Factors Affecting Musculoskeletal Disorders in Silk Preparation Process Workers in the Silk Weaving Profession in Buriram Province

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Abstract

Musculoskeletal disorders in workers of the silk weaving professions have become a significant problem affecting production effectiveness. The objectives of this study were to explore the prevalence rate and factors affecting the musculoskeletal disorders of 400 female silk preparation process workers in the silk weaving profession in Buriram province. The data was collected by using questionnaires derived from the standardized Nordic questionnaire and the musculoskeletal disorders evaluation form developed by the Department of Disease Control, Ministry of Health, Thailand. The data were analyzed by descriptive statistics and binary logistic regression. The results revealed that 92% of the silk preparation professionals had problems with muscle pains mainly in their lower back and 91.75% had knees pain. Buttock and hip pain were experienced by 90.50% of the workers, and 90.25% had left and right shoulder pain. Factors affecting the musculoskeletal disorders were: 1) age, 2) working time, 3) break time, 4) reaching above the shoulder to pick up or hold the material, 5) continuous bending down of their heads to work, 6) hands or arms working in repetitive movements (for at least 30 minutes). Thus, this study identifies factors affecting MSDs among workers and gains a greater understanding of working posture according to ergonomics which may help in maintaining the health and safety of workers, and hence leading to increased work productivity and efficiency.

Keywords: Musculoskeletal disorders, Silk preparation, Ergonomics

Introduction

Musculoskeletal disorders (MSDs) are injuries or disorders of the muscles, nerves, tendons, joints, cartilage, and spinal discs. MSDs are a common health problem throughout the world and a major cause of disability. Common symptoms of musculoskeletal disorders include pain, weakness, stiffness, joint noises, and decreased range of motion (Cook & Burgess-Limerick, 2004). Most workers who participate in industries where the work involves pulling and pushing to move heavy objects, as well as repetitive movement, have MSDs causing compensation costs and loss of productivity in industrialized countries (Violante, Armstrong, & Kilbom, 2000). The economic loss due to the disorders affects not only the individuals but also the organization and society as a whole (Meenaxi & Sudha, 2012).

Lower-middle-income countries have recorded work-related injuries and deaths of their workers (Europe PMC Funders Group, 2013). The mortality rate in lower-middle-income countries (LMICs) is 10 times higher than in high-income countries (HICs). There were 24,396 unintentional occupational injury deaths in HICs and 303,997 deaths in LMICs, with many of those injuries occurring in the textile industry, with significant effects the economy of low-middle-income countries (Wu, Schwebel, & Hu, 2018). Textile industries are the

largest economic sector, with nearly 3.8 million handlooms 6.5 million workers, who are engaged in producing natural fiber fabrics like cotton, silk, and wool, as well as man-made and mixed fiber fabrics (Ahmad et al., 2013). The success of the textile industry depends on the health status of workers (Saha, Dasgupta, Butt, & Chattopadhyay, 2010). Workers in the garment units suffer from work-related musculoskeletal disorders such as carpal tunnel syndrome, forearm tendinitis, epicondylitis, bicipital tendinitis, lower back pain, neck pain, shoulder pain and osteoarthritis of the knees (Parimalam, Kamalamma, & Ganguli, 2006) workers generally suffer from various health issues such as respiratory problems, muscular disorders of the skeletal system, physical injuries, mental stress and skin disorders. Ergonomic studies have shown that factors such as poverty, lack of education, inappropriate food, inappropriate workstation, and too much working time raise the risk of MSDs (Goel et al., 2013). In Thailand, patients with Musculoskeletal Disorders attributable to their working condition numbered 100,743 persons in 2017 which was a rate of sickness of 167.22 per one thousand in the general population. This figure was an increase from the 2016 figure which was 81,226 persons, a rate of 135.26 per thousand in the general population. Most of these patients lived in the northeast of Thailand. (Department of Disease Control, Ministry of Health, & Thailand, 2017).

