ORIGINAL ARTICLE

Factors Associated with Work-related Musculoskeletal Disorders Risk among Bamboo Craftsman in Mojorejo Village, Ponorogo Indonesia

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ABSTRACT

Introduction: Work-related Musculoskeletal disorders (WMSDs) becomes the one of most-occupational problem and highly related to the individual and work factors. Eighty percent (80%) workers in the woven bamboo industry in Mojorejo Village dominated by middle aged workers (>40 years) that most of their producing activities are manually handled, without using machine or modern technology. Incompatibility work station, long working hours and repeated movement aggravated the WMSDs risk. This study aims to describe the WMSDs risk and determine its factors based on individual characteristics. **Methods:** There are 58 workers as respondents in this cross-sectional study. Data were collected and analyzed using quantitative method. Posture Exposure (PE) were measured using the QEC instrument. While the WMSDs risk were measured using PLIBEL. Individual factors (PE, Age, Working Period) related to WMSDs were analyzed using Multinomial Logistic Regression (95% CI). The Chi-square test were also used to compare PE rates among WMSDs risk levels. **Results:** Most respondents (48.3%) with 51-70% PE rate have a high level of WMSDs risk. While 27 % respondents with PE rate >70% have a very high level. The neck is the region most exposed to the WMSDs (score 15.5/very high level risk). PE rate is the only factor that significantly related to WMSDs risk (sig. = 0.043; Rsquare = 0.529; r =0.703). While the age and working period has no significant correlation (Sig = 0.859 and 0.851 respectively). **Conclusion:** Based on the result, immediate improvement required to be implemented. It is suggested to redesigned work stations adjusted to the workers posture and position.
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Keywords: WMSDs, Musculoskeletal Disorders, Work Posture, Bamboo Craftsmen, Woven Bamboo Industry

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INTRODUCTION

Musculoskeletal Disorders refer to simptoms caused by disorders or damage to the joints, ligaments or muscles. There are various types of MSDs depends on the region affected or injured. Over-stretching, heavy loads and repetitive activities are the most common causes for most types of MSDs (1). According to Graveling (2), occupational activity recognized as the major factor contributed to MSDs risk due to the intense or long-duration exposure in a human daylife activity.

Work-related Musculoskeletal disorders (WMSDs) is a term used to describe MSDs caused by work activities. WMSDs accumulatively have a major impact on the company and the worker's productivity (1). It is known to be the second leading cause of short-term or temporary illness after the common cold in the workplace (2). Based on Summers (3), WMSDs contribute to absenteeism in many working populations and becoming the one of most-occupational problem due to increased compensation and health costs, reduced productivity, and lower quality of life of the workers.

Work posture known to be most related to the risk of WMSDs (4). Work posture is an accumulation of position, weight of the load lifted, manual handling, repeated movement and static or dynamic position of the workers. Poor position, over-streched muscles, heavy, repetitive, and prolonged lifting can exceed the tolerable tissue stress limit, causing injury due to the overactivity or imbalance (5). Kristensen's research (6) shows that there is an evidences that changing position frequently could reducing a risk of owork related musculoskeletal problems. Static position have been signifficantly to be much more taxing than dynamic forces because of holding the body in the same position. During a static position, more than 50% of the body's muscles contreact to sustain the position agaisnt gravity (7-9).

However, most musculoskeletal disorders (MSDs) are characterized as multifactorial (1). Based on Da Costa (5), there are biomechanical, psychosocial and individual risk factors associated to WMSDs. Biomechanical factors including e heavy lifting, manual handling, repetitive movement, and every kind of awkward static or dynamic postures. Psychosocial fators identified as stress, low motivation, and high work dissatisfaction. While the individual risk factors are identified by older age, female gender, longer working period, smoking, obesity, and comorbidities. Every working activity usually has specific working posture that affect specific body region to WMSDs risks. In order to minimizing WMSDs effect, several programs and policy continuously improve in the most large companies. Meanwhile workers in Small to Medium Enterprises (SMEs) known tobe less prioritized as implementation subject in reducing WMDs risks (10).

