# performance in reducing work musculoskeletal disorders among Sarong Samarinda female weavers: A quasi-experimental study

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# Evaluation and analysis of new design traditional handloom performance in reducing work musculoskeletal disorders among Sarong Samarinda female weavers: A quasi-experimental study

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## ABSTRACT

**Background:** Work musculoskeletal disorder (WMSDs) are occupational health problems whose prevalence is still high in various countries. Ergonomic interventions are the most successful approach to reducing WMSDs. This study evaluated the effect of redesign traditional handloom on the work posture and musculoskeletal disorders of Samarinda Sarong traditional weavers.

**Methods:** The quasi-experiment has been carried out on 40 traditional weavers from February to September 2019 in Samarinda, Indonesia. The weaver using the new design handloom then evaluated its impact on work posture and WMSDs in the first 3 months and the second 3 months. Work posture was assessed using Rapid Upper Limb Assessment (RULA). WMSDs were assessed using a Nordic Body Map questionnaire. Data were analyzed using Friedman and Dunn's test.

**Results:** The RULA score decreased from 7 to 3 and 2, while the WMSD risk at "very high" level decreased from 12.5% to 7.5% and 2.5% and the WMSD at "high" risk level decreased from 87.5% to 10.0% and 5.0% following the introducing of the new design traditional handloom at 3 and 6 months, respectively.

**Conclusions:** The new design of the traditional handloom on Sarong Samarinda female weavers has succeeded in improving work posture and reducing WMSDs.

**Key Words:** Ergonomics, musculoskeletal, posture, work

## INTRODUCTION

Work musculoskeletal disorders (WMSDs) are occupational health problems that still often occur in developing and developed countries,[1] including the USA,[2] European countries,[3] and Korea as well as Japan.[4]

The leading cause of WMSDs is manual material handling work performing repetitive loads carrying, holding, lifting, lowering, pushing, and pulling activities.[5] Other studies showed that awkward postures, prolonged static work, repetitive movements, forceful exertions, and vibrations



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are the other common risk factor of WMSDs.[6,7] WMSDs adversely affect individual workers and business activities, including reducing work productivity and well-being of workers, increasing medical cost,[8-10] decreasing job satisfaction,[11] degrading the quality of the physical and mental dimensions of health, and causing daily activity limitation.[12] A previous research showed that ergonomic interventions were the most successful interventions in preventing or reducing the incidence of WMSDs.[3,13]

A recent study showed that the prevalence of musculoskeletal disorders (MSDs) among female weavers using handlooms in Indonesia was found to be approximately 85%, with the incidence of low, moderate, and high musculoskeletal pain ratings at 15.0, 7.5, and 77.5, respectively. The skeletal muscle pain was primarily in the lower neck, shoulders, upper hands, bottom, waist, thighs, calves, and ankles. MSDs were associated with the education level, work experience, prolonged sitting time, work posture, and body anthropometry of each weaver. Work posture was the dominant variable responsible for MSD prevalence.[14] To overcome the problems, an advanced study to design new traditional handloom based on anthropometry data was constructed.[15]

## METHODS

### Experimental design and data analysis

The old and new design traditional handloom dimensions in this study are presented in Table 1.[15] While the construction of the new design chair and table of traditional handloom are presented in Figures 1 and 2, respectively. A quasi-experiment[16,17] of 40 female weavers of Samarinda Sarong in Samarinda, Indonesia, was conducted from February to September 2019.

The weavers regularly used the new design of traditional handloom during the study. The work posture and WMSDs were measured 3 and 6 months after introducing the traditional handloom to the female weaver of Samarinda Sarong. Most weavers (92%) worked for 4–8 h a day for 6 days per week. Work posture and WMSD data using old traditional handloom (before introducing the new design traditional handloom) on the weavers were used as the baseline data.

Work posture data (Rapid Upper Limb Assessment [RULA] score), WMSD data (Nordic Body Map [NBM] category) for pain level, and the risk category were analyzed by Friedman test followed by Dunn's test ($P = 0.05$).

