REDESIGN WORK CHAIR WEAVER USING ERGONOMICS APPROACH IN SMALL MEDIUM ENTERPRISES OF WEAVING UKM XYZ TROSO JEPARA

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Abstract

Industries of Troso weaving Jepara mostly use a handloom hand or *alat tenun bukan mesin (ATBM)* and their weavers use a work chair while weaving. Their working posture is so poor due to non ergonomic of work chair. It will cause fatigue and musculoskeletal disorder in years ahead as accumulation of their pain. Based on that the aim of this research is to redesign work chair for the weavers in one of Small and Medium Enterprises (UKM) XZY Troso that has 30 weavers as a respondense. The ergonomic approach use Nordic Body Map (NBM) Questionnaire to identify musculoskeletal discomfort of 30 weavers were found 3 pain in the left upper arm, 21 pain in the back, 18 pain in the waist, 9 pain in the buttock, 6 pain in the left calf and 6 in the right calf, 6 pain in the left ankle and 6 in the right ankle, 6 pain in the left foot and 6 in the right foot. To determine anthropometric dimensions of 30 weavers were measured by anthropomethry method and analyzed using statistic steps by calculating mean, standard deviation. An anthropometric calculation 5th, 50th and 95th percentiles used to specify dimensions work chair proposed. This research has generated new dimensions of work chair the seat height is 58 cm, the width is 44 cm, the depth is 35 cm, the height is 117 cm and new design of work chair has additional features like a drawer under the seat and back rest at the back.

Keywords*: weaving; work chair; NBM; anthropometry; redesign;*

INTRODUCTION

Industries of Troso weaving Jepara as the one craft of industries use a handloom hand or *alat tenun bukan mesin* (*ATBM*) to finish their woven fabric and have been supported in economic contribution for such along time period [1]. Troso weaving industries can be catagorized as Small Medium Enterprises due to their employees still in the range between 5-30 workers as call as weavers. The involvement of human being in this industries is still prominently especially in production process of weaving and the weavers hold as the main play role to run this process. The weavers still use manual handloom, not an ergonomic work chair and manual tools also. With 8 hours working period in sitting position during the process of weaving activities will cause fatigue, pain in the back and disorder spine. The sitting position is to be less comfortable [2]. The increasing of musculoskeletal disorders (MSDs) predominance related in the weaving industry [3] in certain countries. 85% of Sarong Samarinda weavers in Indonesia experienced MSDs prevalence has been reported lately [4], with the rating of incidence 15.0% low, 7.5% moderate, and 77.5% high [4]. Skeletal muscle pain was mainly found in the lower neck, shoulders, upper hands, bottom, waist, thighs, calves and ankles[4]. Repetitive work, static work postures, long working period, wrong awkward work and work positions are commonly experienced by the weavers [4] [5] [6].

UKM XYZ Troso one of the weaving industries use handloom equipment and wood work chair to produce their woven fabric and has 30 weavers. The work chair for weaving at preliminary observation in UKM XYZ Troso can be found that work chair of weaver without back rest while weaving in 8 hours period, uneven seater surface, hard pad seater and poor sitting position and cause poor work posture. Another fact is the weaver in work system have to stand up from the work chair and leave the workplace by walking between 1-2,5 meter to get some tools such as measuring tool, paraffin and the woof *(pakan)* to support the weaving process.

LITERATURE REVIEW

In this section describes literatures review related with the research of work chair in weaving industries use anthropomethry method :

1. Poor working posture has found in Samarinda Sarong female weavers caused by non ergonomic handloom design [4]. Redesign proposed has generated by modify the dimension of the traditional handloom refers to

anthropometric data of female weavers which significantly different from previous traditional handloom.

2. According to [7] in their research ergonomic assestmen with REBA found out ergonomic risk factors for weaver in weaving process from coloring yarn, spinning yarn, winding yarn, twisting yarn and milling yarn process. There is no information for ergonomic assestment in sitting position of weaver while weaving the yarn in this article.
3. Another research redesign ergonomic work chair for weaver found in UKM Tenun Ikat Medali Mas [8]. The dimension work chair prototype that has been developed are the height of the work chair 95 cm and seat cushion 52 cm measured from floor, width of the seat base 39 cm, width of the backrest 35 cm, back length 31 cm, back height 49 cm. This work chair prototype only redesign for the dimension size without adding some features.
4. Prevention of fatigue research in snack industry Small and Medium Enterprises (UKM) Lestari Jaya [9] a producen of cracker with cassava based redesign work chair for employee who sitting to make dough. The previous work chair is not ergonomic, discomfort due to not fit with the employee body's and cause pain after work.

