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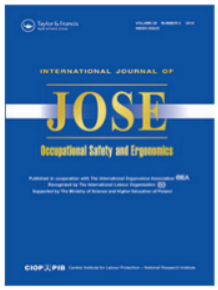

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Factors affecting musculoskeletal disorder prevalence among women weavers working with handlooms in Samarinda, Indonesia

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A cross-sectional study was conducted on 40 women weavers of Samarinda sarongs to identify the prevalence and risk factors of musculoskeletal disorders (MSDs). A Nordic body map, rapid upper limb assessment and anthropometric tools were used to plot the MSD severity, work posture and anthropometric dimensions of the weavers, respectively. The age, education background, working period and prolonged sitting position distributions of the weavers were collected by direct interview. Pearson's product-moment correlation was applied to identify correlations between the MSD prevalence and other parameters. An MSD prevalence of 80.5% was found among the women weavers, with the MSDs categorized as low, moderate and high in 15.0, 75.0 and 7.5% of the respondents, respectively. The MSD prevalence was significantly correlated with education background ($p = 0.025$), working period ($p = 0.015$), prolonged sitting hours ($p = 0.032$), work posture ($p < 0.001$) and weavers' anthropometry ($p < 0.001$).

Keywords: Samarinda sarong; traditional loom; *gedokan*; work posture; working period; prolonged sitting hours; anthropometry; ergonomic

1. Introduction

Like souvenirs such as *amplang* (fish cracker), *batik* printed fabrics with Dayak carving designs, *mandau* (a Dayak sword) and Dayak handicrafts, the Samarinda sarong is an iconic handicraft from Samarinda. This sarong, which has a square design in black and red colours, is identified with the Samarinda people. Samarinda sarongs have been produced since 1607 by the people of Samarinda [1] and are traded with the neighbouring country of Malaysia. Samarinda sarongs are produced by women weavers using a traditional loom called the *gedokan*, which is constructed from wood (Figure 1). Using a *gedokan*, a weaver needs 15 days to complete one sarong that is $200 \times 80\,cm^2$ in size. To date, the Samarinda sarong has been produced manually primarily to maintain its high artistic value.

The entire weaving process is performed manually, including the fibre colouring, yarn spinning and washing steps. The loom consists of four parts: the *unuseng* (spinning wheel), *saureng* (design instrument), appraising (yarn inserting instrument) and *pemalu* (yarn roller). The handloom dimensions are as follows: height 33 cm, foot height of frame 48 cm, length 156 cm, height of frame 114 cm, length of hand range to handloom 57 cm, width of hand grips to handloom 4 cm, height of foot support 50 cm, width of chair 35 cm, thickness of sitting pedestal on chair 5 cm and length of chair 36 cm.

Through initial observation, musculoskeletal disorders (MSDs) have been detected among women weavers who produce Samarinda sarongs. However, no study has investigated the factors responsible for MSDs among them. Factors such as non-ergonomic facilities and devices [2], high frequency of repetitive motion, high work load, unsuitable working position, vibration exposure and overwork are responsible for MSDs [3–6]. In Asia, MSDs have been detected in shoe craftsmen [7], potato processors [4], sugar cane [8] and palm oil farmers [9], dentists [10] and paramedics [11].

This study aims to investigate the prevalence of MSDs in traditional women weavers of Samarinda sarongs, to analyse the influencing factors and to find a proper way to overcome problems (i.e., MSD prevalence) for weavers based on the rules of ergonomics and the health and safety control hierarchy.

2. Methods

A cross-sectional study was conducted from May to September 2016 on all weavers (40 women) at the sole sarong producer in Samarinda in the East Kalimantan province of Indonesia. The MSD prevalence of the weavers was measured using a standardized Nordic body map questionnaire [12]. The questions included in the questionnaire were based on nine different anatomical body parts (e.g.,

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(a)

(b)

Figure 1. (a) Women weaver with handloom; (b) handloom to produce Samarinda sarongs.

neck, shoulder, elbow, wrist/arm, upper back, lower back, hips/thighs, knees and ankle/leg). The three questions asked were as follows: (a) have you had any MSD complaints (illness, pain, inconvenience and insensitivity) within the last 12 months; (b) have you had any difficulties with daily activities (inside and outside home) within the last 12 months; (c) have you had any MSDs in your body in the last 7 days?