### Measurement of work posture and work musculoskeletal disorder complaint

The weavers' work posture of musculoskeletal operator system was determined by fast judgment using RULA as suggested by McAtammney and Corlet,[18] with four levels, i.e., low (0-20), medium (21-41), high (42-62) and very high (63-84). WMSD complaint of the weavers was measured by standardized NBM questionnaire as suggested by Kourinka *et al.*,[19] with four levels, i.e., low (1-2), medium (3-4), high (5-6) and very high (7+) [Table 2].

**Table 1: Old and new design traditional handloom dimensions**

| Handloom component | Old design | New design |
|---|---|---|
| Chair (cm) | | |
| Height | 56.00 | 55.35 |
| Depth | 27.00 | 47.00 |
| Width | 40.00 | 48.65 |
| Backrest tilt angle | * | 120° |
| Upper backrest | * | 47.00 |
| Lower backrest | * | 24.10 |
| Armrest height | * | 37.45 |
| Armrest length | * | 37.00 |
| Table (cm) | | |
| Surface height | 79.00 | 88.44 |
| Surface width | 92.00 | ** |
| Surface depth | 150.00 | ** |
| Footrest/step-on height | 17.00 | ** |
| Swingarm handle | 33-37 | ** |
| Angle to horizontal | 0° (flat) | ** |

*Not available, **Not changed

**Table 2: The risk level of work posture and work musculoskeletal disorders and recommendation**

a. RULA

| Score | Risk level | Risk category | Recommendation |
|---|---|---|---|
| 0-20 | 0 | Low | Acceptable posture |
| 21-41 | 1 | Medium | Further investigation, change may be needed |
| 42-62 | 2 | High | Further investigation, change soon |
| 63-84 | 3 | Very high | Investigation and implement change |

b. NBM

| Score | Pain level | Risk category | Recommendation |
|---|---|---|---|
| 1-2 | 0 | Low | Does not need improvement |
| 3-4 | 1 | Medium | Maybe need improvement |
| 5-6 | 2 | High | Need improvement |
| 7+ | 3 | Very high | Need improvement as soon as possible |

RULA: Rapid Upper Limb Assessment, NBM: Nordic Body Map

## RESULTS

In the present study, at first, a total number of 40 female weavers, who used old traditional handloom, were determined for handloom performance (work posture, MSD pain, and risk category). By introducing the new design traditional handloom, the handloom performance was determined by measure work posture, MSD pain, and risk category of the female weavers after 3 and 6 months. All the weavers completed the experiment without any withdrawal. The flow of the present study is presented in Figure 3.

### Respondents' characteristics

Most weavers are at the age of 38–44 (35%) and 45–51 years (17.5%). Elementary school is the dominant education background level (52.2%), and 60% have

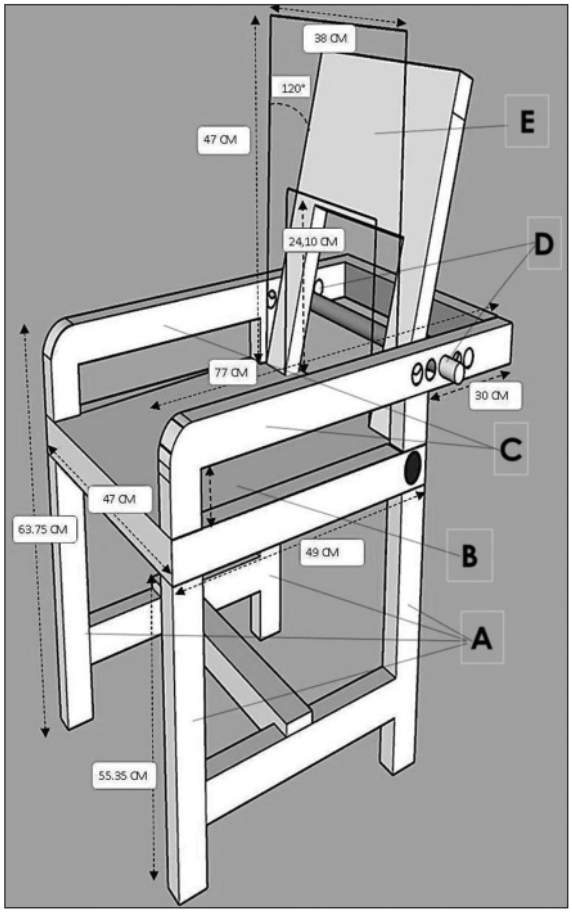


**Figure 1:** Handloom chair. A: Front/rear legs, B: Cushion/seat, C: Armrest, D: Backrest adjuster (manual), E: Backrest