METHODOLOGY

The method use ergonomic approach like Nordic Body Map (NBM) questionnaire, anthropometry and descriptive statistic. A preliminary observation was conducted to find out picture of previous work chair weaver, sitting position of weaver, lay out of work station to analyze the woof and paraffin location, the dimensions body of the weaver for collecting the anthropometric data then will be proceed using data normality test; statistic analysed by calculating mean, standard deviation, upper control limit and lower control limits; anthropometric calculation of precentiles.

a. Picture for previous work chair of weaver, sitting position of weaver
b. Data Normality test. This test aim to determine whether the antropometric data follows a normal distribution. In this test use spss version 16.

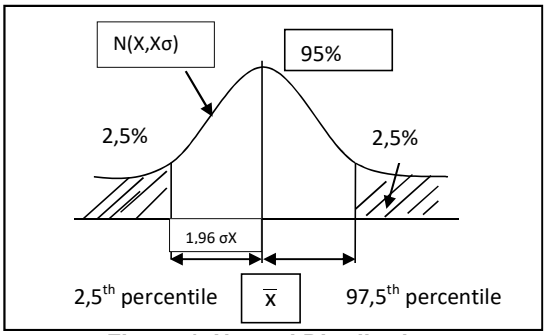


Figure 1. Normal Distribution

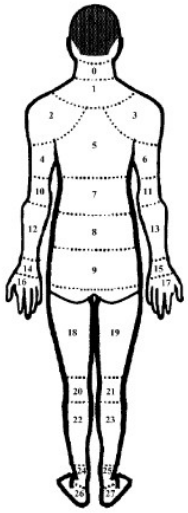
Hipotesis Test

H0 : Normal distribution data

H1 : Not normal distribution data

1) Statistik Test : Test of Kolmogorof-Smirnov
2) α= 0,05
3) Critical Area : H0 rejected if Sig. < α

c. Controlled state test
d. Descriptive statistics which are calculating mean, standard deviation, upper contol limit, lower control limit
e. The ergonomic approach uses Nordic Body Map Questionnaire that distributed to weaver as responden for identify musculoskeletal discomfort of weavers and antrhopometry method by calculating the precentiles to determine the latest dimensions to redesign work chair weavers.



No	Location	Grade of complaints			
0	Pain/stiff in the upper neck	A	B	C	D
1	Pain in the lower neck				
2	Pain in the left shoulder				
3	Pain in the right shoulder				
4	Pain in the left upper arm				
5	Pain in the back				
6	Pain in the right upper arm				
7	Pain in the waist				
8	Pain in the buttock				
9	Pain in the bottom				
10	Pain in the left elbow				
11	Pain in the right elbow				
12	Pain in the left lower arm				
13	Pain in the right lower arm				
14	Pain in the left wrist				
15	Pain in the right wrist				
16	Pain in the left hand				
17	Pain in the right hand				
18	Pain in the left thigh				
19	Pain in the right thigh				
20	Pain in the left knee				
21	Pain in the right knee				
22	Pain in the left calf				
23	Pain in the right calf				
24	Pain in the left ankle				
25	Pain in the right ankle				
26	Pain in the left foot				
27	Pain in the right foot				

Figure 2. A Modified Nordic Body Map Questionnaire [10]

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RESULT AND DISCUSSION

a. **Data Collecting**

The data has collected after preliminary observation in this research include the pictures of previous work chair that has been using for weaving. From the pictures there are some note can be informed which are the previous work chair does without back rest and without drawer under the seat as showed as below figure 3 and figure 4.
<one space>

Figure 3. Previous Work Chair of Weaver Without Back Rest and Drawer

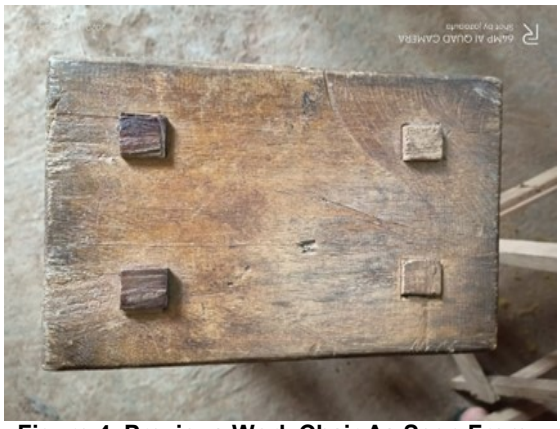

Figure 4. Previous Work Chair As Seen From Above

From the picture as shown in figure 4 can be informed that the seat of the work chair was too small to cover the average of the buttock dimension of the weaver, looked not comfort because hard pad seater and the surface of the seat was uneven seat surface.