Anthropometric tools and measurement sheets were used to determine the anthropometric measurements of the weavers in a sitting position for 13 body dimensions (body height, eye height, elbow height, thigh thickness, thigh

length from the buttocks to the knees, knee height, back knee height, shoulder width, hip width, length of elbow to the fingertips, thenar width, wide range of shoulder to the fingertips and waist width). The weaver anthropometric value is the value obtained from the sum of each body dimension measurement.

A rapid upper limb assessment (RULA) [13,14] is used to make a fast judgement on the work posture of the operator musculoskeletal system (OMS). Here, the RULA procedure was divided into three stages. (a) To develop a recording method, the OMS work posture was analysed on two body segments per group, i.e., group A (upper arm, lower arm, wrist and wrist twist) and group B (neck, trunk and legs). The OMS measurements in groups A and B are noted as the A and B scores, respectively. (b) The C and D scores were based on the use of muscle and force during activities and were obtained from the A and B scores, respectively. Each score was added to the muscle and force scores, respectively. (c) A grand score was developed by adding the C and D scores. The grand score guides the risk and action levels.

The first action level (low/value 1–2) indicates a negligible risk with no action required. The second action level (medium/value 3–4) indicates a low risk and suggests that change may be needed. The third action level (high/value 5–6) indicates a medium risk that requires further investigation and suggests that a change should occur soon. The fourth action level (very high risk/value >6) indicates a very high risk and that changes should be implemented immediately.

Pearson's product-moment correlation was applied to determine the correlations between MSDs and independent variables (age, education background, workload and body size). A normality test was applied prior to the product-moment analysis.

3. Results

The characteristics, working conditions and MSD prevalence among women weavers of Samarinda sarongs are presented in Table 1.

Most weavers were aged 44–50 and 30–36 years (15 and 12.5%, respectively). Elementary school was the dominant education background level of the weavers (52.2%), and 60% of the women weavers had less than 5 years of work experience. The highest proportion of the weavers reported prolonged sitting of less than 4 h (57.5%); however, 52.5% of the weavers had very high-risk working postures. The MSD prevalence was low, moderate and high for 15.0, 77.5 and 7.5% of the woman weavers, respectively. Pearson's product-moment correlation analysis showed that all of the characteristics observed for the Samarinda sarong women weavers were significantly associated with MSD prevalence except age (Table 2).

Table 1. Characteristics of Samarinda sarong women weavers ($N = 40$) and the associations between variables and MSD prevalence.

Variable	Number	%	r*	p*
Age (years)			0.226	0.160
23–29	4	10.0		
30–36	5	12.5		
37–43	14	35.0		
44–50	7	17.5		
51–57	6	15.0		
58–64	4	10.0		
Education background			0.608	0.025
Never went to school (elementary school, did not graduate)	6	15.0		
Elementary school (graduated 6th grade)	21	52.5		
Secondary high school (graduated 9th grade)	9	22.5		
Senior high school (graduated 12th grade)	4	10.0		
Working experience (years)			0.511	0.025
<5	10	25.0		
≥5	30	75.0		
Prolonged sitting (h)			0.904	0.032
<4	23	57.5		
≥4	17	42.5		
Anthropometric size			0.721	<0.001
Risk level based on work posture			0.663	<0.001
Negligible	0	–		
Low	0	–		
Medium	19	47.5		
Very high	21	52.5		
MSDs				
None	0	–		
Low	6	15.0		
Moderate	31	77.5		
High	3	7.5		

*Pearson's product-moment correlation coefficient; data normally distributed (Shapiro–Wilk test, $p = 0.814$).
Note: MSD = musculoskeletal disorder.

