Table 6 – Forearm posture scoring

Score	Posture description
+1	Forearm flexed 60°– 100°
+2	Forearm flexed <60° or >100°

Source: McAtamney & Hignett (2004)

7. Step 7: Wrist posture scoring focuses on flexion/extension and radial/ulnar deviation. The scoring is scored as follows;

Table 9 – Wrist posture scoring

Score	Posture description
+1	Wrist flexion/extension 0°–15°
+2	Wrist flexion/extension >15°
+1	Add if wrist is bent or deviated beyond midline

Source: McAtamney & Hignett (2004)

Posture Score B (Table B). Combine scores from Steps 7-9 (upper arm, forearm, wrist) and reference Table B (Figure 3) to calculate Score B, representing upper-limb risk.

8. Step 8: Coupling score. Evaluate grip quality and assign scores;

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

Figure 3. Table C scoring

Source: McAtamney & Hignett (2004)

Table 10 – Coupling score

Score	Posture description
+0 (Good)	Secure, comfortable grip
+1 (Fair)	Acceptable grip with body assistance
+2 (Poor)	Unreliable grip but feasible
+3 (Unacceptable)	No grip, unsafe, or awkward positioning

Source: McAtamney & Hignett (2004)

9. Step 9: Sum score B and the coupling score, then cross-reference in Table C (Figure 4) to determine Table C.

Score A	Table C											
	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

Figure 3. Table C scoring

Source: McAtamney & Hignett (2004)

10. Step 10: Activity scoring. Activity related risk factors are scored as follows;

Table 11 – Activity scoring

Score	Posture description
+1	When one or more bodily areas are kept static (fixed posture >1 minute)
+1	If repetitive movements occur (≥4 repetitions per minute)
+1	If rapid movements cause abrupt postural changes or instability.

Final REBA score calculation is scored by summing the Table C score and the Activity Score to determine the final REBA score.

Table 12 – Final REBA score interpretation

Response Level	REBA Score	Risk Level	Action
0	1	Very Low	Risk is acceptable; no changes required
1	2-3	Low	Possible changes may be needed

Response Level	REBA Score	Risk Level	Action
2	4-7	Medium	Improvements required
3	8-10	High	Immediate corrective action necessary
4	11-15	Very High	Urgent redesign and implementation of ergonomic intervention

Source: McAtamney & Hignett (2004)

RESULTS AND DISCUSSION

The observational findings of this study are presented in the following table.

Tabel 13. HTA 1: Showing the main tasks

Task	Code	Picture
Cloth Preparation	CP	
Marking Line	ML	
Motifs Stamping	MS	
Finishing	FS	

Source: Primary data analysis

Task durations were documented to identify those requiring extended time. Video observations also highlighted potential ergonomic risks faced by batik stamping workers. The results are summarized in Table 14.

Tabel 14. HTA 2: Work stages and description of workers' movements

Code		Stages
CP	1.1	The worker retrieves white fabric from the *gawangan* (batik frame)
	1.2	The fabric is spread on the table and straightened
ML	2.1	Marking lines are drawn on the fabric using a ruler and tailor’s chalk.
	2.2	A cardboard template is place to guide the stamping pattern

Code		Stages
MS	3.1	The worker selects and heats the canting cap on a warming tray.
	3.2	Excess batik wax is removed by tapping the canting cap
	3.3	The canting cap is aligned with the motif and placed on the marking lines.
	3.4	The worker presses the canting cap firmly and strikes it 2-3 times for a clear imprint.
	3.5	The process is repeated until the entire fabric is stamped
FS	4.1	The worker folds the stamped fabric.
	4.2	The folded fabric is placed on the gawangan (batik frame)
	4.3	New piece of white fabric is retrieved for stamping.

Source: Primary data analysis

Activities with specific durations and identified postural risks requiring further análisis are detailed in Table 15.

Table 15. Time required and workload description of batik stamping workers

Task	Time (s)	Task Description
CP	51	No significant risks identified.
ML	127	Workers tend to lean forward while making the fabric's top edge. Manual ruler adjustmens may increase task duration.
MS	1,295	The *canting cap* weighs approximately ±1.1kg Excess wax is removed by tapping the *canting cap*. Workers lean forward to ensure *canting cap* alignment and precision during motif stamping. Task are repetitive.
FS	18	No significant risks identified.

