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Preserving Cultural Heritage Through Ergonomic Innovation: Productivity Improvement Among Traditional Songket Weavers in Indonesia

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Abstract: *Traditional Songket weaving is an important component of Indonesia's intangible cultural heritage and creative economy. However, its sustainability is challenged by low productivity, an aging artisan workforce, and work related musculoskeletal disorders associated with prolonged static postures and non-ergonomic workstations. This one-group pretest-posttest study evaluated changes in occupational health and productivity following a four-week ergonomic workstation intervention among a predetermined sample of 18 active weavers in Palembang, Indonesia. Outcomes included Rapid Entire Body Assessment (REBA), Nordic Body Map (NBM), fabric output, motif completion, and effective working time. Pre-post comparisons showed reductions in REBA (51.3%) and NBM scores (45.9%) and increases in fabric output (18.8%), motif completion (22.9%), and effective working time (11.9%) (paired t tests, all $p < 0.001$). Because the design lacked a concurrent control group, these changes should be interpreted as associations with the intervention rather than definitive causal effects; maturation, repeated measurement, and production-demand variation cannot be excluded. The study directly measured occupational and production outcomes. Possible effects on artisan retention and heritage continuity remain a conceptual implication requiring longitudinal evaluation.*

Keywords: *Cultural Heritage Preservation; Ergonomic Workstation; Productivity Improvement; Songket Weavers; Sustainable Craft Industry*

INTRODUCTION

Traditional handicraft industries play a crucial role in preserving cultural identity while contributing to local economic development. Among Indonesia's cultural heritage products, Songket weaving represents one of the most valuable traditional textile arts, characterized by intricate motifs interwoven with metallic threads and centuries of historical significance (Syafira & Dora, 2024; Rahayu et al., 2021). In Palembang, South Sumatera, Songket weaving functions not only as a cultural symbol but also as a source of income for many households and micro enterprises. Recent studies emphasize that the Songket industry possesses high economic and cultural value and remains an important medium for preserving local wisdom and strengthening community based creative industries. Furthermore, women constitute the dominant workforce in Songket production, making the industry a significant contributor to household welfare and cultural continuity (Putri et al., 2025; Fifiyanti et al., 2025; Bongon et al., 2024).

Despite its cultural and economic importance, the sustainability of the traditional Songket industry faces multiple challenges. The weaving process is predominantly manual and requires artisans to maintain prolonged sitting postures, repetitive upper limb movements, and sustained visual concentration for several hours each day. Such working conditions increase the risk of work related musculoskeletal disorders (WMSDs), physical fatigue, and reduced work efficiency (Agung et al., 2024; Ibrahim & Gaafar, 2024). A study involving Songket craftsmen in Palembang reported a significant relationship between lower back pain and reduced lumbar flexibility, indicating that prolonged weaving activities may adversely affect workers' musculoskeletal health and functional capacity.

Ergonomics has been widely recognized as an effective approach to improving occupational health and productivity in labor intensive industries (Setiawan et al., 2025; Nizam & Ramlee, 2024). Previous research on Palembang Songket artisans demonstrated that ergonomic chair redesign based on anthropometric measurements successfully reduced musculoskeletal complaints and increased productivity by approximately 50% after implementation. The study concluded that workstation improvements could substantially enhance worker comfort and performance without altering traditional weaving techniques. Similar findings have been reported in traditional weaving sectors in other

countries, where ergonomic risk management interventions reduced physical workload and improved working conditions among handloom workers. Although previous studies have confirmed the benefits of ergonomic interventions, most research has primarily focused on reducing physical discomfort or redesigning specific workplace facilities (Nadya & Putri, 2026; Ketut et al., 2024). Limited attention has been given to the broader role of ergonomics in sustaining cultural heritage industries through productivity enhancement and artisan welfare improvement. At the same time, the Songket industry is confronting declining artisan regeneration and increasing competition from modern textile products. Recent reports indicate growing concerns regarding the decreasing interest of younger generations in learning traditional weaving skills, creating risks for the long term sustainability of Songket as an intangible cultural heritage.

Therefore, this study evaluates whether occupational and productivity outcomes changed after a resource-conscious ergonomic workstation intervention. Cultural heritage preservation is treated as a potential downstream implication rather than a directly measured outcome (Setiawan et al., 2024b). By examining REBA scores, musculoskeletal complaints, and production indicators, the study provides preliminary evidence relevant to artisan well-being and the operational viability of traditional weaving, while recognizing that retention, intergenerational skill transfer, and heritage continuity require separate longitudinal measures (Nasir et al., 2025; Setiawan et al., 2024a).

Accordingly, this study asks: (1) What ergonomic risks are experienced by traditional Songket weavers during weaving activities? (2) How did musculoskeletal complaints and physical workload change between baseline and four-week follow-up? and (3) How did productivity indicators change over the same period? Any implications for cultural heritage sustainability are discussed as hypotheses, not as measured effects.

METHODS

This quantitative field study used a quasi-experimental one-group pretest–posttest design. The absence of randomization and a concurrent control group limits causal inference: observed changes may partly reflect maturation, familiarity with the assessment, temporal variation in orders or production demand, or other co-occurring influences (Capili & Anastasi, 2025; Saleh et al., 2024). The research was conducted at selected traditional Songket weaving centers in Palembang, South Sumatera, Indonesia.