Table 2 presents the distribution of MSD prevalence for each body section. On average, 40.0, 17.5, 35.0 and 7.5% of the women had low, moderate, high and very high overall prevalence rates, respectively. Low MSD prevalence rates were reported for the elbow, ankle, arm, knee, wrist, buttocks, leg, lower hand, upper hand, bottom, thigh and shoulder (100, 77.3, 65.0, 57.5, 52.5, 37.5, 25.0, 22.5, 20.0, 17.5, 12.5 and 7.5%, respectively). Moderate MSD prevalence rates were reported for the upper hand, wrist, neck, ankle, thigh, back/buttocks/knee, leg, shoulder, waist and bottom/calf (30.0, 25.0, 22.5, 21.3, 20.0, 17.5, 15.0, 12.5, 10.0 and 7.5%, respectively). High MSD prevalence rates were reported for the calf, shoulder, waist, thigh, lower hand, back, bottom, upper hand, leg, neck and wrist (72.5, 62.5, 60.0, 55.0, 47.5, 47.5, 45.0, 37.5, 30.0, 29.8

Table 2. MSD prevalence levels of women weavers working with traditional looms to produce Samarinda sarongs.

	MSD prevalence			
Body section	Low	Moderate	High	Very high
Neck				
Upper	24 (60.5)	7 (17.5)	9 (22.5)	0 (0.0)
Lower	11 (27.5)	11 (27.5)	15 (37.5)	3 (7.5)
Shoulder				
Left	5 (12.5)	5 (12.5)	25 (62.5)	5 (12.5)
Right	5 (12.5)	5 (12.5)	25 (62.5)	5 (12.5)
Hand				
Upper left	10 25.0)	12 (30.0)	15 (37.5)	3 (7.5)
Upper right	10 (25.0)	12 (30.0)	15 (37.5)	3 (7.5)
Lower left	15 (37.5)	6 (15.0)	19 (47.5)	0 (0.0)
Lower right	15 (37.5)	6 (15.0)	19 (47.5)	0 (0.0)
Elbow				
Left	40 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)
Right	40 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)
Hand wrist				
Left	23 (57.5)	10 (25.0)	7 (17.5)	0 (0.0)
Right	23 (57.5)	10 (25.0)	7 (17.5)	0 (0.0)
Arm				
Right	26 (65.0)	6 (15.0)	8 (20.0)	0 (0.0)
Left	26 (65.0)	6 (15.0)	8 (20.0)	0 (0.0)
Back	9 (22.5)	7 (17.5)	19 (47.5)	5 (12.5)
Waist	3 (7.5)	4 (10.0)	24 (60.0)	9 (22.5)
Buttocks	21 (52.5)	7 (17.5)	10 (25.0)	2 (5.0)
Bottom	8 (20.0)	3 (7.5)	18 (45.0)	11 (27.5)
Leg				
Left	21 (52.5)	6 (15.0)	12 (30.0)	1 (2.5)
Right	21 (52.5)	6 (15.0)	12 (30.0)	1 (2.5)
Thigh				
Left	7 (17.5)	8 (20.0)	22 (55.0)	3 (7.5)
Right	7 (17.5)	8 (20.0)	22 (55.0)	3 (7.5)
Knee				
Left	23 (57.5)	7 (17.5)	8 (20.0)	2 (5.0)
Right	23 (57.5)	7 (17.5)	8 (20.0)	2 (5.0)
Calf				
Left	0 (0.0)	3 (7.5)	29 (72.5)	8 (20.0)
Right	0 (0.0)	3 (7.5)	29 (72.5)	8 (20.0)
Ankle				
Left	32 (80.0)	8 (20.0)	0 (0.0)	0 (0.0)
Right	31 (77.5)	9 (22.5)	0 (0.0)	0 (0.0)
Mean	16 (40.0)	7 (17.5)	14 (35.0)	3 (7.5)

Note: Data presented as frequency (%) of sample with specific MSD type. $N = 40$ women weavers. MSD = musculoskeletal disorder.

and 17.5%, respectively). Very high MSD prevalence rates were reported for the bottom, waist, calf, back/shoulder, upper hand/lower neck/thigh, buttock/knee and leg (27.5, 22.5, 20.0, 12.5, 7.5, 5.0 and 2.5%, respectively).