Source: Primary data analysis

Table 3 shows that the motif stamping (MS) task is the most time-intensive stage in the batik stamping process, lasting 1,295 seconds (21.59 minutes) and constituting 86.85% of the total workflow. This stage involves significant physical effort and potentially high-risk postures, requiring further análisis. The urgency for intervention in each work posture was determined by scoring with the Rapid Entire Body Assessment (REBA).

Tabel 16. Task mapping for batik cap making and REBA scores

No.	Task	Duration (second)	REBA Score	Information
1	Fabric preparation	51	2	Low risk level.
2	Marking line	127	4	Moderate risk level requiring improvement consideration.
3	Motifs stamping	1,295	10	High risk level requiring immediate corrective actions.
4	Finishing	18	1	Very low risk level with no actions needed.

Source: Primary data analysis

Description:

1 (Negligible Risk): No action required.

2–3 (Low Risk): Changes may be needed.

4–7 (Moderate Risk): Caution advised; improvements should be considered.

8–10 (High Risk): Corrective actions required.

11+ (Very High Risk): Immediate response necessary.

As shown in the final REBA score table, the motif stamping stage stands out as the most critical, lasting 1,295 seconds with a REBA score of 10 indicating a high ergonomic risk that necessitates immediate intervention. This task involves sustained postural exertion and repetitive upper limb movements, underscoring the need for workstation redesign, tool modifications, or scheduled breaks. In contrast, other stages such as fabric preparation (REBA score: 2) and the final step (REBA score: 1) pose minimal risk, while the marking line stage (REBA score: 4) suggests moderate risk and could benefit from minor ergonomic adjustments. These findings reaffirm the motif stamping activity as the primary focus for ergonomic improvement in batik cap production.

Prolonged repetitive tasks involving trunk flexion and static postures have been strongly associated with lumbar musculoskeletal disorders. According to McGill in Oakley (2004), repetitive forward-bending movements and sustained static loads on the spine, especially without adequate recovery, can lead to micro-damage in spinal tissues, increasing the risk of chronic low back pain (Oakley, 2004). This is further supported by Gallagher & Marras (2012), who emphasize that cumulative loading of the lumbar spine, common in occupations with repetitive trunk flexion, is a key biomechanical factor contributing to the development of lumbar disc degeneration and low back pain (Gallagher & Marras, 2012). In tasks such as batik stamping, where workers frequently bend forward while applying force, the lumbar spine is subjected to continuous stress, making postural correction and ergonomic interventions essential Overall, the findings highlight the motif stamping process as the most critical stage in batik production, requiring ergonomic improvements to minimize health risks for workers. Other stages can be prioritized for intervention based on the identified risk levels.

CONCLUSION

This study contributes both theoretically and practically by demonstrating how ergonomic assessment tools like HTA and REBA can be adapted to traditional craft settings, offering valuable insights for the creative industries and advancing ergonomic practices beyond industrial environments. HTA highlights that the motif stamping process in batik production consists of four main stages: fabric preparation, marking line creation, motif stamping, and finishing. REBA analysis identifies motif stamping as the most critical stage, with a risk score of 10, indicating a high-risk level. This stage consumes the most time (21.59 minutes or 86.85% of the total process) and poses significant postural strain, including frequent bending, excessive force application, and repetitive movements. Ergonomic interventions are a priority to mitigate health risks for workers. Recommended interventions include improving workstation design, such as adjusting table height and introducing assistive tools to reduce physical strain. Modifying tools, such as making the canting cap lighter and more ergonomic, is also advised. Additionally, restructuring work schedules with scheduled rest breaks is essential to reduce repetitive strain on the musculoskeletal system. The marking line stage, with a REBA score of 4 (moderate risk), can benefit from efficiency improvements through worker training on better techniques and precision tools. Meanwhile, fabric preparation and finishing stages, with low to very low risk levels, require no immediate action but can be periodically reviewed for further efficiency gains. This study also highlights opportunities for technology adoption in batik production, such as introducing simple automation tools to reduce the physical workload of repetitive tasks. A participatory design approach, involving workers in developing ergonomic solutions, is suggested to enhance acceptance of proposed interventions. Limitations of this study include the lack of physiological measurements, such as direct muscle strain or heart rate monitoring. Future research using technologies like electromyography or wearable devices can provide more objective data, resulting in more comprehensive recommendations. Overall, an ergonomic approach to improving worker health and productivity in batik production is critical. Well-designed interventions can enhance worker well-being while positively impacting the sustainability of the batik industry.

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