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Designing an Ergonomic Chair for Songket Weavers to Reduce Musculoskeletal Complaints Using Rapid Entire Body Assessment at Maisyarah Songket House

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ABSTRACT

UMKM Rumah Songket Maisyarah is one of the micro, small, and medium enterprises in the field of songket weaving. The process of making songket fabric still uses Alat Tenun Bukan Mesin (ATBM) with seating consisting of simple boards without cushions or backrests. The weavers for 8 hours a day in a sitting posture. Based on the results of the Nordic Body Map questionnaire distribution, it was found that the weavers complained of pain in the back, shoulders, waist, buttocks, thighs, and calves. If this is left untreated for a long time, it will result in weavers suffering from musculoskeletal disorders. The purpose of this research is to assess the work posture and propose an ergonomic seating arrangement for weavers to reduce the risk of musculoskeletal disorders. The method used in this research is Rapid Entire Body Assessment. The results of the posture assessment show that the weavers are at a high level of musculoskeletal risk. The researchers proposed the design of a songket weaving seat that aligns with the anthropometric data of the weavers, with a seat height of 47.1 cm, a seat depth of 48.65 cm, a seat length of 100 cm, a backrest height of 59.9 cm, a backrest length of 100 cm; and seat and backrest thickness of 4 cm. It is hoped that this proposal can reduce the risk of musculoskeletal disorders among songket weavers in Batu Bara.
Keyword: Anthropometry, Nordic Body Map, Rapid Entire Body Assessment, Songket Weavers

ABSTRAK

UMKM Rumah Songket Maisyarah merupakan salah satu usaha mikro kecil menengah di bidang pembuatan kain tenun songket. Proses pembuatan kain tenun songket masih menggunakan Alat Tenun Bukan Mesin (ATBM) dengan tempat duduk berupa papan sederhana tanpa alas duduk dan sandaran punggung. Pengrajin menenun selama 8 jam kerja per hari dengan postur tubuh duduk. Berdasarkan hasil penyebaran kuesioner *Nordic Body Map* diketahui pengrajin mengeluhkan sakit pada bagian punggung, bahu, pinggang, pantat, paha dan betis. Hal ini jika dibiarkan terjadi dalam waktu yang lama akan mengakibatkan pengrajin terkena *musculoskeletal disorders.* Tujuan penelitian ini adalah untuk menilai postur kerja dan mengusulkan tempat duduk pengrajin tenun yang ergonomis sehingga mengurangi resiko *muscoluskeletal*. Metode yang digunakan dalam penelitian ini adalah *Rapid Entire Body Assessment*. Hasil penilaian postur pengrajin tingkat level risiko *musculoskeletal* tinggi. Peneliti mengusulkan perancangan tempat duduk tenun songket yang sesuai dengan data antropometri pengrajin dengan dimensi tinggi tempat duduk 47,1 cm; kedalaman tempat duduk 48,65 cm; panjang tempat duduk 100 cm; tinggi sandaran punggung 59,9 cm; panjang sandaran punggung 100 cm; ketebalan alas duduk dan sandaran punggung 4 cm. Diharapkan usulan ini dapat mengurangi risiko *muscoluskeletal* pada pengrajin songket di Batu Bara.
Keyword: Antropometri, Nordic Body Map, Rapid Entire Body Assessment, Pengrajin songket

1. Introduction

Weaving is the process of interlacing the weft and warp threads [1]. The warp threads are the threads attached to the loom, while the weft threads are the threads interwoven with the warp threads, which, when combined, create patterns [2][3]. Weaving is a product that represents the culture of its community. The craft of songket woven fabric is one of the cultural heritages that holds high artistic value and has become a regional identity, including in Batu Bara Regency, North Sumatra.

Rumah Songket Maisyarah is a small and medium-sized enterprise (SME) engaged in the woven craft industry. Rumah Songket Maisyarah has been established since 2005, founded by Mrs. Maisyarah. Rumah Songket Maisyarah employs 10 female workers.