Pearson's product-moment correlation analysis for the association of anthropometric size with MSD prevalence is presented in Table 3. All variables were significantly associated with MSDs except the eye and elbow height,

Table 3. Association between anthropometric size dimensions and musculoskeletal disorders.

Variable	r*	p*
Body height in a sitting position	0.382	0.015
Eye height in a sitting position	0.271	0.091
Shoulder height in a sitting position	0.282	0.071
Elbow height in a sitting position	0.072	0.660
Thighs	0.080	0.622
Length of the thighs from the buttocks to the knees	0.278	0.082
High knee	0.205	0.205
High folding knees	0.975	0.005
Shoulder width	0.405	0.010
Hip width	0.453	0.003
Elbow length to fingertips	0.373	0.018
Wide palms	0.314	0.048
Distance range from shoulder to fingertips	0.302	0.058
Waist width	0.508	0.001

*Pearson's product-moment correlation; data normally distributed (Shapiro–Wilk test, $p = 0.702$).

sitting position, thighs, high knee and distance range from shoulder to fingertips.

4. Discussion

4.1. *MSD prevalence*

The MSD complaint prevalence was relatively high among women weavers of Samarinda sarongs (85%) and was dominated by moderate-level MSDs (75%). Complaints of very painful (4 based on a score of 1–4) musculoskeletal issues were mostly found for the bottom, waist and calf. Complaints of musculoskeletal pain (score 3) were mostly found for the shoulders, waist, thighs, calves and legs. Complaints of moderate musculoskeletal pain (score 2) were found for the bottom, neck, upper hands, wrist, thighs and ankle.

These results indicated that the MSDs experienced by women weavers of Samarinda sarongs were very serious and required immediate intervention. Weavers who experience MSDs may have low productivity. Similarly, Daneshmandi et al. [16] showed that MSDs were correlated with work fatigue and work productivity. All of the weavers in this study are housewives, and their MSD experiences may result in more severe injuries and interfere with their household management activities. MSDs have been correlated with work–life conflict [16] and broadly affect daily job activities [17].

In this study, MSDs were measured subjectively using the Nordic body map questionnaire. Although these measurements are considered highly sensitive [18], are acceptable for MSD assessments [19] and are the most commonly used tool for MSD evaluations [20], advanced research using objective measurements, such as medical examinations, is needed to justify the MSD experiences among these weavers.

4.2. Factors that affected MSD prevalence

4.2.1. Age of the women weavers

The age distribution of the women weavers in this study was dominated by the 44–64 age group (42.5%), followed by the 37–43 (35.0%) and 23–36 (22.5%) age groups. In this study, we showed that the age of the women weavers was not associated with MSD prevalence. This observation indicated that neither work experience nor the strength and resiliency of muscles affected MSD prevalence among women weavers of Samarinda sarongs. This MSD prevalence is contradicted by nature, because MSDs are more often found in the elderly due to the decrease in muscle strength and resiliency [21]. These results also contradict some reports about the association between the age distribution and MSDs [4,7,22,23]. This phenomenon is very interesting and should be proven by observing other communities of women weavers in other districts. Indonesia includes more than eight districts, each of which has a unique linen-weaving motif created by women weavers using a handloom.

This study showed that age was not associated with MSD prevalence in Samarinda sarong women weavers. This lack of an association may be due to the other four factors (education background, working experience, prolonged sitting and anthropometric size), which all affected MSD prevalence among the women weavers. People are thought to be more susceptible to severe MSDs in old age due to a physiological function decline. Okunribido and Wynn [24] reported that MSDs often occurred in old age due to differences in job demands and workers' physical workloads.

Therefore, determining the correlation between age and MSD prevalence in women weavers will be interesting when the other four factors are eliminated by activities, such as ergonomic training.

4.2.2. Education background

The education levels of the women weavers included the following: did not graduate elementary school, graduated elementary school (6th grade), graduated junior high school (9th grade) and graduated senior high school (12th grade). The women weavers' education backgrounds were dominated by the elementary school level (graduated 6th grade, 52.5%). In this study, we showed that education background was associated with MSD prevalence. Other studies have also reported that education background is associated with MSD prevalence [21,23]. These data support the consistency of the association between education level and health [25].