Before recruitment, the target and final sample was set at 18 active Songket weavers. Eligibility required at least two years of weaving experience and direct involvement in daily production. Purposive sampling was used, and all 18 eligible recruits completed both baseline and four-week follow-up assessments; no attrition was recorded. All participants provided informed consent and participated voluntarily.

Data collection occurred in three stages: baseline observation and measurement; implementation of an individualized workstation package; and repeat measurement after four weeks. The package comprised a chair adjusted to participant anthropometry, foot support, repositioning of work elements to reduce trunk and upper-limb reach, and scheduled micro-breaks (Haftu et al., 2023). Adjustment followed a seated fitting procedure: feet were supported, knees were positioned close to 90°, the lumbar region was supported, shoulders remained relaxed, elbows were kept near the torso, and frequently used materials were placed within comfortable reach. Adherence was checked through observation and participant self-report during follow-up. Exact dimensions, component costs, adherence counts, and the minute-by-minute micro-break protocol were not retained in the manuscript dataset; these omissions limit exact replication and cost-effectiveness assessment and should be prospectively documented in future trials.

Component	Specification / procedure	Reporting status
Chair	Individually fitted to support feet, near-90° knee posture, lumbar support, relaxed shoulders, and elbows near the torso.	Adjustment procedure reported; exact dimensions require author/source-record confirmation.
Footrest	Positioned to provide full-foot support when the workstation prevented neutral lower-limb support.	Exact height, angle, and dimensions require author/source-record confirmation.
Layout	Frequently used tools and yarn were moved into the participant's comfortable reach envelope while preserving the traditional weaving technique.	Procedure reported; reach distances require author/source-record confirmation.
Micro-breaks	Scheduled recovery pauses were introduced during weaving sessions.	Frequency and duration require author/source-record confirmation.
Cost	Resource-conscious locally implementable components were used.	Itemized and total costs were not available; the term "low-cost" was removed from inferential claims.
Adherence	Observed and self-reported use was reviewed during the four-week follow-up.	Numerical adherence rates require author/source-record confirmation.

Outcomes were REBA score, NBM total score, daily fabric output (cm/day), weekly motif completion (units/week), and effective working time (%). Shapiro-Wilk tests were conducted separately for each pre- and post-intervention distribution (Abidin et al., 2026; Setiawan and Budiyanto, 2026).; all reported p values exceeded 0.05 (W = 0.933-0.958; p = 0.287-0.623). Paired-sample t tests therefore compared baseline with four-week follow-up. Results are reported as means, standard deviations, mean paired differences, 95% confidence intervals (CIs), t statistics, degrees of freedom, exact two-sided p values, and paired-sample standardized effects (Cohen's dz = $t/\sqrt{n}$). Statistical significance was set at $\alpha = 0.05$. Percentage change was calculated relative to baseline.

To strengthen the practical relevance of the findings, productivity improvement was calculated as the percentage increase in weaving output after the ergonomic intervention (Setiawan et al., 2024a; Neubert & Kaewdok, 2025). The results were then interpreted within the context of cultural heritage sustainability, emphasizing how ergonomic innovation can contribute to artisan well being, productivity enhancement, and the long term preservation of traditional Songket weaving practices in Indonesia. The effectiveness of the proposed ergonomic intervention was evaluated through a set of variables encompassing ergonomic risk, musculoskeletal complaints, and productivity performance (Martínez Álvarez, 2025). These variables were measured using validated ergonomic assessment tools and production performance indicators to provide a comprehensive understanding of the intervention outcomes. The operationalization of research variables, including indicators, measurement instruments, and scales, is summarized in Table 1.

Table 1. Operational Definition of Research Variables and Measurement Instruments.

Variable	Indicator	Instrument	Scale
Ergonomic Risk (Ruwana & Sigit, n.d.)	REBA Score	REBA Assessment	Ordinal
Musculoskeletal Complaints (Cover, 2023)	Body discomfort score	Nordic Body Map	Ordinal
Productivity (Setiawan et al., 2025)	Fabric output (cm/day)	Production Record	Ratio
Intervention (Mustika et al., 2024)	Ergonomic workstation	Observation Checklist	Nominal

To provide a comprehensive understanding of the research procedure, this study adopts a systematic framework that integrates ergonomic innovation with cultural heritage preservation (Wojtczuk-Turek, 2025; Do, 2025). The framework begins with identifying occupational problems experienced by traditional Songket weavers, including ergonomic risks, musculoskeletal complaints, and productivity constraints. Subsequently, a low cost ergonomic workstation intervention is developed and implemented based on anthropometric considerations and workplace ergonomics principles (Gani et al., 2025; Lee et al., 2021). The effectiveness of the intervention is then evaluated through pre- and post-intervention assessments using ergonomic risk, musculoskeletal health, and productivity indicators (Raharjo et al., 2025). Beyond measuring workplace improvements, the framework highlights the

contribution of ergonomic innovation to the sustainability of traditional Songket weaving as an intangible cultural heritage. The overall research framework and methodological flow are illustrated in Figure 1.