The manual weaving activity performed by songket weavers requires high concentration and skill and involves static working positions for extended periods. The production of songket fabric is still traditional, and the process of making a single piece of songket fabric takes a considerable amount of time, namely 2-3 weeks. Based on observations during their work, the weavers sit for 8 hours, with working hours from 08:00 to 17:00. Currently, the *Alat Tenun Bukan Mesin* (ATBM) facilities used are still very simple; the seats for the songket weavers consist only of boards without cushions, no backrests, and no footrests. Initial observations show that most of the weavers complain of pain, soreness, and discomfort in their backs, necks, shoulders, wrists and ankles.

Musculoskeletal complaints or Musculoskeletal Disorders (MSDs) have become one of the common occupational health risks in jobs with static and unnatural sitting positions [4][5][6][7]. Muscle soreness, pain, and tingling, especially in the lower back and neck. This indicates a potential ergonomic posture disturbance in the weaving work process [8][9][10].

One of the methods that can be used to assess ergonomic risks due to improper work posture is the Rapid Entire Body Assessment [11]. This method allows researchers to analyse work posture comprehensively and determine the level of injury risk to the musculoskeletal system [12][13][14]. Through the REBA assessment, information can be obtained that serves as a basis for designing ergonomic solutions, one of which is seating adjusted to the needs and work characteristics of weavers.

The design of ergonomic seating not only aims to improve comfort and work health but can also impact the increase in productivity and the quality of woven products. Therefore, this research is important to produce an ergonomic seat design for songket weavers in Batu Bara, to reduce musculoskeletal complaints and create a healthier and more sustainable work environment.

2. Method

This research was conducted at Rumah Songket Maisyarah located in Desa Padang Genting, Talawi District, Batu Bara Regency. The research subjects observed were all the songket weavers working at Rumah Songket Maisyarah.

The type of research used is quantitative descriptive research because it describes how the weaver's work posture during work activities. This study assesses work posture using methods such as REBA, and the evaluation results in a numerical score indicating the level of posture risk. Quantitative descriptive research is a type of research aimed at describing the characteristics or conditions of an event or phenomenon through quantitative data [15][16][17]. The steps taken in this research are as follows:

a. Distribution of the Nordic Body Map (NBM) questionnaire.

The Nordic Body Map (NBM) questionnaire is a tool used in ergonomics to assess musculoskeletal discomfort or pain among workers [18][19]. The NMB questionnaire was distributed to all weavers with the aim of identifying which body parts the weavers felt pain in when performing the weaving process.

b. Measurement of weavers' work posture.

After identifying which parts of the body are experiencing pain, the next step is to measure the weaver's work posture using the REBA method. The REBA method was chosen because it can assess body posture, especially the upper and lower parts [20].

c. Anthropometric calculations.

Anthropometry is a collection of numerical data related to the characteristics of the human body, size, shape and strength [21][22]. Anthropometric measurements are conducted using only the weavers' anthropometry to ensure that the proposed product matches the weavers' body dimensions.

d. Product Proposal Design

The research flow diagram is displayed in Figure 1 below:

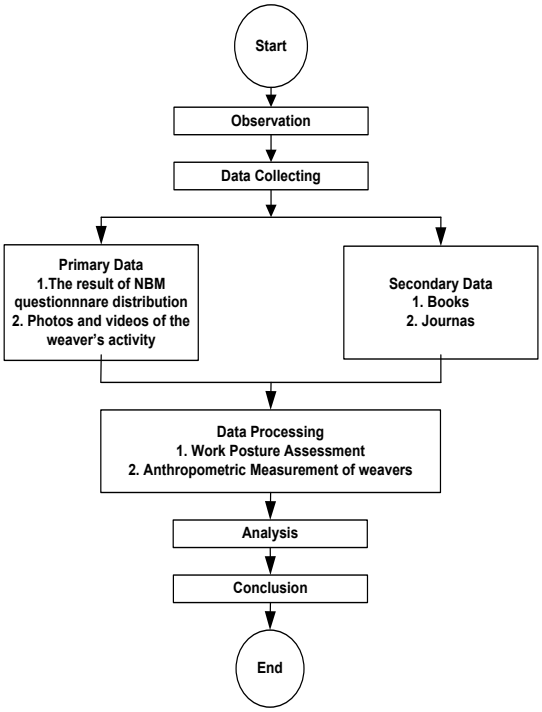

Figure 1. Research Flow Diagram

3. Result and Discussion

3.1. Weavers Data

This research was conducted at Rumah Songket Maisarah, which is one of the SMEs in the field of songket weaving, located in Batu Bara Regency. Working hours are from 08:00 to 17:00. This research involves all the weavers, totalling 10 women. Table 1 shows data from the weavers.

