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The Intervention of Chair and 'Gawangan' Among Batik Workers at a Company in Indonesia

Fandita Tonyka Maharani[1*], L. Meily Kurniawidjaja[2], Indri Hapsari[2], Hendra[2]

[1]*Public Health Department, Universitas Pembangunan Nasional Veteran Jakarta, Depok, Indonesia*

[2] *Occupational Health and Safety Department, University of Indonesia, Depok, Indonesia*

[*]*Corresponding author. Email: fanditatonykamaharani@gmail.com*

ABSTRACT

Background: UNESCO has recognised batik Indonesia as Intangible Cultural Heritage of Humanity since 2009. Batik is a widespread industry and employed many workers. The previous study in a company found that chemical and ergonomic are the highest hazards, which include work for 6-8 hours/day in an awkward position and complaint about the weariness. The purpose of this study was to develop the prototypes according to the workers' anthropometry data and to test them. **Methods**: The study was conducted by observation, interview, and anthropometry measurement. **Results**: It stated that the prototypes decrease the ergonomic risks on the back, wrist/hand, and the neck without considering the MSDs complaints. **Conclusion**: The proposed batik workers' workstation involving chair and 'gawangan' decrease the occupational health risk faced by the workers

Keywords*: ergonomic, intervention, batik, workers*

1. INTRODUCTION

The United Nations Educational, Scientific, and Cultural Organization (UNESCO) has considered batik as an Intangible Cultural Heritage of Humanity since 2009. Batik is a part of Indonesian culture and could not be separated with the nation's life philosophy. It stated that there are 50.000 batik industries across Indonesia which grows every year and employ approximately 100.000 batik workers [1]

The previous study in the same company found that the highest hazards are chemical and ergonomic [2]. The study also found that the workers work for 6-8 hours a day and complained about the weariness. Similarly, study at a batik company in Indonesia found that the workers complained about the ache at the bottom, right knee, and left leg (50 %), the ache at the upper neck, hip, left arm, and left knee (60 %), the ache at down neck, back, and bottom (70 %) [3]. Other studies found the ergonomic hazards among batik workers and recommend to redesign the batik workers' work station [4] [5] [6] [7].

The first process to produce batik is to cut the fabric according to the needs. The fabric then will be put in 'gawangan'. The workers sits in non-ergonomical chair in front of the clothes.

'Gawangan' is a traditional name to call a special place to put the clothes. 'Gawangan' or frames are the equipments used to hold the fabric therefore the craftsmen can work on the fabric easily. Generally, 'gawangan' is made from bamboo. The craftsmen sit 6-8 hours a day patiently. The artists bend their bodies to the 'gawangan'.

Batik workers work within a static posture which can affect the shoulder, arm, back, foot, knee, thigh, and wrist. Previous study in the company found that 25 batik workers complained about the weariness, especially at the arm, back, and foot [2]. It stated that awkward positions and repetitive work processes can lead to muscle fatigue and cause Musculoskeletal Disorders (MSDs) [8]. MSDs is a conditions that affect tendons, muscles, the nerves, and supporting structures, such as the disc in the back. They work harder than they are designed in some situations, leading to the different conditions [9].

The batik company is located in Surakarta, Indonesia. The previous study found that the ergonomic aspect of batik making processes are inadequate, especially in terms of the work station and equipment. Ergonomic is a study to align the workers to their job. The adequate tasks, work station, and the equipment can decrease the pressure to the workers' body and can prevent MSDs [10]. The ergonomic intervention must be conducted to decrease the health and safety effect. This study aims to redesign the chair and 'gawangan', make the prototype, and test them to the workers.

2. METHODS

Direct observation, interview, and anthropometry measurement was conducted in this study. The anthropometry measurement was used to create the prototype which consists of chair and 'gawangan'. The prototype was tested to the batik workers. The direct observation used was Quick Exposure Check to compare the working position before and after using the prototype.