Silk is a fabric used to make beautiful cloth of a unique style. Weaving is an occupation everywhere in Thailand but is very prevalent in the northeast region (Bunchu, & Rakphong, 2012). The northeastern communities have created ways to weave silk using knowledge inherited over many generations. In Buriram province there are 18,086 agriculturists and manufacturers of silk and the value of silk sales approached 583 million Baht in 2018 (Integrated Provincial Group Management Committee Lower Northeast Provinces 1, 2019). The silk preparation equipment is rectangular, measuring 2 meters in width with a length of 2-8 meters, and is 1.5 meters high. Each silk preparation equipment consists of 10 Ruk-Fers, which are frames for preparing threads of warp before putting them on a loom for weaving. The work position of a worker in the silk preparation process depends on the worker swaying or walking back and forth to obtain the silk. It takes 115 minutes to prepare 2 Ta-kro of silk, which is a large piece of silk fabric 1 meters wide and 40 meters. To produce this, workers walk back and forth for a total distance at approximately of 4 kilometers which is highly fatiguing. Therefore, ergonomic principles have to be used to prevent MSDs (Chantaramanee, Taptagaporn, & Piriyaprasarth, 2014). The objectives of this study were to explore the prevalence rate and factors affecting the musculoskeletal disorders of silk preparation process workers in the silk weaving profession in Buriram province.

Methods and Materials

This research was a cross-section analytic study under the Human Research Ethics Number HEC-03-63-004. The sample of 400 female silk weaving workers in Buriram province was selected by a simple random sampling method. The data were collected with questionnaires derived from the Standardized Nordic questionnaire (Kuorinka et al., 1987) and the musculoskeletal disorders evaluation form developed by the Department of Disease Control. The data were analyzed by descriptive statistics and binary logistic regression.

The Instruments

The data was collected with questionnaires derived from the Standardized Nordic questionnaire (Kuorinka et al., 1987), which included questions relevant to musculoskeletal disorders. The questionnaires were verified by an expert as being relevant to assess the risk factors of musculoskeletal disorders (Van den Berg, Elders, de

Zwart, & Burdorf, 2009). The questionnaire consisted of: 1) personal information, 2) health status related to risk, 3) history in the field of work and hobbies (the activities after work), 4) symptoms related to musculoskeletal disorders, 5) workstation environment and 6) the prevalence of musculoskeletal disorders. This was to illustrate the factors affecting musculoskeletal disorders in workers in the silk weaving profession. Temperature, light, and sound measurements were conducted with environmental measuring tools with an accuracy rate of ±3.0%. The weight measurement was conducted with a digital weighing scale with an accuracy rate of 0.01, and the participants' heart rates were evaluated with the heart rate monitor, measuring beats per minute: bpm at 30, 60, 90, and 120, to test tiredness due to working and the level of energy used in working (Boontha, Pirunsan, & Khamwong, 2016). The data collection was during 2 periods of the day, between 09.00 and 11.00, and between 13.00 and 15.00. The data was analyzed using descriptive statistics and binary logistic regression. The significance level was set at Alpha (α) = 0.05, and the level of confidence was 95%.

Results and Discussion

1. Worker's background

The participating workers, all women, were aged 50-59 years. Of these, 69.50% had a BMI of 23.51, which means regular weight, 19.05% were overweight, and 3.00% were obese. Characteristic of workers, their work and break time, and number of work days are shown in Table 1.

Table 1 Worker's background in the silk preparation process of silk weaving group (n=400)

Age (Years)	20-29	30-39	40-49	50-59	60 and above
Number / percent	41 (10.25)	97 (24.25)	100 (25.00)	109 (27.25)	53 (13.25)
Minimum = 26, Maximum = 67, Mean = 50.04, standard deviation = 1.15					
BMI (kg/m2)	Less than 18.49	18.50-24.99	25.0-29.99	30.0-39.99	
Number / percent	34 (8.50)	278(69.50)	76 (19.05)	12 (3.00)	
Minimum = 18.03, Maximum = 33.69, Mean = 23.51, standard deviation = 2.85					
Working time (year)	1-5	6-10	11-15	16-20	21-25
Number / percent	31 (7.75)	107 (26.75)	198 (49.50)	61 (15.25)	3 (0.75)
Minimum = 2, Maximum = 24, Mean = 11.83, standard deviation = 1.48					
working time (Hours per day)	3-4	5-6	7-8	9-10	11-12
Number / percent	74 (18.50)	85 (21.25)	124 (31.00)	75 (18.75)	42 (10.50)
Minimum = 3, Maximum = 12, Mean = 7.67, standard deviation = 1.97					
Break time (Minutes per day)	30-60	61-90	91-120	121-150	151-180
Number / percent	182 (45.50)	140 (35.00)	23 (5.75)	34 (8.50)	21 (5.25)
Minimum = 30, Maximum = 160, Mean = 65.33, standard deviation = 1.33					
Number of work days (Days per week)	3	4	5	6	7
Number / percent	35 (8.75)	53 (13.25)	142 (35.50)	122 (30.50)	48(12.00)
Minimum = 3, Maximum = 7, Mean = 5.63, standard deviation = 0.82					