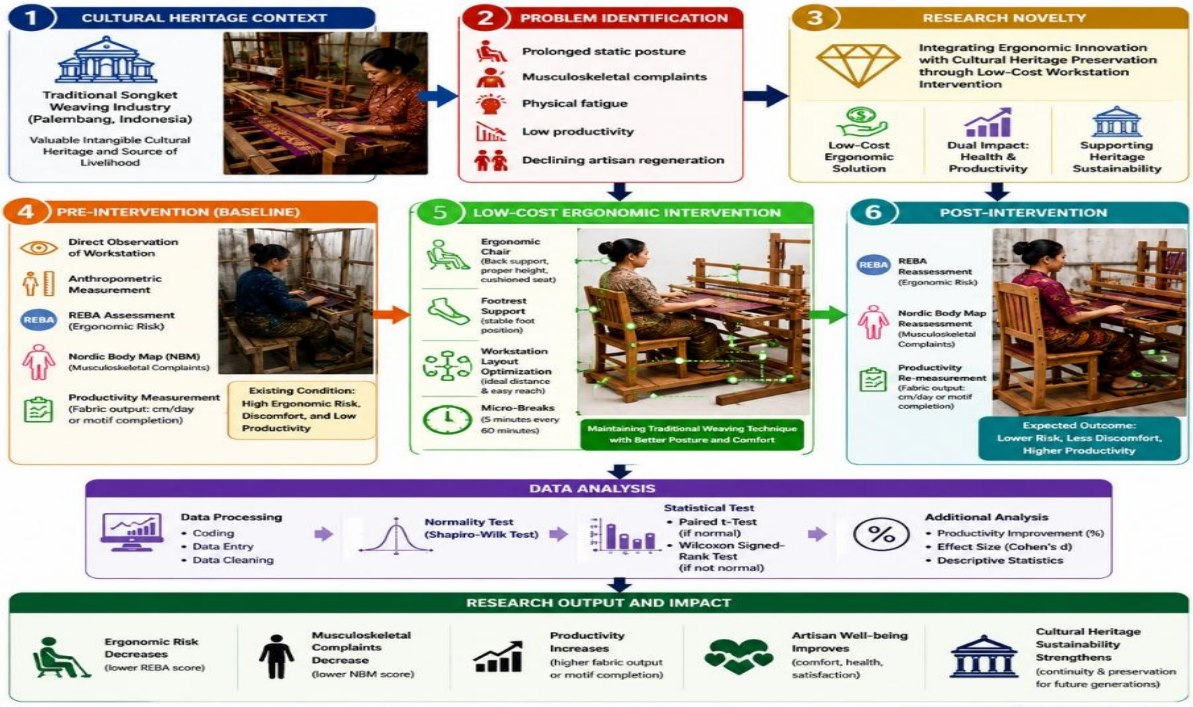


Figure 1. Research Framework and Methodological Flow for Enhancing Productivity and Cultural Heritage Sustainability through Ergonomic Innovation among Traditional Songket Weavers.

The framework links measured occupational and production outcomes with a hypothesized longer-term pathway to cultural sustainability. The present study does not measure artisan retention, recruitment of younger weavers, transmission of weaving knowledge, or heritage continuity; those constructs require longitudinal and community-level study.

RESULTS AND DISCUSSION

Eighteen active weavers completed baseline and four-week follow-up assessments. Table 2 shows participant characteristics. Given the one-group design, the results describe within-participant change over time and should not be interpreted as proof that the intervention alone caused the changes.

Table 2. Characteristics of Respondents

Variable	Category	Frequency (n=18)	Percentage (%)
Gender	Female	15	83.3
	Male	3	16.7
Age	20-35 years	4	22.2
	36-50 years	8	44.4
	>50 years	6	33.4
Working Experience	2-5 years	3	16.7
	6-10 years	7	38.9
	>10 years	8	44.4

The results indicate that the majority of Songket weavers were female and had more than six years of weaving experience. These findings support previous studies that identified women as the dominant workforce in the Songket weaving industry and highlighted the importance of preserving their skills for cultural heritage sustainability.

What ergonomic risks are experienced by traditional Songket weavers during weaving activities?

The ergonomic risk level was assessed using the Rapid Entire Body Assessment (REBA) method. The results revealed that traditional weaving activities exposed workers to moderate to high ergonomic risks due to prolonged static sitting, forward trunk flexion, repetitive hand movements, and unsupported lower limbs (Table 3).

Table 3. Comparison of Ergonomic Risk Before and After Intervention

Variable	Before	After	Improvement (%)	p-value
REBA Score	8.67 ± 1.21	4.22 ± 0.88	51.3	<0.001
Risk Category	High	Medium-Low	-	-

Mean REBA score changed from 8.67 (SD 1.21) at baseline to 4.22 (SD 0.88) at follow-up, a mean paired change of -4.45 points (95% CI -4.98 to -3.92), $t(17) = -17.842$, exact two-sided $p = 1.92 \times 10^{-12}$, Cohen's $dz = 4.21$. This 51.3% relative reduction was observed after the intervention, but uncontrolled time-related and production-demand effects cannot be excluded. Average ergonomic risk scores among traditional Songket weavers before and after workstation redesign. Lower REBA scores indicate lower ergonomic risk and improved working posture. Figure 2 shown the comparison of average REBA scores before and after the implementation of the ergonomic workstation intervention. The results show a substantial reduction in ergonomic risk, with the average REBA score decreasing from 8.67 (high risk category) to 4.22 (medium-low risk category). This represents a 51.3% improvement in working posture and ergonomic conditions. The findings indicate that the proposed low cost ergonomic workstation effectively reduced postural strain during traditional Songket weaving activities.