Anthropometry Measurement

Anthropometry as the science to study the individual's physical measurement, including body size, shape, and the functional capacity [11]. The workers' sitting anthropometry (see figure 1) was measured to design the chair and 'gawangan'. It stated that the chair design must involve [12]:

1. The seat height should not exceed the users' popliteal
2. The seat depth (measured from the front of the seat to backrest) must not exceed the length of the users' buttock to popliteal.

It stated that the seat design must involves the seat height, the seat depth, backrest, armrest, and the seat cushion [13]. The anthropometry dimensions that must be involved are the body height, the eye height, the elbow height, the normal sitting height, the eye height at sitting position, the elbow height at rest position, the height of thigh, the arm reach side, the reach of the tip of the thumb, the maximal body thickness, and the maximal body reach. It stated that the seat height must not exceed

the population popliteal at 1 percentile or 5 percentile [14].

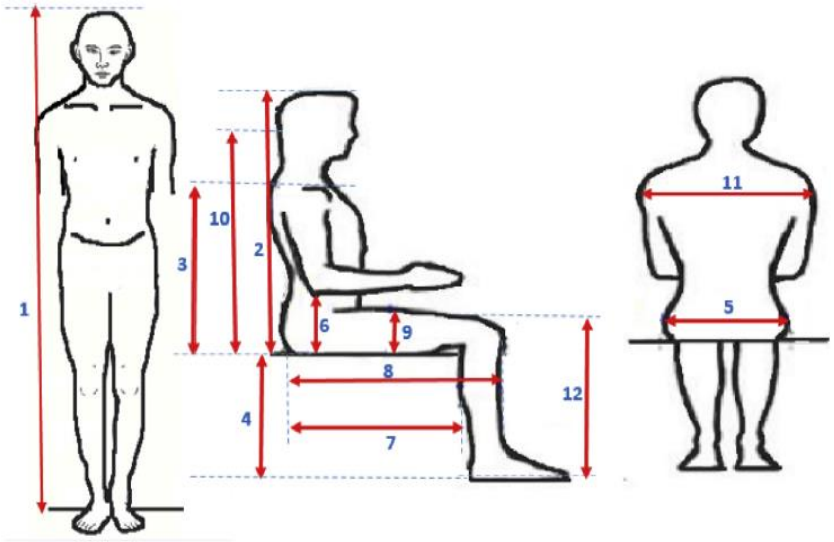


Fig. 2. Anthropometric data required in classroom furniture design: stature (body height) (1), sitting height (erect) (2), shoulder height, sitting (3), lower leg length (popliteal height) (4), hip breadth, sitting (5), elbow height, sitting (6), buttock-popliteal length (seat depth) (7), buttock-knee length (8), thigh clearance (9), Eye height, sitting (10), shoulder (bideltoid) breadth (11), knee height (12), and body mass (weight) (13).

Figure 1. Sitting Anthropometry [15]

Quick Exposure Check

QEC provides the exposure data for all of the body parts, the need of identification to reduce it, and the comparison data of before and after the intervention was conducted [16]. It also mentioned that QEC can deliver the data which come from the observer and the respondent that have considered the individual task involving the back, shoulder, arm/wrist, neck, as well as the driving process when the work is conducted, vibration, working speed, and stress [16].

Worker's name _____ Date _____

Observer's Assessment

Back

A When performing the task, is the back
(select worse case situation)

- A1 Almost neutral?
- A2 Moderately flexed or twisted or side bent?
- A3 Excessively flexed or twisted or side bent?

B Select ONLY ONE of the two following task options:

EITHER

For seated or standing stationary tasks. Does the back remain in a static position most of the time?

- B1 No
- B2 Yes

OR

For lifting, pushing/pulling and carrying tasks (i.e. moving a load). Is the movement of the back

- B3 Infrequent (around 3 times per minute or less)?
- B4 Frequent (around 8 times per minute)?
- B5 Very frequent (around 12 times per minute or more)?

Shoulder/Arm

C When the task is performed, are the hands
(select worse case situation)

- C1 At or below waist height?
- C2 At about chest height?
- C3 At or above shoulder height?