**Table 3: Respondent characteristics of the female weavers ($n = 40$)**

| Variables | *n* (%) |
|---|---|
| Age (years) | |
| 23-30 | 4 (10.0) |
| 31-37 | 5 (12.5) |
| 38-44 | 14 (35.0) |
| 45-51 | 7 (17.5) |
| 52-58 | 6 (15.0) |
| 59-65 | 4 (10.0) |
| Education background | |
| Elementary school/not graduated | 6 (15.0) |
| Elementary school (graduated 6th class) | 21 (52.5) |
| Secondary high school (graduated 9th class) | 9 (22.5) |
| Senior high school (graduated 12th class) | 4 (10.0) |
| Working experience (years) | |
| <5 | 10 (25.0) |
| ≥5 | 30 (75.0) |
| Working hours per day | |
| ≤8 | 37 (92.5) |
| >8 | 7 (7.5) |

working experience of fewer than 5 years. The majority of the weavers have working hours per day of 4–8 h (92.5%) [Table 3].

### Improvement of weaver's work posture

Most of the weavers have low work posture at the beginning of the experiment (before introducing the new design traditional handloom) in the arm, wrist, neck, trunk, and leg segment, i.e. 52.5% and 45.0% for 7 and 6 of RULA score (C score) [Table 4a], which means that the work posture of weavers using old design traditional handloom was "high" and "very high" risk. The condition needs investigation and changes implementation, as also recommended by a previous study.[14]

The weaver's work posture improved significantly ($P < 0.001$) [Table 4b] following introducing a new design of traditional handloom. The RULA score (C score) decreased from 7 to 3 and 2 after introducing the new design traditional handloom at 3 and 6 months.

### Declining of work musculoskeletal disorder pain and risk

The WMSD pain of the most upper and lower body part decreased significantly ($P < 0.001$) except for the left elbow ($P = 0.991$) [Table 5] and right leg wrist ($P = 0.356$) [Table 6]. The data show that the new design of traditional handloom is very compatible with the female weavers. The more they use the new design handloom, the more decreasing of WMSDs occurred. The WMSD risk of the female weavers decreased significantly ($P < 0.001$)following introducing of the new design traditional handloom [Table 7], which the detail data is presented at Supplementary Table 1. The WMSD risk at "very high" risk level of the female weaver decreased from 12.5% to 7.5% and 2.5% at 3 and 6 months, respectively, following introducing of the new design handloom. The WMSDs at "high" risk level decreased from 87.5% to 10.0% and 5.0% at 3 and 6 months of introducing the new design handloom, respectively.

## DISCUSSION

The newly designed handloom with anthropometry based has significantly improved the female weavers' work posture. The work posture was improved by fixing the weaving chair's height and the height of the weaving table.[15] A good work posture achieved in this study indicated that the position of head, neck, trunk, and shoulders does not seem to deviate from a neutral position severely. Besides, the posture of the elbows is appropriate.

The underneath table height was lengthened to provide sufficient space on both legs of the weaver. The handloom's upper backrest height (the vertical distance from the top side of the seat surface to the highest point of the backrest) is set to > 47 cm, which is the ergonomic central key element in chair design to keep the sitting posture and healthy spine.[20] The handloom chair's height is

**Table 4: The acceptance and the change level of female Sarong Samarinda weavers ($n=40$) Work-musculoskeletal disorders (WMSDs) on using old and new traditional handloom**