Figure 5. Sitting Position of Weaver

In the initial observation, it was found that the working position in weaving looked uncomfortable for weavers to sit for long periods of time and the chair used without a backrest. This will create a fatigue that the accumulation of it causes pain and can trigger long-term musculoskeletal disorders (MSDs). To strengthen this suspicion, a test was carried out using the Nordic Body Map (NBM) method by distributing questionnaires to the weavers (weavers). The results of the questionnaire can be seen in the following table:

TABLE 1. Result NBM Questionnaire of Weaver

NO	LOCATION	Grade of Pain			
		NP	MP	P	PF
0	Pain/stiff in the upper neck	12	12	6	0
1	Pain in the lower neck	12	6	12	0
2	Pain in the left shoulder	9	6	15	0
3	Pain in the right shoulder	9	6	15	0
4	Pain in the left upper arm	21	3	3	3
5	Pain in the back	6	0	3	21

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NO	LOCATION	Grade of Pain			
		NP	MP	P	PF
6	Pain in the right upper arm	21	6	3	0
7	Pain in the waist	9	0	3	18
8	Pain in the buttock	18	0	3	9
9	Pain in the bottom	27	0	3	0
10	Pain in the left elbow	24	0	6	0
11	Pain in right elbow	18	9	3	0
12	Pain in the left lower arm	27	3	0	0
13	Pain in the arm lower arm	24	6	0	0
14	Pain in the left wrist	27	3	0	0
15	Pain in the right wrist	18	6	6	0
16	Pain in the left hand	15	0	15	0
17	Pain in the right hand	18	0	12	0
18	Pain in the left thigh	9	9	12	0
19	Pain in the right thigh	15	12	3	0
20	Pain in the left knee	15	6	9	0
21	Pain in the right knee	18	3	9	0
22	Pain in the left calf	21	0	3	6
23	Pain in the right calf	9	12	3	6
24	Pain in the left ankle	12	9	3	6
25	Pain in the right ankle	12	6	6	6
26	Pain in the left foot	12	0	12	6
27	Pain in the right foot	12	0	12	6

Note:
NP = No Pain
MP = Moderate Pain
P = Pain
PF = Painfull

Other information obtained during the initial observation was that weavers had to take *pakan* and paraffin by standing up from the work chair which was located behind the work chair for weaving. The movements are taking the *pakan* (thread), taking the barrier (measuring instrument), taking the paraffin. Good movements must be able to adapt to the workplace which aims to make it easier for weavers to make movements and the time used is shorter. Here is a sketch layout work station of the initial workplace.