D Is the shoulder/arm movement

- D1 Infrequent (some intermittent movement)?
- D2 Frequent (regular movement with some pauses)?
- D3 Very frequent (almost continuous movement)?

Wrist/Hand

E Is the task performed with
(select worse case situation)

- E1 An almost straight wrist?
- E2 A deviated or bent wrist?

F Are similar motion patterns repeated

- F1 10 times per minute or less?
- F2 11 to 20 times per minute?
- F3 More than 20 times per minute?

Neck

G When performing the task, is the head/neck bent or twisted?

- G1 No
- G2 Yes, occasionally
- G3 Yes, continuously

Worker's Assessment

Workers

H Is the maximum weight handled MANUALLY BY YOU in this task?

- H1 Light (5 kg or less)
- H2 Moderate (6 to 10 kg)
- H3 Heavy (11 to 20kg)
- H4 Very heavy (more than 20 kg)

J On average, how much time do you spend per day on this task?

- J1 Less than 2 hours
- J2 2 to 4 hours
- J3 More than 4 hours

K When performing this task, is the maximum force level exerted by one hand?

- K1 Low (e.g. less than 1 kg)
- K2 Medium (e.g. 1 to 4 kg)
- K3 High (e.g. more than 4 kg)

L Is the visual demand of this task

- L1 Low (almost no need to view fine details)?
- *L2 High (need to view some fine details)?

* *If High, please give details in the box below*

M At work do you drive a vehicle for

- M1 Less than one hour per day or Never?
- M2 Between 1 and 4 hours per day?
- M3 More than 4 hours per day?

N At work do you use vibrating tools for

- N1 Less than one hour per day or Never?
- N2 Between 1 and 4 hours per day?
- N3 More than 4 hours per day?

P Do you have difficulty keeping up with this work?

- P1 Never
- P2 Sometimes
- *P3 Often

* *If Often, please give details in the box below*

Q In general, how do you find this job

- Q1 Not at all stressful?
- Q2 Mildly stressful?
- *Q3 Moderately stressful?
- *Q4 Very stressful?

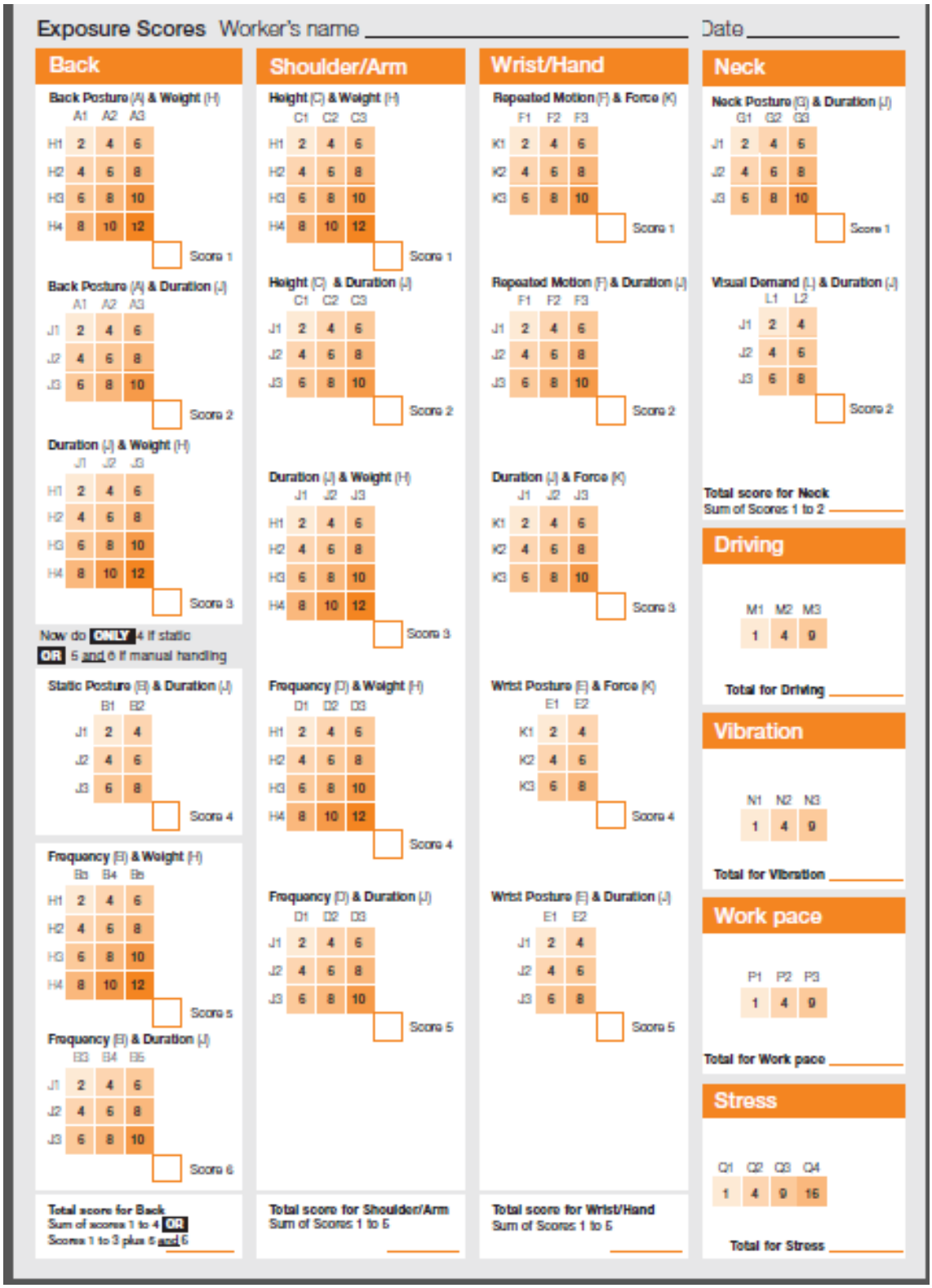
* *If Moderately or Very, please give details in the box below*