Table 1. Weavers Data

No	Name	Age	Work Experience
1	Linda	48	10
2	Yeni	45	8
3	Sriani	43	5
4	Lina	48	8
5	Diana	43	4
6	Maisyarah	50	15
7	Tina	46	7
8	Jamila	50	10
9	Tena	45	6
10	Sipon	50	10

3.2. Nordic Body Map (NBM) Questionnaire

The NBM questionnaire was distributed to 10 weavers to identify which body parts felt pain during the weaving process. The following Table 2 shows the results of the NBM questionnaire distribution. Grade of Complaint is A to D, in this context, A is not sick, B is somewhat sick, C is sick, and D is very sick.

Table 2. The results of the NBM Questionnaire Distribution

No	Location	Grade of Complaint			
		A	B	C	D
1	Pain in the Upper Neck			7	3
2	Pain in the Lower Neck		4	6	
3	Pain in the Left Shoulder		5	4	1
4	Pain in the Right Shoulder		6	3	1
5	Pain in the Left Upper Arm		2	7	1
6	Pain in the Back			1	9
7	Pain in Right Upper Arm		3	7	
8	Pain in the Buttock			2	8
9	Pain in the Buttom		1	2	7
10	Pain in the Left Elbow			3	7
11	Pain in the Right Elbow	2	2	6	
12	Pain in the Left Lower Arm	2	5	3	
13	Pain in the Right Lower Arm	1	3	6	
14	Pain in the Left Wrist	2	4	4	
15	Pain in the Right Wrist		3	7	
16	Pain in the Left Hand	2	5	3	
17	Pain in the Right Hand		1	7	2
18	Pain in the Left Thigh		3	6	1
19	Pain in the Right Thigh		1	4	5
20	Pain in the Left Knee		2	4	4
21	Pain in the Right Knee			6	4
22	Pain in the Left Calf			3	7
23	Pain in the Right Calf	3	2	5	
24	Pain in the Left Ankle	1	7	2	
25	Pain in the Right Ankle		4	6	
26	Pain in Left Foot		3	7	
27	Pain in Right Foot		1	6	3

In Table 2 above, we can see that the most common complaints of pain experienced by the weavers are in the neck, shoulders, arms, wrists, back, and buttocks.

3.3. Work Posture

Work Posture Using Rapid Entire Body Assessment (REBA). Posture assessment was conducted on 10 weavers, the posture assessment for 1 weaver will be detailed below, and for the other nine weavers, it can be seen in the recapitulation Table of posture assessment results. The calculation results of group A scores in Table 2 are as follows.

Table 3. REBA Scoring Results Group A Weavers 1

Group A Score	Movement	Score	Change Score
Trunk	90^0	4	1
Neck	40^0	2	0
Legs	82^0	3	2

Figure 2. Assessment of the weaver's 1 Work Posture

After each result has been obtained, the next step is to match each score to find the score for group B, as shown in Table 4.

Table 4. REBA Scoring Results Group B Weavers 1

Group B Score	Movement	Score	Change Score
Upper Arm	50^0	2	1
Lower Arm	44^0	2	0
Wrist	25^0	2	0

Following the assessment of the scoring for each body part and the weight of the object being lifted, it is necessary to also consider coupling and worker activity, as seen in Table 5.