a The acceptance of WMSDs

| WMSDs Score | WMSDs | | |
|---|---|---|---|
| | Arm and Wrist (A) ($n$; %) | Neck, Trunk and Leg (B) ($n$; %) | Final sore (C) ($n$; %) |
| | Using old traditional handloom | | |
| 1 | 0; 0.0 | 0; 0.0 | 0; 0.0 |
| 2 | 0; 0.0 | 0; 0.0 | 0; 0.0 |
| 3 | 0; 0.0 | 0; 0.0 | 0; 0.0 |
| 4 | 0; 0.0 | 2; 5.0 | 0; 0.0 |
| 5 | 16; 40.0 | 35; 87.3 | 1; 2.5 |
| 6 | 23; 57.5 | 3; 7.5 | 18; 45.0 |
| 7 | 1; 2.5 | 0; 0.0 | 21; 52.5 |
| | Three months following using new design traditional handloom | | |
| 1 | 0; 0.00 | 0; 0.00 | 0; 0.00 |
| 2 | 0; 0.00 | 0; 0.00 | 0; 0.00 |
| 3 | 0; 0.00 | 29; 72.5 | 29; 72.5 |
| 4 | 40; 100.0 | 11; 27.5 | 11; 27.5 |
| 5 | 0; 0.0 | 0; 0.0 | 0; 0.0 |
| 6 | 0; 0.0 | 0; 0.0 | 0; 0.0 |
| 7 | 0; 0.0 | 0; 0.0 | 0; 0.0 |
| | Six months following using new design traditional handloom | | |
| 1 | 0; 0.0 | 0; 0.0 | 0; 0.0 |
| 2 | 0; 0.0 | 0; 0.0 | 0; 0.0 |
| 3 | 0; 0.0 | 29; 72.5 | 29; 72.5 |
| 4 | 40; 100.0 | 11; 27.5 | 11; 27.5 |
| 5 | 0; 0.0 | 0; 0.0 | 0; 0.0 |
| 6 | 0; 0.0 | 0; 0.0 | 0; 0.0 |
| 7 | 0; 0.0 | 0; 0.0 | 0; 0.0 |

b Effect of introducing the new design traditional handloom on WMSDs Score

| Body parts | WMSDs Score | | |
|---|---|---|---|
| | Using the old design traditional handloom | Using the new design traditional handloom | |
| | | After 3 months | After 6 months |
| Arm and Wrist (A) | 6[a] | 4[b] | 4[b] |
| Neck, Trunk and Leg (B) | 5[a] | 3[b] | 3[b] |
| Final score (C) | 7[a] | 3[b] | 3[b] |

In Table 4a, the experiment used WMSDs level using RULA with the score of 1-2 for "acceptable posture", 3-4 for "further investigation, change may be needed", 5-6 for "further investigation, change soon", >7 for "investigate and implement change". Data in Table 4b (median) were derived from Table 4a., data were analysed by Friedman test followed comparison test (Dunn's method), data within the same row followed by different subscript letter show significantly different (Friedman test, $P<0.001$; Dunn's method, $P<0.05$)

designed based on the size of the popliteal height,[21] which effectively improved work posture and reduced the hazards associated with prolonged standing. A previous study showed that the changes in workstations in the spice packaging in a food factory line with the appropriate workers' anthropometric data reduced the awkward postures in the neck and shoulders.[22]

The addition of handloom chair backrest (the tilt can be adjusted at 90°–120°) significantly improved sitting posture and reduced complaints of WMSDs, especially on the back, waist, buttock, and bottom. In line with the previous studies, the chair's backrest is beneficial for reducing disc pressure and avoiding the risk of MSD and discomfort.[23]

In this research, we also added armrest height and armrest length for handloom chair and set 37.45 and 37.00 cm, respectively. It is intended to provide the opportunity for relaxation on the shoulder, upper and lower hand, elbow, and hand-wrist. In addition to armrest in the new design, traditional handloom could reduce WMSD complaints on these body parts. Following previous research, the appropriate height adjustment, sufficient armrests, and padding can reduce pressure on the forearms and elbows' undersides.[24,25]

The primary modification of the traditional handloom in this study was in chair design. The anthropometric approach in designing the new traditional handloom resulted in an ergonomic chair of traditional handloom for the female weavers of Sarong Samarinda. In line with previous work that ergonomic chairs positively impact the reduction of WMSDs, such as arm and low back pain.[26,27] Ergonomic interventions can have a beneficial effect on improving work posture and reducing MSDs among workers.[24,28] The traditional handloom chair dimension in this study is recommended for traditional handloom in Southeast Asia due to the relatively same body dimension as the female weaver of Sarong Samarinda.[29] It is better than practicing exercises in between of using the old handloom, which only reduce a bit MSDs among the weavers.[30]

### Limitations

Advanced research is planned to design the handloom chairs with some different soft cushion materials to reduce the WMSD complaints on buttock and bottom muscles. Lee *et al.*[31] reported that chair cushion choice could distribute interface pressure differently.