* *Additional details for L, P and Q if appropriate*

* **L**

* **P**

* **Q**



Exposure Scores Worker's name _____ Date _____

Back

Back Posture (A) & Weight (H)

	A1	A2	A3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

Score 1

Back Posture (A) & Duration (J)

	A1	A2	A3
J1	2	4	6
J2	4	6	8
J3	6	8	10

Score 2

Duration (J) & Weight (H)

	J1	J2	J3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

Score 3

Now do **ONLY** 4 if static
OR 5 and 6 if manual handling

Static Posture (B) & Duration (J)

	B1	B2
J1	2	4
J2	4	6
J3	6	8

Score 4

Frequency (B) & Weight (H)

	B3	B4	B5
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

Score 5

Frequency (B) & Duration (J)

	B3	B4	B5
J1	2	4	6
J2	4	6	8
J3	6	8	10

Score 6

Total score for Back
Sum of scores 1 to 4 **OR**
Scores 1 to 3 plus 5 and 6 _____

Shoulder/Arm

Height (C) & Weight (H)

	C1	C2	C3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

Score 1

Height (C) & Duration (J)

	C1	C2	C3
J1	2	4	6
J2	4	6	8
J3	6	8	10

Score 2

Duration (J) & Weight (H)

	J1	J2	J3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

Score 3

Frequency (D) & Weight (H)

	D1	D2	D3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

Score 4

Frequency (D) & Duration (J)

	D1	D2	D3
J1	2	4	6
J2	4	6	8
J3	6	8	10

Score 5

Total score for Shoulder/Arm
Sum of Scores 1 to 5 _____

Wrist/Hand

Repeated Motion (F) & Force (K)

	F1	F2	F3
K1	2	4	6
K2	4	6	8
K3	6	8	10

Score 1

Repeated Motion (F) & Duration (J)

	F1	F2	F3
J1	2	4	6
J2	4	6	8
J3	6	8	10

Score 2

Duration (J) & Force (K)

	J1	J2	J3
K1	2	4	6
K2	4	6	8
K3	6	8	10

Score 3

Wrist Posture (E) & Force (K)