Table 5. Load/Force, Coupling, *Activity* of Weavers 1

Score			
Load/Force	5 kg	2	1
Coupling	Not good	2	The roller handle is not suiTable and uncomforTable
Activity	Repetition	1	Repetitive action

Table 5 above shows the activity scores and the weight of the wood in the Rumah Songket Maisyarah. The scores reflect the load pulled by the artisans during the weaving process. This Table is used to calculate the C score, which is obtained from the sum of the A and B scores. After obtaining the C score, the result is added to the activity score to produce a total REBA score. Thus, to get the REBA C score, the results of group A are added to the results of group B. The results of the REBA score are shown in Table 6.

Table 6. REBA Score of Weavers 1

Score Group C	Use Group	Load/ Force	Coupling	Activity Score	Description
Group A	7	3			High risk level with action level 3, hence the need for immediate action.
Group B	3		2	1	
Group C	7				
REBA *Score*	7 + 1 (*Activity Score*) = 8				

Table 6 shows that the REBA score for Weaver 1 is 8, which means the work posture is highly risky. In the same way, the results of the work posture assessment for Weavers 1 to 10 are shown in the following Table.

Table 7. Recapitulation of REBA Score All Weavers

No	Name	REBA Score	Risk Level
1	Linda	8	High
2	Yeni	8	High
3	Sriani	8	High
4	Lina	8	High

No	Name	REBA Score	Risk Level
5	Diana	8	High
6	Maisyarah	8	High
7	Tina	8	High
8	Jamila	8	High
9	Tena	8	High
10	Sipon	8	High

The researcher suggests a work assist in the form of a chair with a backrest that will be customized to the weaver's anthropometry, as indicated by the REBA score.

3.4. Anthropometry Measurement

The initial stage in designing the proposed weaving chair is to identify the body dimensions that will serve as the reference for the measurement of the item. The current research used the following body dimensions: Sitting Shoulder Height (SSH), Popliteal Height (PH), Shoulder Width (SW), Hip Width (HW), and Buttock-Popliteal Distance (BPD). The Table 8 below presents a summary of the measured body dimensions.

Table 8. Summary of REBA Scores for All Weavers

Weavers	Measurement (in cm)				
	SSH	PH	SW	HW	BPD
Linda	60	43	57	52	55
Yeni	60	46	48	50	50
Sriani	63	47	45	46	52
Lina	62	45	50	48	54
Diana	66	48	47	51	50
Maisyarah	64	47	53	50	52
Tina	65	50	50	48	51
Jamila	65	45	45	47	55
Tena	67	48	46	52	50
Sipon	64	52	53	51	50

Further to conducting the anthropometric measurements, the next phase involves completing a data uniformity assessment on the six body dimensions. The outcomes of the data uniformity test, as summarized, are presented in Table 9.

Table 9. Uniformity Assessment on The Six Body Dimensions

No	Body Dimensions	Average	Std.D	UCL	LCL
1	Sitting Shoulder Height	63,6	2,23	68,07	59,12
2	Popliteal Height	47,1	2,46	52,02	42,18
3	Shoulder Width	49,4	3,77	56,94	41,86
4	Hip Width	49,5	2,01	57,04	45,48
5	Buttock-Popliteal Distance	51,9	1,97	55,84	47,95

The Table above shows that no data exceeds the established top and lower boundaries, signifying uniformity in the dataset. The next stage involves conducting a Data Sufficiency Test, the outcomes of which are presented in Table 10 below.

The researchers conducted percentile calculations, utilizing the 5th, 50th, and 95th percentiles. Utilizing these three percentiles, the researchers have confidence that the developed solution accommodates a variety of users, from the tiniest to the largest, as well as most others. This facilitates the development of a more inclusive and ergonomic product. From the data that has been obtained, the percentile calculation for each measured dimension can be performed as follows:

Table 10. Data Sufficiency Test

No	Body Dimensions	N'	N	Result
1	Sitting Shoulder Height	1,993	10	Sufficient
2	Popliteal Height	4,392	10	Sufficient
3	Shoulder Width	9,336	10	Sufficient
4	Hip Width	2,644	10	Sufficient
5	Buttock-Popliteal Distance	2,310	10	Sufficient

a. For p5 size = $\bar{X}$ – 1,645σ
Small percentile value, taken at the 5th percentile

b. For P50 size = $\bar{X}$
The 50th percentile value is equal to the average value.

c. For P95 size = $\bar{X}$ + 1.645σ
The highest percentile value, taken from the 95th percentile.