## CONCLUSIONS

This study demonstrated that the new design of traditional handloom has succeeded in improving work posture and reducing WMSDs. The new design handloom dimension in this report enriches the consideration of designing a traditional handloom for weavers in the Southeast Asian region.

### Research quality and ethics statement

This study was approved by the Ethical Commission of Health and Medical Research, Faculty of Medicine, Mulawarman University, Indonesia (Approval number [illegible]/KEPK-FK/ IV/2018; Approval date Apr 9, 2018). Written informed consent was obtained from the participants prior to their participation. The authors followed applicable EQUATOR Network (http://www.equator-network.org/) guidelines during the conduct of this research project.

**Table 5: The pain level of musculoskeletal disorder symptoms in upper body parts (based on Nordic Body Map) of female Sarong Samarinda weavers ($n=40$) and performance of the old and new design traditional handloom**

a. The risk level of upper body parts of Sarong Samarinda female weaver using the traditional handloom

| Pain level | Neck | | Shoulder | | Upper hand | | Lower hand | | Elbow | | Hand wrist | | Arm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Upper, *n* (%) | Lower, *n* (%) | Left, *n* (%) | Right, *n* (%) | Left, *n* (%) | Right, *n* (%) | Left, *n* (%) | Right, *n* (%) | Left, *n* (%) | Right, *n* (%) | Left, *n* (%) | Right, *n* (%) | Left, *n* (%) | Right, *n* (%) |
| **Using old traditional handloom** | | | | | | | | | | | | | | |
| 0 | 24 (60.0) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 7 (17.5) | 11 (27.5) | 5 (12.5) | 5 (12.5) | 10 (25.0) | 9 (22.5) | 10 (25.0) | 3 (7.5) | 21 (52.5) | 8 (20.0) | 40 (100) | 40 (100) | 15 (37.5) | 15 (37.5) |
| 2 | 9 (22.5) | 11 (27.5) | 5 (12.5) | 5 (12.5) | 12 (30.0) | 7 (17.5) | 12 (30.0) | 4 (10.0) | 7 (17.5) | 3 (7.5) | 0 | 0 | 6 (15.0) | 6 (15.0) |
| 3 | 0 | 18 (45) | 30 (75.0) | 30 (75.0) | 18 (45.0) | 24 (60) | 18 (45.0) | 33 (82.5) | 12 (30.0) | 29 (72.5) | 0 | 0 | 19 (47.5) | 19 (47.5) |
| **3 months following using new design traditional handloom** | | | | | | | | | | | | | | |
| 0 | 14 (35.0) | 13 (32.5) | 11 (27.5) | 10 (25.0) | 16 (40.0) | 4 (10.0) | 14 (35.0) | 3 (7.5) | 7 (17.5) | 6 (15.0) | 28 (70.0) | 30 (75.0) | 20 (50.0) | 20 (50.0) |
| 1 | 13 (32.5) | 11 (27.5) | 11 (27.5) | 11 (27.5) | 9 (22.5) | 7 (17.5) | 10 (25.0) | 7 (17.5) | 8 (20.0) | 8 (20.0) | 5 (12.5) | 3 (7.5) | 10 (25.0) | 10 (25.0) |
| 2 | 9 (22.5) | 12 (30.0) | 16 (40.0) | 16 (40.0) | 12 (30.0) | 18 (45.0) | 11 (27.5) | 26 (65.0) | 18 (45.0) | 22 (55.0) | 5 (12.5) | 5 (12.5) | 8 (20.0) | 8 (20.0) |
| 3 | 4 (10.0) | 4 (10.0) | 2 (5.0) | 3 (7.5) | 3 (7.5) | 11 (27.5) | 5 (12.5) | 4 (10.0) | 7 (17.5) | 4 (10.0) | 2 (5.0) | 2 (5.0) | 2 (5.0) | 2 (5.0) |
| **6 months following using new design traditional handloom** | | | | | | | | | | | | | | |
| 0 | 15 (37.5) | 11 (27.5) | 21 (52.5) | 10 (25.0) | 16 (40.0) | 7 (17.5) | 22 (55.0) | 0 | 0 | 15 (37.5) | 33 (82.5) | 30 (75.0) | 29 (72.5) | 29 (72.5) |
| 1 | 11 (27.5) | 15 (37.5) | 15 (37.5) | 13 (32.5) | 9 (22.5) | 16 (40.0) | 12 (30.0) | 9 (22.5) | 14 (35.0) | 21 (52.5) | 3 (7.5) | 6 (15.0) | 9 (22.5) | 9 (22.5) |
| 2 | 13 (32.5) | 13 (32.5) | 4 (10.0) | 15 (37.5) | 13 (32.5) | 16 (40.0) | 6 (15.0) | 31 (77.5) | 26 (65.0) | 4 (10.0) | 4 (10.0) | 4 (10.0) | 2 (5.0) | 2 (5.0) |
| 3 | 1 (2.5) | 1 (2.5) | 0 | 2 (5.0) | 2 (5.0) | 1 (2.5) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