	E1	E2
K1	2	4
K2	4	6
K3	6	8

Score 4

Wrist Posture (E) & Duration (J)

	E1	E2
J1	2	4
J2	4	6
J3	6	8

Score 5

Total score for Wrist/Hand
Sum of Scores 1 to 5 _____

Neck

Neck Posture (G) & Duration (J)

	G1	G2	G3
J1	2	4	6
J2	4	6	8
J3	6	8	10

Score 1

Visual Demand (L) & Duration (J)

	L1	L2
J1	2	4
J2	4	6
J3	6	8

Score 2

Total score for Neck
Sum of Scores 1 to 2 _____

Driving

M1	M2	M3
1	4	9

Total for Driving _____

Vibration

N1	N2	N3
1	4	9

Total for Vibration _____

Work pace

P1	P2	P3
1	4	9

Total for Work pace _____

Stress

Q1	Q2	Q3	Q4
1	4	9	16

Total for Stress _____

	Exposure level			
Score	Low	Moderate	High	Very High
Back (static)	8-15	16-22	23-29	29-40
Back (moving)	10-20	21-30	31-40	41-56
Shoulder/arm	10-20	21-30	31-40	41-56
Wrist/hand	10-20	21-30	31-40	41-46
Neck	4-6	8-10	12-14	16-18

	Exposure level			
Score	Low	Moderate	High	Very High
Driving	1	4	9	-
Vibration	1	4	9	-
Work pace	1	4	9	-
Stress	1	4	9	16

3. RESULTS

The company is located in Surakarta, Indonesia and employs 25 workers. The workers' age is around 21-56 years old. All of the workers are female. It was found that the workers work for 6-8 hours/day. The job was conducted in a sitting position. Figure 2 showed that the job was done at the yard of each workers and was done together.

Figure 2. The Batik Workers

The workers used the chair, 'gawangan', stove, and 'canting' to do their job. The interview result revealed that the chair and 'gawangan' are provided by the company (see figure 3 and figure 4). They made collectively by the craftsmen hired by the company. The company agreed to refer to the

prototype for the next chair and ‘gawangan’ production. The ‘Gawangan’ used by the workers are 105 cm long and 56 cm tall.

Figure 3. The Chair Used by the Craftsmen

Figure 4. The ‘Gawangan’

Table 1. The Batik Workers' Anthropometry Data

Workers	A (cm)	B (cm)	C (cm)	D (cm)	E (cm)	F (cm)	G (cm)	H (cm)	I (cm)	J (cm)	K (cm)	L (cm)
1.	157	73	56	40	26	13	39	42	11	62	35	44
2.	152	67	47	38,5	26,5	14	37	45	8	59	33	45
3.	161	80	58	42	27	15	39	43	10	64	34	42
4.	159	78	56	41	26	13	38	41	12	63	33	40
5.	155	69	49	39	28	14	36	39	9	61	32	38
6.	158	74	56	41	25	13	39	43	11	61	36	41
7.	151	65	47	39	29	14	36	44	9	58	35	43
8.	156	68	49	40	27	15	37	40	8	59	34	39
9.	153	68	48	38	28	13	39	42	9	60	33	40
10.	160	79	55	39	25	14	35	42	10	63	34	41
11.	158	81	53	37	26	13	39	40	12	60	35	41
12.	149	65	44	36	24	12	35	41	10	62	32	42
13.	155	81	47	38	28	12	36	40	11	60	32	43
14.	161	75	59	41	29	11	39	41	9	61	34	42
15.	152	66	47	37	26	10	38	44	7	58	32	44
16.	154	70	51	40	28	13	37	43	9	62	32	41
17.	150	63	45	39	30	12	34	43	10	57	33	37
18.	159	79	54	38	25	13	36	41	9	60	32	39
19.	153	69	51	38	39	13	36	42	9	61	31	40
20.	155	72	51	42	28	13	38	44	9	61	33	42
21.	158	78	54	37	26	11	35	41	8	59	31	39
22.	149	63	43	38	27	10	33	42	8	55	32	36
23.	160	80	54	39	26	13	37	43	10	61	33	38
24.	157	75	54	46	36	10	33	42	9	58	32	38
25.	156	74	52	42	30	13	38	46	8	62	34	43