The calculation of the anthropometric dimension percentiles for the users of the seat for songket weavers is as follows:

Sitting Shoulder Height = $\bar{X}$ – 1.645σ
P5 = 59.93 cm
P50 = $\bar{X}$
= 63.6
P95 = $\bar{X}$ + 1.645σ
= 67.26 cm

The percentile estimations for the five utilized body dimensions are presented in the subsequent Table 11.

Table 11. The Percentile Estimations for The Five Utilized Body Dimensions

No	Body Dimensions	P5 (Cm)	P50 (Cm)	P95 (Cm)
1	Sitting Shoulder Height	59.93	63.6	67.26
2	Popliteal Height	43.05	47.1	51.14
3	Shoulder Width	43.19	49.4	55.60
4	Hip Width	46.19	49.5	52.80
5	Buttock-Popliteal Distance	48.65	51.9	55.14

The design dimensions of the seat are as follows; (a) The sitting shoulder height is used to determine the height of the backrest to be designed, which is P5 = 59.93 cm. (b) The popliteal height is used to determine the height of the seat to be designed, which is P5 = 47.1 cm. (c) The shoulder width is used to determine the length of the backrest to be designed. P95 = 55.60 cm. (d) Hip width is used to determine the length of the seat to be designed: P95 = 52.80 cm. (e) The popliteal buttock distance is used to determine the depth of the seat being designed. P5 = 48.65 cm

The results of the anthropometric measurements yielded a product design proposed by the researcher for the improvement of the songket weaver's chair, making the chair more ergonomic so that the working posture has changed and the workers no longer must bend excessively while weaving. The product size specifications to be designed according to the anthropometric calculations and the results of direct research surveys on the songket weavers at Rumah Songket Maisyarah can be seen in Table 12 and as follows

Table 12. Product Specification

No	Components	Size (cm)
1	Seat height	47.1 cm
2	Seat depth	48.65 cm
3	Length of the seat	100 cm

No	Components	Size (cm)
4	Backrest height	59.9 cm
5	Length of the backrest	100 cm
6	The thickness of the seat cushion and backrest	4 cm

A representation of the ergonomic chair that has been suggested is provided below.

Figure 3. Ergonomic Chair for Songket Weaver

The ergonomic design of the songket weaver's seat, following measurements adjusted to anthropometry, is expected to support the health and physical comfort of the weavers, allowing them to work more comfortably and reducing the risk of musculoskeletal disorders.

3.5. Comparison of Existing Weave Chairs with Proposed Weave Chairs

The comparison of the actual weaving chair with the proposed chair can be seen in Table 13 as follows.

Table 13. Comparison of Existing Weave Chairs with Proposed Weave Chairs

No	Existing Weave Chairs	Proposed Weave Chairs
1.	the chair only uses a board without a seat cushion	The seating area is covered with sponge and carpet, aiming to provide comfort and reduce pain in the body parts from the buttocks to the toes of the weavers during weaving.
2.	There is no chair backrest.	The addition of a backrest to the weaver's chair, with a height of 59.9 cm and a length of 100 cm, on the front part of the backrest covered with sponge and carpet, aims to reduce pain in the hips and lower back of the weavers while weaving.
3.	There is no lock on the backrest.	Having a lock on the backrest that functions to lock the backrest so it can move forward and backward, this is adjusted according to the weaver's chair.
4.	There is no footrest.	There is a footrest so that the weaver's feet are comforTable while weaving.

4. Conclusion

The assessment of work posture utilizing REBA on 10 weavers yielded a score of 8, indicating a high risk of musculoskeletal disorders. To mitigate this, the researcher endeavoured to redesign the weaver's chair with dimensions tailored to the weaver's anthropometry. The seat height measures 47.1 cm, seat depth 48.65 cm, seat length 100 cm, backrest height 59.93 cm, backrest width 100 cm, and the thickness of both the seat and backrest cushions is 4 cm.

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