b. Performance of traditional-handloom based on MSD pain of the Sarong Samarinda female weaver

| Lower body parts | Using old traditional handloom | Using new design traditional handloom | | *P*‡ |
|---|---|---|---|---|
| | | After 3 months | After 6 months | |
| Neck | | | | |
| Upper | 1 | 1* | 1* | 0.024 |
| Lower | 2 | 1* | 1* | <0.001 |
| Shoulder | | | | |
| Left | 3 | 1* | 0* | <0.001 |
| Right | 3 | 1* | 1* | <0.001 |
| Hand | | | | |
| Upper left | 2 | 1* | 1* | <0.001 |
| Upper right | 3 | 2* | 1* | <0.001 |
| Lower left | 2 | 1* | 0* | <0.001 |
| Lower right | 3 | 2* | 2* | <0.001 |
| Elbow | | | | |
| Left | 3 | 2 | 2 | 0.991 |
| Right | 3 | 2* | 1* | <0.001 |
| Hand wrist | | | | |
| Left | 1 | 0* | 0* | <0.001 |
| Right | 1 | 0* | 0* | <0.001 |
| Arm | | | | |
| Left | 2 | 0.5* | 0* | <0.001 |
| Right | 2 | 0.5* | 0* | <0.001 |

In Table 5a, the pain level of 0, 1, 2, and 3 is based on NBM score of 0-20, 21-41, 42-62, and 63-84, respectively. In Table 5b, data show the MSD pain level (median) of the Sarong Samarinda female weaver were derived from Table 5a. Data in Table 5b were analyzed by Friedman test‡, data within the same row followed by asterix (*) show a significant difference (Dunn's test, $P < 0.05$). NBM: Nordic Body Map, MSD: Musculoskeletal disorder

**Table 6: The risk level of musculoskeletal disorder symptoms in the lower body part (based on Nordic Body Map) of female Sarong Samarinda weavers ($n = 40$) and performance of old and new design traditional handloom**

a. The risk level of lower body parts of Sarong Samarinda female weaver using the traditional handloom