Better education can lead individuals to think more logically and rationally, and, thus, people tend to accept and implement new knowledge or experiences [26]. This finding will be a very interesting topic for investigation in the case of Samarinda sarong women weavers by introducing training to increase awareness about MSD prevalence. Indeed, previous studies [27–29] found that ergonomic training programmes for workers could prevent and manage MSDs.

4.2.3. Working experience

The Samarinda sarong woman weavers were divided primarily into two different categories, i.e., weavers with <5 years (25%) and ≥5 years (75%) of working experience. Working experience was associated with MSD prevalence. More working experience significantly lowered the MSD prevalence ($p = 0.025$). This finding is similar to the effect of the education background of the weavers described earlier. To reduce more severe MSDs due to an increased working period, the workload and working hours should be reduced and the weavers should receive adequate rest and proper work conditions [30].

4.2.4. Prolonged sitting

In this study, we showed that prolonged sitting by women weavers was associated with MSD prevalence. The handloom is not equipped with an adjustable chair. Prolonged sitting (in an uncomfortable sitting posture) was also associated with MSD prevalence among office workers in Qom Province, Iran [31], who also had no access to adjustable desks. To overcome this risk, stretching exercises are suggested to reduce the MSD severity in women weavers. Da Costa and Vieira [6] showed that stretching exercises had several beneficial effects on preventing work-related MSDs, whereas Gasibat et al. [32] reported that regular stretching exercises contributed to a reduction in discomfort/pain and an increased range of motion (ROM).

4.2.5. Anthropometry

Anthropometry is a body size dimension that is connected to the physical anthropology sub-category, body movement and muscle strength. Anthropometric data are used as a basic tool to design ergonomic workstations, equipment, furniture and clothing [5,22,33]. In this study, we found that the anthropometric measurements of the women weavers were associated with MSDs. The handloom workstation used by the Samarinda sarong women weavers is equipped with a chair of fixed dimensions, whereas the weavers have different body sizes (Figure 1). This forces the women weavers to adjust their body sizes to the size of the chair. Weavers with taller or shorter bodies than the chair need additional effort to adjust to the handloom chairs, which contributes to the MSD prevalence among the female Samarinda sarong weavers. The same conclusion was reported for public transport drivers [5] and for sand core making workers [33], for whom the discrepancy in furniture dimensions was also associated with MSDs.

We recommend the establishment of standard operational procedures, including with regard to work time, the provision of training on MSDs and the provision of ergonomic weaving equipment based on weavers' anthropometry to address the prevalence of MSDs among weavers.

4.2.6. *Work posture*

The work postures of the women weavers in this study were significantly associated with MSD prevalence ($p < 0.001$). The weavers' activities are monotonous movements that require lifting weights, twisting and bending. These data confirmed previous reports showing that work posture was significantly associated with MSD prevalence in Iranian hand weavers of shoe soles [7], Iranian hand-sewn shoe workers [22], white-collar workers in a Portuguese company [34], Iranian sugar-producing factory workers [3] and sand core-making workers in West Bengal [33]. A work posture involving lifting weights while twisting or bending can increase the MSD prevalence for the lower back, especially when the work is performed in a confined space [30].

This finding implies that construction of an ergonomic handloom based on the anthropometric measurements of a woman weaver's body is highly required to prevent adverse effects on the weaver's musculoskeletal system.

5. Conclusions

The MSD prevalence of women weavers of Samarinda sarongs is approximately 85% and is categorized as low, moderate and high for 15.0, 7.5 and 77.5% of the weavers, respectively. Skeletal muscle pain was detected mostly in the lower neck, shoulders, upper hand, bottom, waist, thigh, calf and ankle. These MSDs were associated with the education level, work experience, prolonged sitting, work posture and body anthropometry of the weavers. The handloom should be redesigned based on the anthropometry of the weavers, standard operational procedures should be developed and regular training should be provided to improve knowledge about MSDs and skill in using the handloom.

Disclosure statement

No potential conflict of interest was reported by the authors.

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