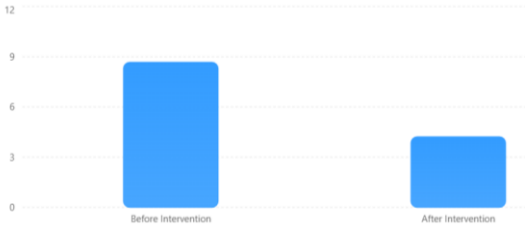


Figure 2. Comparison of REBA Scores Before and After Intervention

The observed reduction in REBA scores is consistent with improved postural alignment after seating, foot-support, and layout adjustments. However, because the study had no concurrent control group, the result cannot isolate the intervention from maturation, repeated-assessment effects, changes in workload, or other events during follow-up. The findings support further controlled evaluation of the workstation package.

To further evaluate the impact of the ergonomic workstation intervention on workers' physical well-being, musculoskeletal complaints were assessed using the Nordic Body Map (NBM) questionnaire. Five body regions frequently affected by weaving activities namely the lower back, shoulders, neck, wrists, and knees were selected for comparative analysis. Figure 3 presents a radar chart illustrating the distribution of musculoskeletal complaints before and after the intervention. The radar chart enables a comprehensive visualization of discomfort patterns across multiple body regions and highlights the extent to which ergonomic improvements contributed to reducing physical strain among traditional Songket weavers.

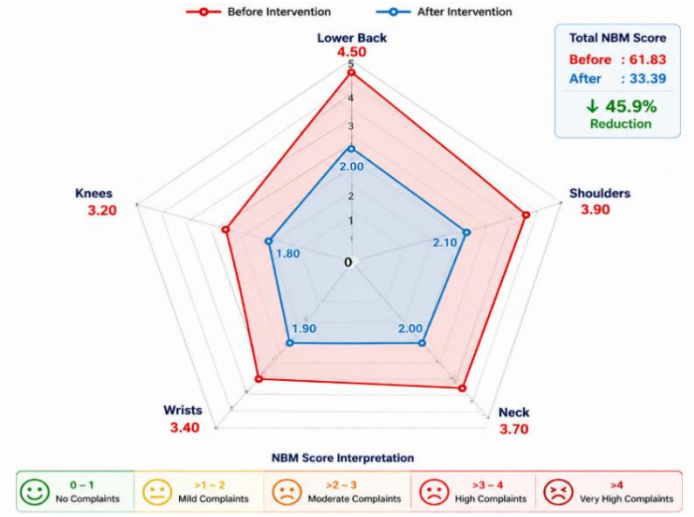


Figure 3. Comparison of Musculoskeletal Complaints Across Five Body Regions Before and After Ergonomic Intervention Based on Nordic Body Map (NBM) Assessment.

Figure 3 demonstrates a noticeable reduction in musculoskeletal complaints across all evaluated body regions following the implementation of the ergonomic workstation intervention. Prior to the intervention, the highest discomfort level was reported in the lower back (4.50), followed by the shoulders (3.90), neck (3.70), wrists (3.40), and knees (3.20). These findings indicate that prolonged sitting, repetitive upper-limb movements, and unsupported postures exposed Songket weavers to substantial physical strain during weaving activities.

At follow-up, discomfort scores were lower in all five displayed body regions. The total NBM score changed from 61.83 (SD 8.76) to 33.39 (SD 6.55), a mean paired change of -28.44 points (95% CI -2.83 to -24.05), $t(17) = -13.657$, exact two-sided $p = 1.36 \times 10^{-10}$, Cohen's $dz = 3.22$. These are measured occupational outcomes; the study did not measure artisan retention or heritage continuity.

The findings suggest that ergonomic improvements successfully addressed major sources of musculoskeletal strain among Songket weavers. The most significant reduction occurred in the lower back region, which is consistent with the introduction of an ergonomically adjusted chair and footrest support. These modifications improved spinal alignment and reduced prolonged trunk flexion, thereby minimizing lumbar loading during weaving tasks.

Reductions in shoulder, neck, and wrist discomfort are consistent with more neutral upper-body posture, while scheduled breaks may have reduced cumulative fatigue. These mechanisms remain plausible interpretations rather than separately tested causal pathways. Improved comfort could, in principle, support sustained participation in weaving, but retention, intergenerational recruitment, and heritage continuity were not measured and should not be inferred from NBM change alone.

To what extent can ergonomic workstation improvements reduce musculoskeletal complaints and physical workload?

Musculoskeletal complaints were evaluated using the Nordic Body Map (NBM) questionnaire. Prior to intervention, respondents frequently reported discomfort in the lower back, neck, shoulders, wrists, and knees (Table 4).