| Pain level | Back, *n* (%) | Waist, *n* (%) | Buttock, *n* (%) | Bottom, *n* (%) | Leg | | Tight | | Knee | | Calf | | Leg wrist | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Left, *n* (%) | Right, *n* (%) | Left, *n* (%) | Right, *n* (%) | Left, *n* (%) | Right, *n* (%) | Left, *n* (%) | Right, *n* (%) | Left, *n* (%) | Right, *n* (%) |
| Using old traditional handloom | | | | | | | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 (10.0) |
| 1 | 23 (57.5) | 23 (57.5) | 26 (65.0) | 26 (65.0) | 7 (17.5) | 7 (17.5) | 23 (57.5) | 23 (57.5) | 0 | 0 | 32 (80.0) | 31 (77.5) | 21 (52.5) | 25 (62.5) |
| 2 | 10 (25.0) | 10 (25.0) | 6 (15.0) | 6 (15.0) | 8 (20.0) | 8 (20.0) | 7 (17.5) | 7 (17.5) | 3 (7.5) | 3 (7.5) | 8 (20.0) | 9 (22.5) | 6 (15.0) | 8 (20.0) |
| 3 | 7 (17.5) | 7 (17.5) | 8 (20.0) | 8 (20.0) | 25 (62.5) | 25 (62.5) | 10 (25.0) | 10 (25.0) | 37 (92.5) | 37 (92.5) | 0 | | 13 (32.5) | 3 (7.5) |
| 3 months following using new design traditional handloom | | | | | | | | | | | | | | |
| 0 | 24 (60.0) | 23 (57.5) | 15 (37.5) | 12 (30.0) | 21 (52.5) | 17 (42.5) | 21 (52.5) | 22 (55.0) | | 14 (35.0) | 19 (47.5) | 20 (50.0) | 15 (37.5) | 15 (37.5) |
| 1 | 8 (20.0) | 7 (17.5) | 22 (55.0) | 14 (35.0) | 13 (32.5) | 14 (35.0) | 8 (20.0) | 6 (15.0) | 15 (37.5) | 7 (17.5) | 8 (20.0) | 9 (22.5) | 10 (25.0) | 10 (25.0) |
| 2 | 7 (17.5) | 8 (20.0) | 3 (7.5) | 11 (27.5) | 3 (7.5) | 6 (15.0) | 7 (17.5) | 8 (20.0) | 21 (52.5) | 16 (40.0) | 10 (25.0) | 9 (22.5) | 12 (30.0) | 13 (32.5) |
| 3 | 1 (2.5) | 2 (5.0) | 0 | 3 (7.5) | 3 (7.5) | 3 (7.5) | 4 (10.0) | 4 (10.0) | 4 (10.0) | 3 (7.5) | 3 (7.5) | 2 (5.0) | 3 (7.5) | 2 (5.0) |
| 6 months following using new design traditional handloom | | | | | | | | | | | | | | |
| 0 | 24 (60.0) | 24 (60.0) | 21 (52.5) | 13 (32.5) | 23 (57.5) | 23 (57.5) | 21 (52.5) | 22 (55.0) | 19 (47.5) | 14 (35.0) | 21 (52.5) | 22 (55.0) | 17 (42.5) | 15 (37.5) |
| 1 | 11 (27.5) | 7 (17.5) | 14 (35.0) | 18 (45.0) | 15 (37.5) | 10 (25.0) | 10 (25.0) | 12 (30.0) | 13 (32.5) | 7 (17.5) | 10 (25.0) | 10 (25.0) | 11 (27.5) | 9 (22.5) |
| 2 | 5 (12.5) | 9 (22.5) | 5 (12.5) | 8 (20.0) | 2 (5.0) | 7 (17.5) | 6 (15.0) | 3 (7.5) | 8 (20.0) | 19 (47.5) | 9 (22.5) | 8 (20.0) | 9 (22.5) | 14 (35.0) |
| 3 | 0 | 0 | 0 | 1 (2.5) | 0 | 0 | 3 (7.5) | 3 (7.5) | 0 | 0 | 0 | 0 | 3 (7.5) | 2 (5.0) |

b. Performance of traditional handloom based on MSD pain of the Sarong Samarinda female weaver

| Lower body parts | Using old traditional handloom | Using new design traditional handloom | | *P* |
|---|---|---|---|---|
| | | After 3 months | After 6 months | |
| Back | 1 | 0* | 0* | <0.001 |
| Waist | 1 | 0* | 0* | <0.001 |
| Buttock | 1 | 1* | 0* | <0.001 |
| Bottom | 1 | 1* | 1* | <0.001 |
| Leg | | | | |
| Left | 3 | 0* | 1* | <0.001 |
| Right | 3 | 1* | 0* | <0.001 |
| Tight | | | | |
| Left | 1 | 0* | 0* | <0.001 |
| Right | 1 | 0* | 0* | <0.001 |
| Knee | | | | |
| Left | 3 | 2* | 1* | <0.001 |
| Right | 3 | 1* | 1* | <0.001 |
| Calf | | | | |
| Left | 1 | 1 | 0* | 0.003 |
| Right | 1 | 0.5* | 0* | <0.001 |
| Leg wrist | | | | |
| Left | 1 | 1* | 1* | <0.001 |
| Right | 1 | 1 | 1 | 0.356 |