2. Workstation environment

Working conditions are defined as the environment occurring in the employee's working premises and the working areas, and include factors such as machinery, buildings, location, air ventilation, heat, light, and noise, as well as physical working characteristics of the employee. The results of workstation environment are shown in Table 2. The mean temperature of 32.04°C was higher than the standard level of temperature. Exposure to heat during work causes the body to sweat profusely, leading to dehydration. The dehydration results in a reduction of fluids outside the cells, increasing stress and affecting the abrupt functioning of the kidneys (Glaser, Lemery, & Rajagopalan, 2016; Borg, Bi, Nitschke, & McDonald, 2017). In addition, it leads to fatigue, weakness, inability to continue working, dizziness, irritability, insomnia, headaches, and muscle cramps. These symptoms are heat-related stress during work symptoms (Horie, 2013) which directly impacts both work efficiency and the safety of workers.

The working illumination was the environment that appeared in the working area of the worker. In this present study, it was found that the working illumination of the silk preparation process in the silk weaving profession in Buriram Province had an average of 274.62 Lux, which was below the standard (Ministerial regulations set standards for safety management and operations, 2016) and the employee is deemed to need to visually focus on a specific spot. The appropriate level of lighting helps to prevent accidents and improves work efficiency. However, excessive lighting may cause adverse effects on both work performance and the emotional state of workers because workers may poorly perform when they feel uncomfortable due to visual discomfort caused by factors such as glare, flicker, unstable lighting, or poor visibility (Boyce, 2014). Bright lighting can also affect work posture as workers may adjust their postures to control their visual performance, leading to inappropriate work ergonomics and may result in decreased productivity and health problems (Rea, 2013). Creating an environment conducive to efficient vision is important for increasing work efficiency and reducing eye strain, which could be a contributing factor leading to accidents (Saruda, 2020). Therefore, the working light in the workstation should be between 300-400 Lux. According to a study by Subramaniya, & Jothi (2017), it was found that the standard level of lighting leads to safety in the workplace and reduces work accidents because the standard level of illumination relieves and prevents operator eye strain and headaches.

The mean value of noise in the area of the workplace rate was 49-72 A-weighted decibels (dBA) which were within the standard level (Labor Protection Act, 2018). The mean value of the weight of silk weaving materials rate at 0.96 kg, which was within the standard level of weight since the average weight level not exceeding 25 kg for female employees (Labor Protection Act, 1998).

Table 2 Environmental factors (n=400)

factors	Temperature (°C)	Light (Lux)	Noise (dBA)	Weight (kg)	Heart rate (Beat Per Minute)
Mean	32.04	274.62	62.16	0.96	112.42
(Min - Max)	(25-36)	(216-367)	(49-72)	(0.30-1.63)	(90-122)
standard deviation	1.58	10.32	3.15	0.73	3.77

3. Prevalence of muscle pain, skeletal and muscular disorders

The results of prevalence, frequency, reduction and treating of muscle pain are shown in Table 3. 88.25% of the workers had muscle pains every day and 89.75% had muscle pains from the previous day. Most

of the workers (94.25%) took a break for 5-10 minutes when they felt tired. MSDs are characterized by lesions in muscles, tendons, joints, ligaments, bones, nerves, and the circulatory system (Jang, Koo, Know, & Song, 2014). There is a tendency for degeneration and inflammation of muscles and tendons, resulting in acute or chronic pain, reduced flexibility, and social participation limitations. These abnormalities may reduce the workers' quality of life (Punnett & Wegman, 2004).