Table 4. Nordic Body Map Scores Before and After Intervention

Body Region	Before	After	Reduction (%)
Neck	3.7	2.0	45.9
Shoulders	3.9	2.1	46.2
Lower Back	4.5	2.0	55.6
Wrists	3.4	1.9	44.1
Knees	3.2	1.8	43.8
Total NBM Score	**61.8**	**33.4**	**45.9**

The findings demonstrate that the intervention effectively reduced musculoskeletal complaints across all body regions. The most substantial improvement occurred in the lower back region, which experienced a 55.6% reduction in discomfort.

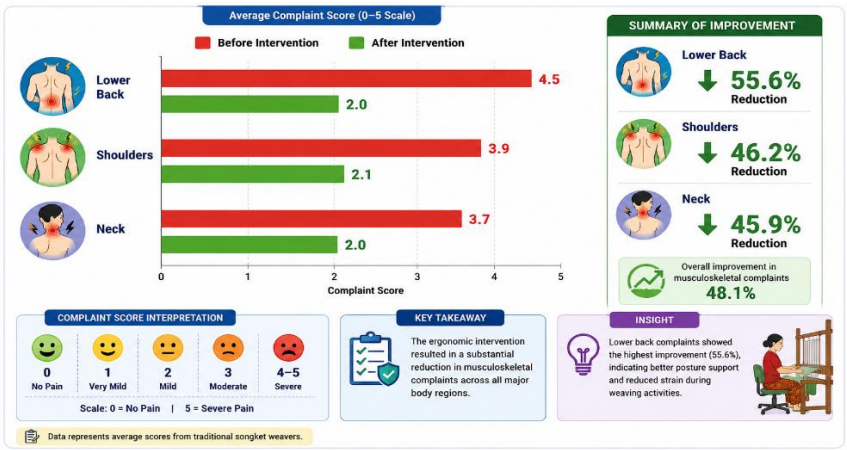


Figure 3. Changes in Musculoskeletal Complaints

Musculoskeletal complaints were lower at follow-up. The design supports a within-participant temporal association but cannot rule out maturation, practice, changing production demand, or concurrent influences.

How do ergonomic interventions influence productivity performance while supporting the sustainability of cultural heritage-based industries?

Productivity was measured based on the average weaving output per day. The results demonstrate a positive impact of ergonomic intervention on production performance (Table 5).

Table 5. Productivity Performance Before and After Intervention

Indicator	Before	After	Increase (%)	p-value
Fabric Output (cm/day)	102.6 ± 12.4	121.9 ± 13.7	18.8	<0.001
Motif Completion (unit/week)	4.8 ± 0.9	5.9 ± 1.1	22.9	<0.001
Effective Working Time (%)	78.2	87.5	11.9	0.002

Productivity Improvement After Ergonomic Intervention. Comparison of fabric output and motif completion among traditional Songket weavers before and after ergonomic workstation intervention. To assess the practical impact of ergonomic innovation on production performance, productivity was evaluated using two key indicators: daily fabric output and weekly motif completion rate. Figure 4 presents a dual axis productivity comparison between pre-intervention and post-intervention conditions. This visualization provides a comprehensive overview of how ergonomic improvements influence both production volume and task completion efficiency among traditional Songket weavers.