Information

A: body height
B: height at normal sitting position
C: shoulder height at sitting position
D: popliteal height
E: waist wide at sitting position
F: elbow height at sitting position
G: the length of buttock-popliteal
H: the length of buttock-knee
I: the length of thigh
J: the height of eye at sitting position
K: the shoulder wide
L: the knee length

Table 2. Anthropometry Data

Dimension (cm)	Standard Deviation	Percentile		
		5	50	95
Body Height	3,68	149.2	156	160.8
Height at Normal Sitting Position	5,97	63.4	73	80.8
Shoulder Height at Sitting Position	4,44	44.2	51	57.6
Popliteal Height	2,17	37	39	42
Waist Width at Sitting Position	3,33	25	27	35.1
Elbow Height at Sitting Position	1,41	10	13	14.8
Length of Buttock-Popliteal	1,88	33.2	37	39
Length of Buttock-Knee	1,68	40	42	44.8
Length of Thigh	1,29	8	9	11.8
Height of Eye at Sitting Position	2,07	57.2	61	63
Shoulder Wide	1,32	31.2	33	35
Knee Length	2,34	37.2	41	44

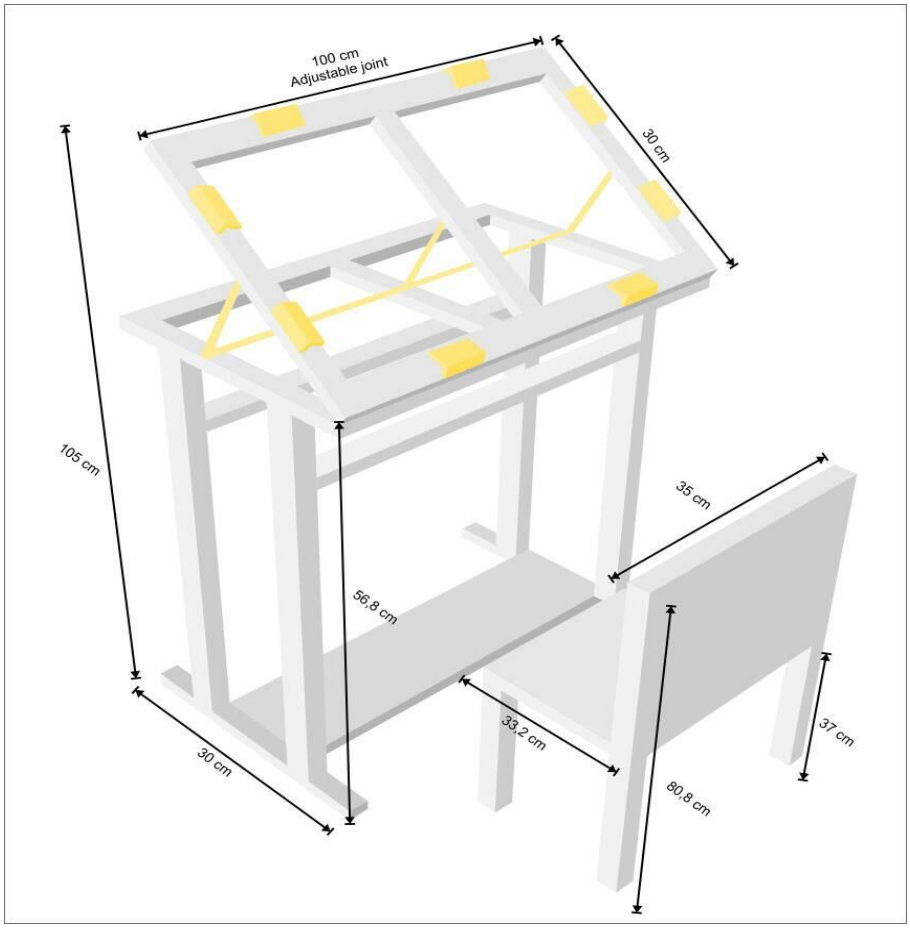


Figure 5. The Design of the Prototype

Figure 6. The Prototype

4. DISCUSSIONS

We designed the prototype based on the workers' anthropometry data collected (figure 5). The prototype was customizedly made using materials that can be found easily in the company's surrounding (see figure 6). Each of the measurements will be discussed below, involving the detail of the proposed chair and 'gawangan'.