One of the SMEs with the high risk factors of WMSDs is traditional creative industries due to the most of its productions are manually handled. Culture-based industries as part of the creative industries has a significant contribution to national economic growth in Indonesia (11). According to the data from the Ministry of Tourism and Creative Economy, in 2013, the contribution of the creative industry to GDP reached Rp 578 trillion where 11.8 million people were involved in creative industry employment and 3.1 million people of them hired in the craft industry (12). In some creative industry, not all products are mass-produced. Some of them are hand-crafting with a high artistic feel in the home industry. In Indonesia, home industry is mostly carried out by people in rural areas, where they only have small capital, and also do not have much network in their business (13).

One of the popular creative industry in Indonesia is woven bamboo-based handcrafts. The craft of woven bamboo is very familiar, frequently used and continuously produced because traditional packaging are more interested recently. The bamboo material is cheap and could be simply planted in all over rural areas (14). Producing bamboo handcraft has its own complexity since every part must be carefully made, mostly using manual equipment (15). Due to the less-applied technology, the operational production usually takes longer process depending on worker's skill and expertise.

In the Mojorejo village Jetis Ponorogo, East Java, woven bamboo industry has succeeded to employ local workers and improve the regional economy within 10 years. There are 40 families who were actively participated in the production process of woven bamboo crafts in Mojorejo Village. The products produced are besek, steamer, capil and chicken cage etc (16). Eighty percent (80%) workers in this industry dominated by middle aged workers (>40years old). Based on Diannita (16) working as a woven craftsman is less attractive to young people because their motivation is low to produce traditional products. The workers mostly work in a sitting position and make handicraft products for approximately 10 hours a day using makeshift tools and facilities. The 6 main variety of bamboo crafts produced in the industry including : Besek, cone steamer, basket, farmers hat and chicken cage. No job divission or activity so that the workers randomly did the entire stage to make a woven bamboo product. After choped bamboo tree were obtained, the production steps described in the table I.

Table I: The Production Process

Production Steps	Activity	Duration
Making sharpened and mashed bamboo sheets	Slice bamboo into sheets, mashed and sharpened it with a knife and sandpaer based on the size required in the products	± 2 hours/ 500 sheets
Making hard sheet product frame	Slice bamboo into hard sheets as a product frame for basket, hat and chicken cage	± 2 hours/ 20 sheets
Weaving bamboo sheets	Manually waving bamboo sheets into various form of the product	± 5 hours/ 20 woven sheets
Tie up woven sheet with frame	Manually tie woven sheet with a frame using ropes	± 10 minutes/ product

In a day, an average worker can make 10-15 woven bamboo products, depending on the type and complexity of the product produced. The salary obtainded based on the amount and type of product they can produce. There are no binding regulations, facilities or safety guarantees because the workers are voluntarily participated (17).

Based on biomechanical factors, statically bending in the sitting position and frequently involved manual handling are the common activity in the traditional woven bamboo craft industry. Working position and activities in the woven bamboo craft industry ilustrated in the Figure 1. Work that frequently supported by hand activity increase risk carpal tunnel syndrome, shoulder and neck pain (17, 18). While static sitting and bending position are biomechanical factors causing shoulder, neck and low back pain (19).

Based on the individual factors, working in the older age and long working period are two common characteristics among respondents. Age-related musculoskeletal disorders (MSDs) are characterized by loss of muscle strength, bone fragility, loss of cartilage strength, and reduced elasticity of ligaments (20). While working period related to the repetitive activities that continuously carried out for a long time. Static workloads may be acceptable in normal working hours (8 hours), but workers with 10 working hours per day, even with normal working week often proved to be an important factor regarded the developing of WMSD (21).