In Table 6a, the pain level of 0, 1, 2, and 3 is based on NBM score of 0-20, 21-41, 42-62, and 63-84, respectively. In Table 6b, data show the MSD pain level (median) of the Sarong Samarinda female weaver were derived from data of Table 6a. Data of Table 6b were analyzed by Friedman test‡, data within the same row followed by asterix (*) show a significant difference (Dunn's test, $P<0.05$). NBM: Nordic Body Map, MSD: Musculoskeletal disorders

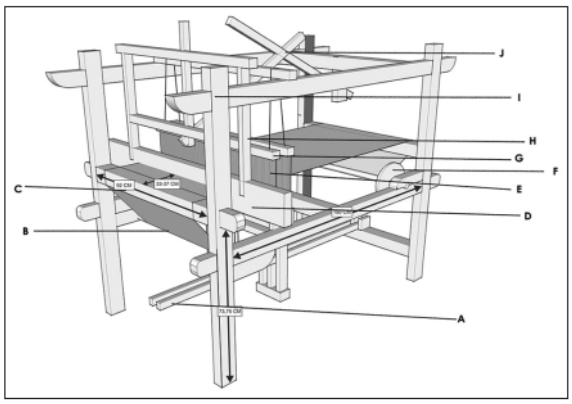


**Figure 2:** Handloom table. A: Footstep, B: Cloth boom, C: Chest block, D: Swing arm, E: Weaving comb, F: Warp boom, G: Gun/Beater, H: Lade for threading, I: Handloom frame, J: Batting rod

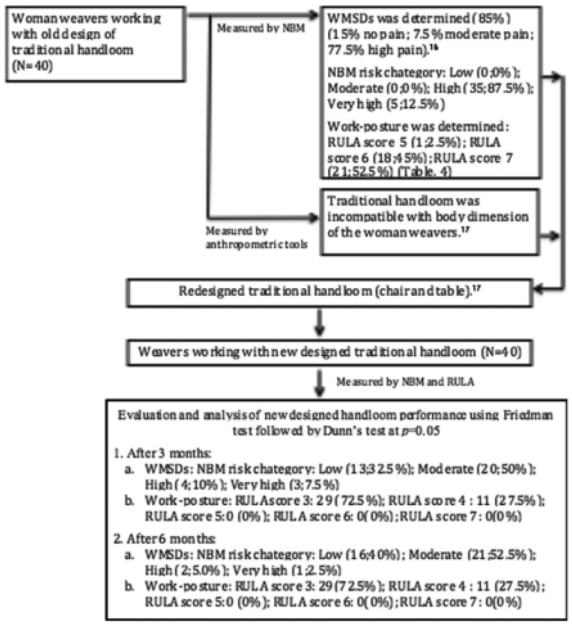


**Figure 3:** Research flowchart. WMSDs: Work Musculoskeletal disorders, RULA: Rapid Upper Limb Assessment, NBM: Nordic Body Map

**Table 7: Effect of new design traditional handloom introduction on Nordic Body Map score and risk category of a female weaver**

| NBM risk category | Using old handloom, *n* (%) | Using new design handloom | | *P* |
|---|---|---|---|---|
| | | After 3 months, *n* (%) | After 6 months, *n* (%) | |
| 0 (low) | 0 | 13 (32.5) | 16 (40.0) | |
| 1 (moderate) | 0 | 20 (50.0) | 21 (52.5) | |
| 2 (high) | 35 (87.5) | 4 (10.0) | 2 (5.0) | |
| 3 (very high) | 5 (12.5) | 3 (7.5) | 1 (2.5) | |
| Median ($\tilde{X}$) | 2[a] | 1[b] | 1[b] | <0.001 |

NBM scores derived from 28 body parts. The risk category of 0 (low), 1 (moderate), 2 (high), and 3 (very high) is leveled by NBM score of 0-20, 21-41, 22-62, and 63-84, respectively. The data were analyzed by Friedman test followed by the comparison test. The median in the column within each "NBM score" or "risk category" followed by different letters shows significantly different (Dunn's test, $P<0.05$). NBM: Nordic Body Map

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## Conflicts of interest

There are no conflicts of interest.

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