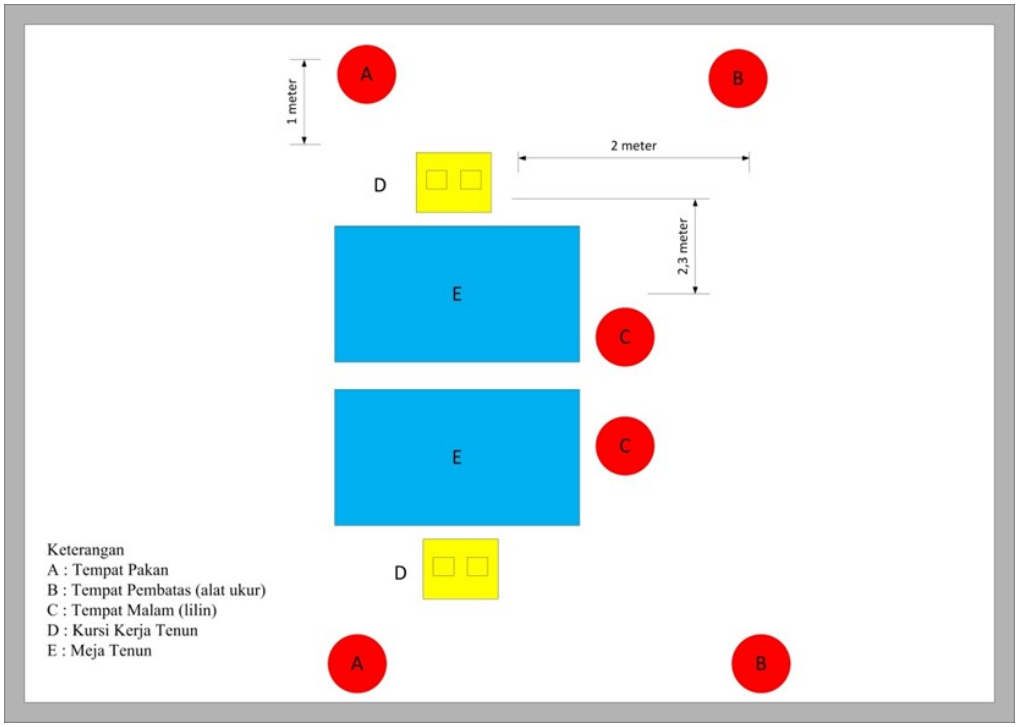

Figure 6. Previous Lay Out before improvement of work chair

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The picture in Figure 6 show the current lay out of workplace for weaving process before improvement. From this picture can be found that the weaver has to get the woof (pakan) by walking around 1 meter, walking 2,3 meter to get paraffin and walking around 2 meter to get measuring tool. This analysis can be used to add the drawer feature of work chair to reduce motion and movement.

The next step is redesigning work chairs for weavers using the Anthropometric method. The anthropometric data that will be used to redesign the weaving work chairs are presented in Table 2. Then the body dimensions of the weaving workers are measured based on the anthropometric data that will be used to design the weaving work chairs.

Tabel 2. Antrhopometries Data [11]

No	Data Antropometri	Keterangan
1	Popliteal Length	The horizontal distance from the back of the buttocks (hip) to the back of the right knee
2	Popliteal Height	The vertical distance from the floor to the popliteal corner which is located under the thigh, right behind the knee of the right leg.
3	Thight Width	The horizontal distance between the outside of the left hip and the outside of the right hip
4	Sitting shoulder height	The vertical distance from the seat cushion to the top of the right shoulder.
5	Shoulder Width	The horizontal distance between the right shoulder and the left shoulder

Tabel 3. Recapitulation of Statistic Test (mm)

Description	X	STD	UCL	LCL
Popliteal Length	414,7	391	533	397,4
Popliteal Height	577,7	163	626,7	528,7
Thight Width	383	317	479	288
Sitting Shoulder Height	586	309	678,8	493,2
Shoulder Width	399	223,3	466	332

After the anthropometric data have been collected, a data normality test is performed. The results of the data normality test are as follows:

One-Sample Kolmogorov-Smirnov Test

		Panjang_ Popliteal	Tinggi_ Popliteal	Lebar_ Pinggul	Tinggi_Bahu_ Duduk	Lebar_Bahu
N		30	30	30	30	30
Normal Parameters[a]	Mean	41.47	57.77	38.33	58.60	39.90
	Std. Deviation	3.910	1.633	3.177	3.092	2.234
Most Extreme Differences	Absolute	.153	.147	.150	.156	.136
	Positive	.146	.147	.150	.149	.136
	Negative	-.153	-.090	-.098	-.156	-.097
Kolmogorov-Smirnov Z		.835	.807	.823	.857	.744
Asymp. Sig. (2-tailed)		.488	.533	.508	.455	.637

a. Test distribution is Normal.

Figure 7. The Result of Normality Test

From the measurement of the normality test for the anthropometric data above, it shows that the popliteal length of Kolmogorov-Smirnov test is 0.488, popliteal height is 0.533, hip width is 0.508, sitting shoulder height is 0.455, shoulder width is 0.637. From the processing of the anthropometric data normality test, it is considered normally distributed because it is more than 0.05

b. Designing Work Chair of Weaver

The design of tools or facilities in industries used the concept of range estimation instead of average concept. The range estimation concept is commonly as percentile values. Percentage value which are often used are the 5th percentile (smaller percentile) and percentile 95th (large percentile) [12]. After the percentile calculation is done, it is then used for the size of the work chair design. The percentage values can be seen in the table below:

Table 4. Result of Precentiles Calculation

No	Pengukuran	Persentil (mm)		
		5	50	95
1	Popliteal Length	350	410	480
2	Popliteal Height	550	580	600
3	Tight Width	330	380	440
4	Sitting Shoulder Height	530	590	640
5	Shoulder Width	360	400	430

The latest percentiles will be used to redesign new version Work Chair of Weaver as seen below:

1. Popliteal Length persentil 5 is 35 cm, this dimension will be used as the depth of Work Chair to make the weaver more easier while stepped on handloom. This popliteal length is used as the length of the weaving work chair base. Percentile 5 was chosen to make it easier for weaver's feet to step on the weaving table.
2. Percentile Popliteal 50 Height is 58 cm. This popliteal height dimension will be used for the height of the weaving work chair. Percentile 50 was chosen so that weaver with short or tall stature can sit comfortably.
3. Percentile 95 Tight Width is 44 cm. This hip width dimension will be used for the seat width of the weaving work chair. Percentile 95 was chosen so that weaver who have a fat body posture will feel comfortable using it and for body postures other than fat they can move freely to the right or left when stepping on the weaving table footing.
4. Sitting Shoulder Height percentile 50 is 59 cm. This sitting shoulder height dimension will be used for the back height of the weaving work chair. Percentile 50 was chosen so that weaver with short or tall stature can lean comfortably.
5. Shoulder Width percentile 50 is 40 cm. The shoulder width dimension will be used for the width of the back of the weaving work chair. Percentile 50 was chosen so that people with short, medium or long shoulder widths can lean comfortably. The length of the backrest from the back is 7 cm with the aim that when the weaver leans back with the foot position on the woven tread and the hand lays the thread, the weaver's posture can remain upright and lean back comfortably. Because the average weaver when stepping on the popliteal woven table that is not attached to the seat cushion is 7 cm.

After selecting the percentile for the size of the weaving work chair, then carrying out the design of the weaving work chair. The new size of the weaving work chair can be seen in the table below:

Tabel 5. New Dimension Redesign Work Chair of Weaver

No	Dimension Work Chair	Size (mm)	Used As (cm)
1	Poplitheal Length	350	Depth 35 cm
2	Poplitheal Height	580	
3	Thight Width	440	Width 44 cm
4	Sitting Shoulder Height	590	
Poplitheal Height combined with Sitting Shoulder Height turn into The Total Height of Work Chair		1170 (58 + 59)	Height 117 cm

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No	Dimension Work Chair	Size (mm)	Used As (cm)
5	Shoulder Width	400	Width for Additional Back Rest

Based on table 5 the next step is redesigning the design of the weaving work chair. The design of a weaving work chair can be seen in the image below :

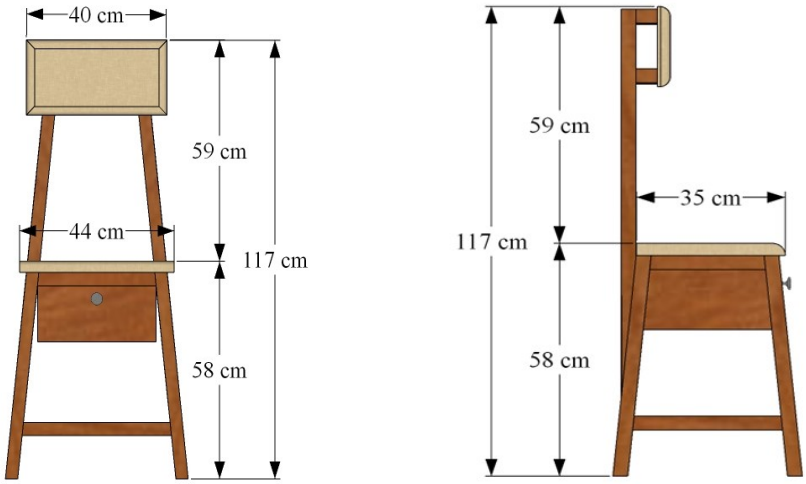

Figure 8. Redesign Work Chair Of Weaver Proposed
A. Seen From Front **B. Seen From Side**

The drawing that shown in Figure 8 is new design and dimension for work chair of weaver based on table 5. From this drawing can be seen the work chair of weaver significantly different from previous work chair. One feature drawer has been added in this redesign. The function of the additional drawer is to put the woof, paraffin and measuring tool to reduce motion and walking movement of weaver.

CONCLUSION

This research used ergonomic approach which are Nordic Body Map to find out musculoskeletal discomfort of weaver like pain in the left upper arm, pain in the back, pain in the waist, pain in the buttock, pain in the left calf, pain in the right calf, pain in the left ankle, pain in the right ankle, pain in the left foot, pain in the right foot and based this information using anthropometry method can be used to redesign the work chair of weaver proposed with new design using back rest and additional drawer feature to replace an old work chair for weaving

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