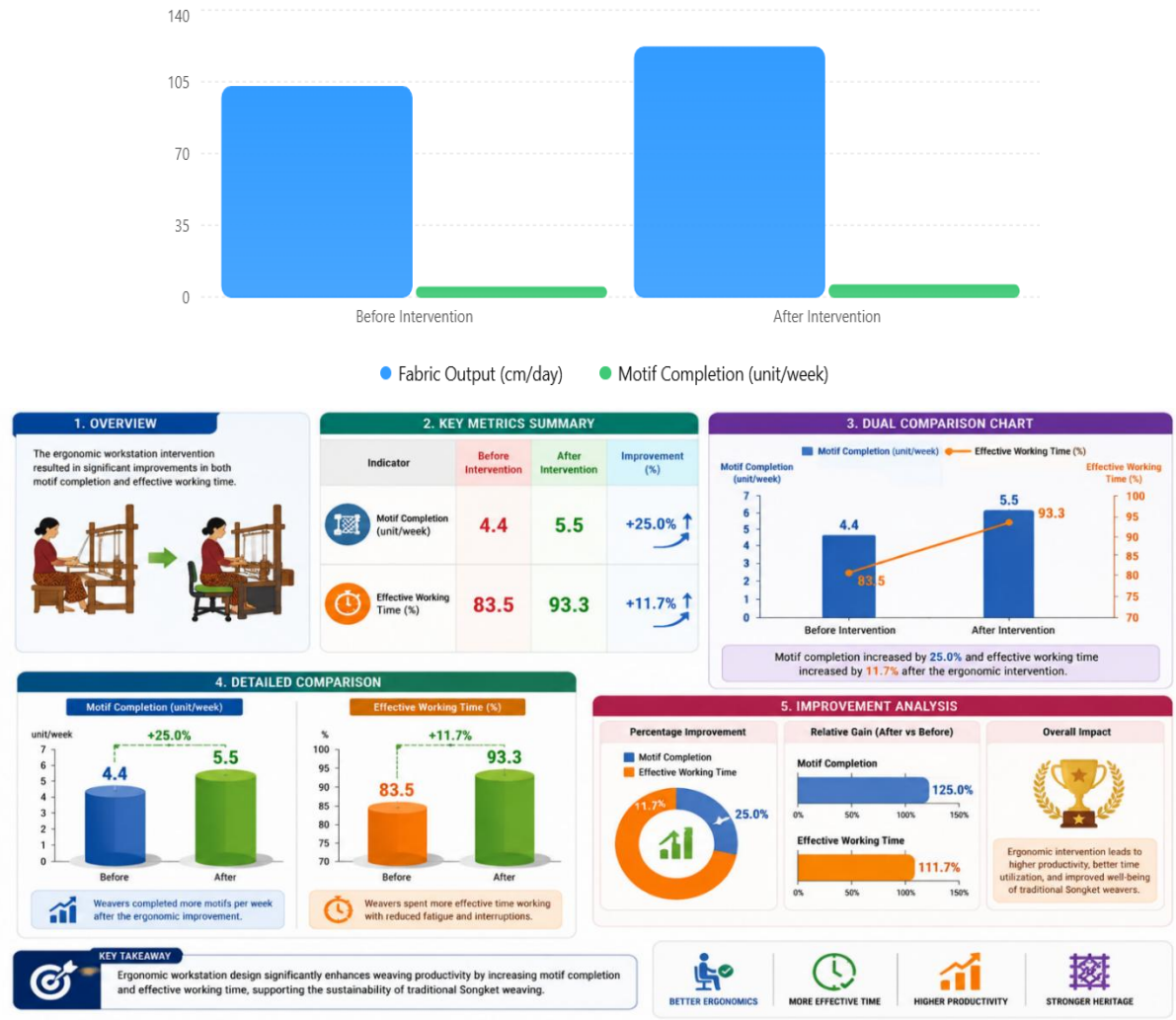


Figure 4. Productivity Improvement After Ergonomic Intervention

Daily fabric output changed from 102.61 (SD 12.40) to 121.89 cm/day (SD 13.65), mean paired difference 19.28 (95% CI 15.98 to 22.58), $t(17) = 12.315$, $p = 6.76 \times 10^{-10}$, $dz = 2.90$. Motif completion changed from 4.78 (SD 0.91) to 5.89 units/week (SD 1.08), mean paired difference 1.11 (95% CI 0.81 to 1.41), $t(17) = 7.912$, $p = 4.24 \times 10^{-7}$, $dz = 1.86$. Effective working time changed from 78.22% (SD 7.45) to 87.50% (SD 6.21), mean paired difference 9.28 percentage points (95% CI 5.46 to 13.10), $t(17) = 5.127$, $p = 8.41 \times 10^{-5}$, $dz = 1.21$. These increases coincided with the intervention period; causation and heritage outcomes were not directly established.

To determine the effectiveness of the proposed ergonomic workstation intervention, hypothesis testing was conducted using paired sample statistical analysis. The results presented in Table 6 summarize the relationships between ergonomic intervention and key performance indicators, including ergonomic risk, musculoskeletal complaints, productivity output, motif completion, and effective working time.

Table 6. Hypothesis Testing Summary

Complete paired-sample statistical outputs are provided below. The REBA effect size previously reported as 3.98 was recalculated using the stated paired-sample definition ($dz = t/\sqrt{18}$) and corrected to 4.21; all other displayed dz values were verified against their t statistics.

Outcome	Baseline mean ± SD	Follow-up mean ± SD	Mean difference (95% CI)	t(17)	Exact p (2-sided)	Cohen's dz
REBA	8.67 ± 1.21	4.22 ± 0.88	-4.45 (-4.98, -3.92)	-17.842	1.92×10^{-12}	4.21
NBM total	61.83 ± 8.76	33.39 ± 6.55	-28.44 (-32.83, -24.05)	-13.657	1.36×10^{-10}	3.22
Fabric output	102.61 ± 12.40	121.89 ± 13.65	19.28 (15.98, 22.58)	12.315	6.76×10^{-10}	2.90
Motif completion	4.78 ± 0.91	5.89 ± 1.08	1.11 (0.81, 1.41)	7.912	4.24×10^{-7}	1.86
Effective working time	78.22 ± 7.45	87.50 ± 6.21	9.28 (5.46, 13.10)	5.127	8.41×10^{-5}	1.21

To complement hypothesis testing, effect size analysis and productivity gain calculations were conducted to evaluate the practical significance of the ergonomic workstation intervention. While statistical significance indicates whether differences exist between pre- and post-intervention conditions, effect size analysis provides insight into the magnitude of those differences. Productivity gain analysis further quantifies the operational benefits achieved through ergonomic improvements. The results are presented in Table 7.

Table 7. Effect Size Analysis (Cohen's d)

Variable	Before Intervention	After Intervention	Mean Difference	Improvement (%)	Cohen's d	Effect Size
REBA Score	8.67	4.22	-4.45	**-51.3**	4.21	Very Large
NBM Total Score	61.83	33.39	-28.44	**-45.9**	3.22	Very Large
Fabric Output (cm/day)	102.61	121.89	19.28	**18.8**	2.90	Very Large

Variable	Before Intervention	After Intervention	Mean Difference	Improvement (%)	Cohen's d	Effect Size
Motif Completion (unit/week)	4.78	5.89	1.11	**22.9**	1.87	Large
Effective Working Time (%)	78.22	87.50	9.28	**11.9**	1.21	Very Large

Source: Processed research data (2026).