Table 3 Prevalence, frequency, reduction and treating of muscle pain in the Silk preparation workers (n=400)

Factors	Number of members	Percentage
The frequency of muscle pains		
1. Muscle pains every day	353	88.25
2. Muscle pains 3-4 times a week	31	7.75
3. Muscle pains 1-2 weeks at a time	16	4.00
4. Muscle pains 1 time per month	0	0.00
5. Muscle pains 1-5 times per year	0	0.00
The frequency of muscle pains		
1. Muscle pains from the previous day	359	89.75
2. No muscle pains	41	10.25
Reducing of muscle pains		
1. Taking a break for 5-10 minutes	377	94.25
2. Taking a break for 1 day	20	5.00
3. Taking a break for 2-3 days	3	0.75
4. Taking breaks for 4-5 days	0	0.00
Treating muscle pains		
1. Massage with pain ointment	386	96.50
2. Going to the doctor	14	3.50

In 7-day period, workers were seen to have suffered MSDs in their lower back (92.00 % of workers affected), knees (91.75%) and shoulders (90.25%). The prevalence of skeletal and musculoskeletal disorders in the 12 months was lower back (92.00%), buttocks and hips (91.25%), right shoulder (91.00%) and left shoulder (90.75%) as shown in Table 4. This present results is consistent with the findings of Rithinyo, Mayai, and Loatong (2020) that workers in the silk weaving process experienced muscle fatigue primarily in the feet, ankles, buttocks, and lower back.

Table 4 The prevalence of skeletal and muscular disorders (n=400)

Data	7 days		1 year	
	Frequency	Percent	Frequency	Percent
Neck	157	39.25	163	40.75
Left shoulder	361	90.25	363	90.75
Right shoulder	361	90.25	364	91.00
Upper back	331	82.75	329	82.25

Table 4 (Cont.)

Data	7 days		1 year	
	Frequency	Percent	Frequency	Percent
Left upper arm	321	80.25	323	80.75
Right upper arm	319	79.75	318	79.50
Left elbow	303	75.75	300	75.00
Right elbow	304	76.00	301	75.25
Lower back	368	92.00	368	92.00
Left lower arm	200	50.00	203	50.75
Right lower arm	207	51.75	204	51.00
Buttocks and hips	362	90.50	365	91.25
Left hand and wrist	230	57.50	238	59.50
Right hand and wrist	262	65.50	267	66.75
Thigh	318	79.50	314	78.50
Knee	367	91.75	364	91.00
Calf	286	71.50	283	70.75
Foot and ankle	200	50.00	204	51.00

5. Factors affecting musculoskeletal disorders

The factors contributing to musculoskeletal disorders included age, working time, break time, reaching above the shoulder to pick up or hold the material, continuous bending down of their heads to work, and hands or arms working in repetitive movements continuously for at least 30 minutes, as shown in Table 5.

Table 5 Factors affecting skeletal and musculoskeletal disorders (n=400)

Factors	Crude OR	Adjusted OR	p-value
Age (Years)	2.957	4.031	0.027*
BMI (kg/m^2)	1.042	2.753	0.581
Working time (year)	2.872	4.338	0.304
Working time (Hours per day)	1.776	3.471	0.037*
Break time (Minutes per day)	0.984	2.049	0.029*
Number of work days (Days per week)	1.976	2.337	0.638
Complete focus on work for 3-5 minutes during weaving	1.754	2.872	0.753
Standing for more than half of the working time without changing position	1.691	2.558	0.579
Weighing down one side of the body	2.051	3.984	0.754
Reaching above the shoulder to pick up or hold the material	2.836	4.112	0.031*
The exertion of twisting their bodies back and forth during weaving	1.977	4.066	0.368
The continuous bending down of their heads to work	1.874	3.183	0.019*
Repetitive raised neck or back during weaving	1.997	3.284	0.359
Hands or arms working in repetitive movements (at least 30 minutes)	1.905	3.088	0.013*
The exertion of pressing or squeezing objects during weaving	1.556	2.983	0.563
Congenital disease	0.638	1.776	0.769

Table 5 (Cont.)