The Batik Equipment

Chair

The Height of Chair Surface

We recommend the height of chair surface for 37 cm. The recommendation was made based on the popliteal height at percentile 5 %. It stated that the decision to determine the height of the chair surface on anthropometric dimension was based on the height of the inner knee fold at percentile 5 % [17]. Similar to that, it stated that the height of chair

surface which can accommodate the users who have the smallest inner knee fold may comfort the users who have the biggest inner knee fold [13]. The 5% percentile was chosen to avoid the workers' leg to hang.

The Seat Depth

We recommend the seat depth to be 33.2 cm. The data was based on the data from the length of buttock to popliteal with percentile of 5 %. It was used to accommodate the small size population.

The Chair Wide

We recommend the chair width to be 35 cm. The data was based on the data from the shoulder wide with percentile of 5 %. It was designed to make the workers feel more flexible to do their job. It revealed that the too narrow chair's width may make the users feel 'overturned' [13].

The Chair Height

We recommend the chair height to be 80.8 cm. The data was based on the normal sitting height at percentile of 95 %.

Gawangan

The Length of 'Gawangan'

We recommend the length of the 'gawangan' at 100 cm to be able to accommodate the clothes' length which is 1 to 1.5 meters at average. Furthermore, the 'gawangan' was made with clearance consideration to enable the workers to move freely.

The Height of 'Gawangan'

We recommend the height of 'gawangan' to be 56,8 cm which based on the popliteal height at percentile of 95 % (42 cm) and the height of elbow at sitting position at percentile of 95 % (14,8 cm). We recommend the entire height of 'gawangan' to be 105 cm which designed based on popliteal height at percentile of 95 % (42 cm) and the eye height at sitting position at percentile of 95 % (63 cm). It was proposed to ensure that the workers can work at neutral position and will not bend their spine. The percentile of 95 % was chosen to accommodate the big size of the population. Furthermore, we have also add a footrest to increase the workers' comfort.

The Comparison of Ergonomic Risk Factors Before and After the Intervention was Conducted

We compared the ergonomic risk factors before and after the intervention (see figure 7) through direct observation using *Quick Exposure Check* (QEC) to 3 batik workers. The comparison involved the used chair and 'gawangan' and the prototype.