This study aims to describe the risk of WMSDs and determine its factors represented by working posture, age

Figure 1. The activity in the woven bamboo industry: (1) Making hard-shaped product frame, (2) Making sharpened and Mashed-bamboo sheets, (3) Waving bamboo sheets

Source : Muslih's documentation (18)

and working period among woven bamboo craftmens in Mojorejo Village. The results of this study could represent how workers in traditional creative industries are exposed to occupational risks that may affect their quality of life. It is hoped that further research or programs could determine the appropriate interventions to be applied based on the problems faced by SME's workers.

MATERIALS AND METHODS

Data collection and Respondents

The observational study with cross-sectional method was conducted to obtain entire data in this research quantitatively. The study involved all of woven bamboo craftsmans in Mojorejo Village who were joined in the Industry as a population consisting of 67 workers. Selected respondent qualify as a sample should been working for at least 5 years and had no injuries or chronic diseases in the last 10 years.

Even though targeting entire population, the missing in data collection was anticipated with require minimum sample size following the formula for finite population :

$$n = \frac{N}{1(Ne^2)}, (22)$$

with (n = minimum sample size required; N = total population; and e = tolerable error rate = 5% = 0,05).

so that the minimum sample size estimated as :

$$n = \frac{67}{1\ (67 \times 0.05^2)} = 57.38 \sim 58 \text{ respondents}$$

Due to the missing in data collection, there are 58 workers who were selected as respondents in this study. They were informed about the objectives and procedures of the study and voluntary participated as respondent by signing an informed consent.

Ethical Issue

This research has complied with the ethical guidelines set by the Ethical Research Publishing Committee and has been approved by the Review Board of the Harjono S Hospital Ethics Committee with the registered number 005421350212124202210040O/X/KEPK/2022. All respondents are voluntarily participate after they get a full explanation about procedures, benefits and consequences of the research so that there is no ethical isues in this study.

Variables and Instruments

The Posture rating score were measured using the Quick Exposure Check (QEC) questionnaire. Risk rating score obtained based on the complaints experienced in eight (8) components (Back, Shoulder/arm, Wrist/hand, Neck, Stable base, Vibration, Work pace and Environtmet) which is categorized into Low, Moderate, High and Very High risk. Rating score for each category described in the table II.

Table II: Risk Rating levels each region and activity in QEC

Exposure	Risk Rating (RR)			
	Low	Moderate	High	Very High
Body region				
Back	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	41-56
Neck	2-6	7-10	11-14	15-18
Activity				
Stable Base	1	4	9	
Vibration	1	4	9	-
Work Pace	1	4	9	-
Environment	1	4	9	16

While the Work Related Musculoskeletal Disorders (WMSDs) risk were measured using PLIBEL instrument. In the measurement process, the work condition and body region exposured (neck shoulder, upper back, elbows, forearm, hands, feed, knees and hips, dan low back) being evaluated to gain exposure risk in the percentage rates then categorized into four (4) level of exposure rates (≤40; >40 - 50 ; >50 - 70 ; and >70).

Validity and Reliability Test

There are no validity and reliability test for QEC since it objectively assumed and measured by observator team. The item validity of the PLIBEL was tested involving a

separate group consisting 30 samples with the similar characteristic as respondents in the study. Item validity determined based on the Pearson correlation between item to the total answers then compared to the r-table at df = 28 (n-2) and 95% CI. There were no droped out item (pearson correlation score was more than (≥) r-table) so that all items are qualify as valid.

The instrument reliability test also conducted to measure answer consistency among respondents based on the Cronbach Alpha score. In this study, the Cronbach Alpha score obtained is 0.868 or > 0.7 (23) so that the instrument interpreted as sufficiently reliable.

Data Analysis

Data were both descriptively and analytically processed. Microsoft Excel and Statistical Package for Social Sciences Software (SPSS) version 24.0 was used in most steps of data analysis. The multivariate analysis to determine factors (PE, Age and Working Period) related to WMSDs risk were analyzed using Multinomial Logistic Regression Model with 95% of Confidence Interval (CI). The Chi-square test also used as non-parametric test to compared PE rate among WMSDs risk levels.

RESULTS

Respondent's individual characteristics were described by age and work period in years. Table III describe the respondents distribution based on age and work period.