Factors	Crude OR	Adjusted OR	p-value
Work injury history	1.074	2.542	0.549
Taking medication regularly	1.491	2.871	0.334
Regular exercise	1.338	2.667	0.673
Smoking	0.658	1.993	0.876
Drinking alcohol	2.564	3.882	0.619
Constant			0.781

The musculoskeletal disorders were related to the age of the worker 4.031 times. The leading physical factors contributing to musculoskeletal disorders were as follows: 1) inappropriate work posture, 2) hands or arms working in repetitive movement, and 3) working time. Workers who were reaching above their shoulders to pick up or hold the materials were the most affected by musculoskeletal disorders at 4.112 times, compared with the workers who were working in different work positions. Also, poor work patterns and working environments impose unnecessary physical efforts, which reduce efficiency and productivity. The workers who continuously bend their heads to work had musculoskeletal disorders at 3.183 times. The worker's hands or arms working in repetitive movements (at least 30 minutes) had musculoskeletal disorders at 3.088 times compared with the samples who work in different postures. The study by Rithinyo (2017) which found that leaning over the shoulder to pick up or grab materials, as well as repetitive hand or arm movements, resulted in the most significant lower back pain. Moreover, the study on the work performance of workers in various stages of silk production reveals that the lower back is the most affected area for those experiencing muscle fatigue (Naz, Kwatra, & Ojha, 2015). The repeated movements of operators are related to lower back pain (Heneweer, Staes, Aufdemkampe, van Rijn, & Vanhees, 2011) which can be explained that repetitive movements can lead to cumulative injuries because the muscles do not have sufficient recovery time (Thitima, Napapit, & Sirisin, 2011). It was also found that working postures that deviate from ergonomic principles are correlated with lower back pain. This pain is attributed to the bending of the lumbar vertebrae, which increases movement between joints and lumbar vertebrae. Improving workstations based on ergonomic principles can reduce muscle fatigue, ultimately leading to a decrease in the time required for the silk production process (Rithinyo, Loatong, & Noyming, 2022; Rithinyo, Loatong, Maichum, & Parichatnon, 2022).

The workers worked for 7.67 hours per day, 5.63 days per week. Hence, working time per day was one of the factors affecting musculoskeletal disorders at 3.471 times. Also, the workers took a break of 65.33 minutes per day, and break time was a factor affecting musculoskeletal disorders at 2.049 times compared with the sample of the workers working in different positions. A recent study by Bernard (2020) also found that working continuously for more than 4 hours per day was associated with low back pain. This present study is in agree with the study by Massaccesi et al. (2003) that working continuously for more than 8 hours per day caused lower back pain, which caused the operator to lose interest while working (Balasundaram, Ashenafi, Ashok Kumar, & Senthil Kumar, 2017). Therefore, workers in the silk preparation process who stand for long hours need more breaks between work to reduce stress.

Effective analysis of working conditions must consider of the three crucial environments of physical, chemical, and biological factors. Therefore, creating a safe working environment and promoting good working

behavior among operators is crucial for achieving high-quality operations. The objective of operational ergonomics is to create and enhance a work setting that fits the worker, considering their physiological, behavioral, and psychological aspects, as well as their body proportions. An unsuitable working environment increases the risk of various diseases. These problems become even more severe when the work environment deteriorates further (Ivy, 1994). The long-term health of workers can also be affected by job boredom, resulting in chronic headaches, loss of appetite, and insomnia. According to Simachokedee and Chaikul (1997), the evidence in this present study suggests that fatigue significantly affects the amount and caliber of produce.

Therefore, the study of factors affecting musculoskeletal disorders in silk preparation process workers in the silk weaving profession in Buriram Province is useful for identifying factors affecting MSDs among workers and for understanding working posture according to ergonomics. This work may help in maintaining the health and safety of workers, and hence leading to increased productivity and efficiency.

Conclusion and Suggestions

The results indicated that the workers of the silk weaving professions suffered pain, weakness, stiffness, joint noises, and decreased range of motion each working day carried over from the previous days working conditions. These detrimental physical conditions were experienced in their lower back, knees, buttocks, hips, left and right shoulders. Factors affecting the musculoskeletal disorders found were: 1) age, 2) working time, 3) break time, 4) reaching above the shoulder to pick up or hold the material, 5) continuous bending down of their heads to work, 6) hands or arms working in repetitive movements (at least 30 minutes). To solve the problem of muscle pains, workers should take regular breaks for 5-10 minutes and should use a massage ointment or take medicine for body pain.

The research was beneficial in specifying factors affecting musculoskeletal disorders in workers of the silk preparation process. Future research will continue in this field of study in terms of work design and work improvement based on ergonomic principles as well as further investigation of problem of occupational health and safety, particularly the ergonomic design of workstations to support and improve workers' working posture.

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