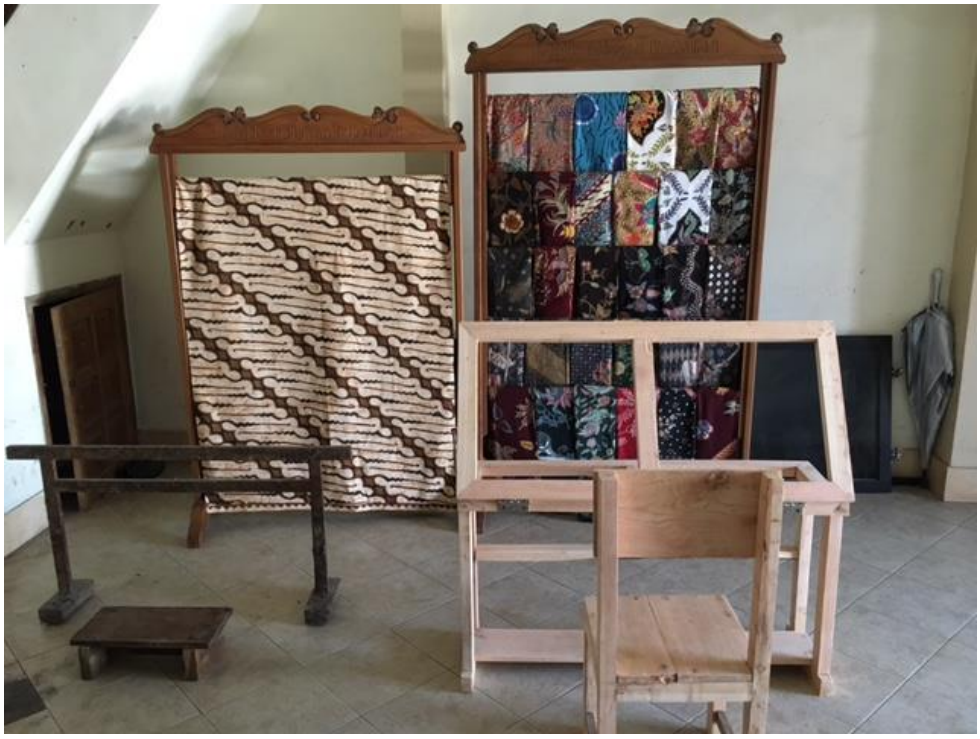


Figure 7. The Comparison of the Prototype and old Equipment

Table 3. Comparison of QEC Result at Worker 1

Before/After Intervention	Back (Total)	Shoulder/Arm (Total)	Wrist/Hand (Total)	Neck (Total)	Driving (Total)	Vibration (Total)	Work Speed (Total)	Stress (Total)
Before Intervention	30 *(VH)*	30 *(M)*	26 *(M)*	18 *(VH)*	1 *(L)*	1 *(L)*	4 *(M)*	4 *(M)*
After Intervention	22 *(M)*	30 *(M)*	22 *(M)*	14 *(H))*	1 *(L))*	1 *(L)*	4 *(M)*	4 *(M)*

Table 4. Comparison of QEC Result at Worker 2

Before/After Intervention	Back (Total)	Shoulder/Arm (Total)	Wrist/Hand (Total)	Neck (Total)	Driving (Total)	Vibration (Total)	Work Speed (Total)	Stress (Total)
Before Intervention	30 *(VH)*	30 *(M)*	26 *(M)*	18 *(VH)*	1 *(L)*	1 *(L)*	1 *(L)*	1 *(L)*
After Intervention	22 *(M)*	30 *(M)*	22 *(M))*	14 *(H)*	1 *(L)*	1 *(L)*	1 *(L)*	1 *(L)*

Table 5. Comparison of QEC Result at Worker 3

Before/After Intervention	Back (Total)	Shoulder/Arm (Total)	Wrist/Hand (Total))	Neck (Total)	Driving (Total)	Vibration (Total)	Work Speed (Total)	Stress (Total)
Before Intervention	30 *(VH)*	30 *(M)*	26 *(M)*	18 *(VH)*	1 *(L)*	1 *(L)*	1 *(L)*	4 *(M)*
After Intervention	22 *(M)*	30 *(M)*	22 *(M)*	14 *(H)*	1 *(L)*	1 *(L)*	1 *(L)*	4 *(M)*

Information:
L: *Low* M: *Moderate* H: *High* VH: *Very High*

The tables above (table 3, 4, and 5) show that the proposed prototype can reduce the ergonomic risks (at the back, wrist/hand, and neck) without considering the MSDs complaints. The further investigation may be needed to understand the result of prototype usage to ergonomic risks among the batik workers.

Figure 8. Worker 1 in Using Old Equipment

Figure 9. Worker 1 is Using the Prototype

Figure 10. Worker 2 is Using Old Equipment

Figure 11. Worker 2 is Using the Prototype

Figure 12. Worker 3 is Using Old Equipment

Figure 13. Worker 3 is Using the Prototype

5. CONCLUSION

We concluded from this study that:

1. All of the workers are female and they complain about the ache all over the body, especially in the arm, shoulder, back, and calf.
2. All of the complaints can be minimised with the use of ergonomic working equipment. The main object of this study is to create the working equipment prototype based on the workers' anthropometry data
3. We found that there is ergonomic risk factors reduction on the back, hand/wrist and neck after the intervention.

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