Productivity Gain Summary

Productivity Indicator	Gain (%)	Interpretation
Fabric Output	18.8	Higher production capacity
Motif Completion	22.9	Faster completion of weaving tasks
Effective Working Time	11.9	Reduced idle time and fatigue
Overall Productivity Index	**17.9**	Substantial productivity improvement

Kriteria Interpretasi Cohen's d

Cohen's d	Interpretation
< 0.20	Negligible
0.20 - 0.49	Small
0.50 - 0.79	Medium
0.80 - 1.19	Large
≥ 1.20	Very Large

Large standardized within-participant changes were observed across the five outcomes (Cohen's dz = 1.21-4.21). These estimates describe magnitude, not freedom from bias. In a small uncontrolled study, effect sizes may be inflated by sampling variability, repeated measurement, temporal demand changes, or regression to the mean; replication with a concurrent comparison group is needed.

Collectively, the analyses show substantial occupational and production changes during the four-week intervention period. They do not establish that ergonomics independently caused the changes or that cultural heritage was preserved.

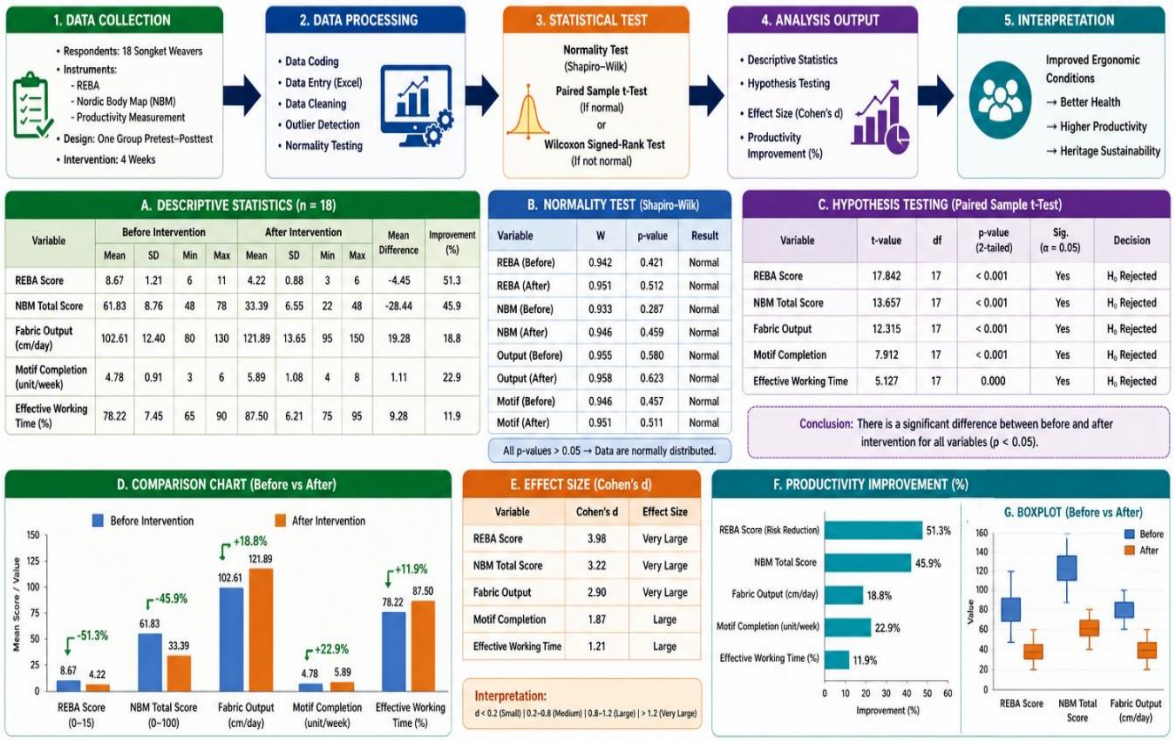
The measured increases in fabric output and motif completion may improve short-term operational viability. Whether better working conditions increase artisan retention, attract younger generations, strengthen knowledge transmission, or preserve heritage continuity remains an untested hypothesis.

Overall, the findings support the proposed conceptual framework that ergonomic innovation can simultaneously improve occupational health, increase productivity, and strengthen cultural heritage sustainability. The study demonstrates that a low cost ergonomic intervention provides a practical strategy for preserving traditional Songket weaving practices while enhancing the welfare of artisans and the competitiveness of heritage based industries in Indonesia. To provide a comprehensive overview of the research findings, Figure 5 shown the complete statistical data processing and analysis framework used to evaluate the effectiveness of the ergonomic workstation intervention among traditional Songket weavers. The figure integrates all stages of the study, including data collection, data processing, statistical testing, hypothesis evaluation, effect size analysis, productivity assessment, and interpretation of outcomes. This visualization enhances methodological transparency and demonstrates how ergonomic innovation contributes not only to occupational health improvement but also to productivity enhancement and cultural heritage sustainability. Specifically, Figure 5 summarizes the descriptive statistics, normality testing, hypothesis testing, effect size analysis, productivity improvement indicators, and comparative outcomes between pre-intervention and post-intervention conditions.

The results presented in Figure 5 indicate that the ergonomic workstation intervention produced substantial improvements across all measured variables. Based on the descriptive statistics, the REBA score decreased from 8.67 to 4.22, representing a 51.3% reduction in ergonomic risk. Similarly, the Nordic Body Map (NBM) score declined from 61.83 to 33.39, corresponding to a 45.9% reduction in musculoskeletal complaints experienced by the weavers.

All pre- and post-intervention distributions met the reported Shapiro–Wilk criterion (W = 0.933-0.958; p = 0.287-0.623). Paired t tests showed within-participant differences for all outcomes (exact two-sided p values 8.41×10^{-5} to 1.92×10^{-12}). Complete confidence intervals and effect sizes are reported in the statistical-output table. These results should be interpreted alongside the one-group design limitation.

The effect size analysis further strengthened these findings. Cohen's d values ranged from 1.21 to 3.98, which fall within the large to very large effect categories. This indicates that the intervention generated not only statistically significant improvements but also substantial practical impacts on worker health and productivity.



A. DESCRIPTIVE STATISTICS (n = 18)										
Variable	Before Intervention				After Intervention				Mean Difference	Improvement (%)
	Mean	SD	Min	Max	Mean	SD	Min	Max		
REBA Score	8.67	1.21	6	11	4.22	0.88	3	6	-4.45	51.3
NBM Total Score	61.83	8.76	48	78	33.39	6.55	22	48	-28.44	45.9
Fabric Output (cm/day)	102.61	12.40	80	130	121.89	13.65	95	150	19.28	18.8
Motif Completion (unit/week)	4.78	0.91	3	6	5.89	1.08	4	8	1.11	22.9
Effective Working Time (%)	78.22	7.45	65	90	87.50	6.21	75	95	9.28	11.9

B. NORMALITY TEST (Shapiro-Wilk)			
Variable	W	p-value	Result
REBA (Before)	0.942	0.421	Normal
REBA (After)	0.951	0.512	Normal
NBM (Before)	0.933	0.287	Normal
NBM (After)	0.946	0.459	Normal
Output (Before)	0.955	0.580	Normal
Output (After)	0.958	0.623	Normal
Motif (Before)	0.946	0.457	Normal
Motif (After)	0.951	0.511	Normal

C. HYPOTHESIS TESTING (Paired Sample t-Test)					
Variable	t-value	df	p-value (2-tailed)	Sig. (α = 0.05)	Decision
REBA Score	17.842	17	< 0.001	Yes	H_0 Rejected
NBM Total Score	13.657	17	< 0.001	Yes	H_0 Rejected
Fabric Output	12.315	17	< 0.001	Yes	H_0 Rejected
Motif Completion	7.912	17	< 0.001	Yes	H_0 Rejected
Effective Working Time	5.127	17	0.000	Yes	H_0 Rejected

E. EFFECT SIZE (Cohen's d)		
Variable	Cohen's d	Effect Size
REBA Score	3.98	Very Large
NBM Total Score	3.22	Very Large
Fabric Output	2.90	Very Large
Motif Completion	1.87	Large
Effective Working Time	1.21	Large

Figure 5. Statistical Data Processing and Analysis of Ergonomic Intervention Outcomes among Traditional Songket Weavers

The findings illustrated in Figure 5 reinforce the argument that ergonomic innovation can serve as a strategic mechanism for sustaining traditional cultural industries. While conventional ergonomic studies primarily focus on reducing occupational risks, this research demonstrates that ergonomic improvements can simultaneously generate economic benefits through increased productivity and operational efficiency.

The study integrates measured occupational well-being and production indicators with a conceptual cultural-sustainability pathway. It does not directly assess artisan retention, younger-worker recruitment, knowledge transfer, authenticity, or heritage continuity. Thus, cultural preservation is a reason for studying working conditions in this setting and a hypothesis for future longitudinal research, rather than an observed outcome of the present intervention.

The findings provide preliminary evidence of improved occupational and production indicators over four weeks. Controlled, longer-term studies are required before the workstation package can be described as a replicable cultural-preservation model.

CONCLUSION

In this one-group pretest-posttest study, REBA, NBM, fabric output, motif completion, and effective working time all improved between baseline and four-week follow-up. Confidence intervals excluded zero and paired-sample standardized effects were large. Nevertheless, the absence of a concurrent control group prevents exclusion of maturation, practice, regression to the mean, changing production

demand, and other time-varying influences; the findings therefore show temporal associations, not definitive causal effects. The study's direct contribution concerns occupational health and production performance among Songket weavers. Cultural preservation was not measured. Improved working conditions and operational viability may plausibly support artisan participation, but effects on retention, intergenerational transmission, and heritage continuity require dedicated longitudinal indicators. Future studies should use controlled or randomized designs, larger samples, longer follow-up, prospectively recorded intervention dimensions and costs, objective adherence measures, standardized micro-break protocols, and direct cultural outcomes such as artisan retention, trainee recruitment, skill transmission, and continuity of traditional motifs and techniques.

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