Respondent's age ranged from 35 to 76 years and the average respondents were 59.1 years. Based on the work period, the respondents has been working for at least 5 years and 8.6 years in average. Table IV showed the QEC measurement result described average score and level of the MSDs risk based on exposure source among 58 workers. The result of the table IV showed that each body region exposed to the risk of MSDs at least in the moderate level. The neck is the region most exposed to the risk of MSDs. Besides, table IV also shows descriptively the Posture Exposure rate and WMSDs risk level each category. Action level described the action needed based on the risk level. Posture Exposure rate shows a percentage of body regions are exposed to un-ergonomic position.

Table III: Descriptive data of the Age and Work Period

	Variables	
	Age (years)	**Work Period (years)**
Average	59.10	8.81
Min	35.00	5.00
Max	76.00	17.00
S.Deviation	9.26	2.97

Table IV: Muskuloskeletal Disorders Risk based on Body Posture, Activity and Risk Level of Exposure

Region and Activity Exposed	**Score**	**Risk Level**
Body Region		
Back	32.2	High
Shoulder/ Arm	30.8	Moderate
Wrist/ Hand	23.5	Moderate
Neck	15.5	Very High
Activity		
Stable Base	1.0	Low
Vibration	1.0	Low
Work Pace	3.7	Low
Environment	2.5	Low

Level/ Rate	**Action Level**	**n**	**%**
Posture exposure (%)			
≤ 40	Acceptable	0	0.0
> 40 - 50	Investigate further	0	0.0
> 50 - 70	Investigate further and change soon	33	56.9
>70	Investigate and change immediately	25	43.1
MSDs Risks			
Low	No action needed	0	0.0
Moderate	Action might be needed	5	8.6
High	Action needed immediately	37	63.8
Very High	Action needed urgently	16	27.6

In the posture exposure rate, it is known that the most of the respondents (56.9%) have 3rd level (51-70% exposure rate) of posture exposure and the rest of it (43.1%) have a higher level. The table shows that all of the workers have at least 51% or higher posture exposure rate of non-ergonomic position so that further investigation needed to determine change. While based on the MSDs Risks measured in PLIBEL, most workers have a high level (63.8%) of subjective MSDs risk level. There are 27.6% of respondents who have a very high level of MSDs risk level so that the actions are urgently needed.

Table V describe WMSDs risk factors based on the Posture Exposure, Age and Working Period. There are 3 predictor variables partially correlated to WMSDs in categorical score (1-4) including Posture Exposure, Age and Working period. Based on significant value, it is known that among all factors correlated to WMSDs, only Posture Exposure (Sig./p-value < 0.05) that is signifficantly qualify as a model predictor for WMSDs

Table V: Logistic Regression Model based on predictors to WMSDs

Variable	Pseude R-square	Sig. (2-tailed)	Model fit Final (Sig. 2-tailed)
(constant)	0.529	0.00*	0.00
Posture Exposure		0.043*	
Age		0.859	
Working Period		0.851	

* α < 0.05 ** α < 0.01

score. Meanwhile the Age and Working period has no significant effect to WMSDs risk (Sig > 0.05). Pseudo R square interpreted as the contribution of Posture Exposure to Increase WMSDs risk is 0.529 or 52.9 %. Since the posture exposure and WMSDs risk are often scaled as categorical, further analysis is non-parametically describe the crosstabulation between PE and WMSDs.

It is known that the most respondents (48.3%) with 51-70% posture exposure rate have a high level of WMSDs risks. While 27 % respondents with an exposure rate >70% have a very high level of MSDs risks. The table VI shows the pearson chi-square analysis (with the 95 % CI) between two variables. The p-value score of 0.00 (<0.05) shows that there are significant relationship between posture exposure rate and WMSDs risk variables with a correlation score 0.703. Likelihood ratio interpreted as the possibility of an increased WMSDs risk due to an increased posture exposure rate is 38.24 %.

Table VI: The chi-square test result between Posture Exposure and WMSDs risk

Indicators	Value
Pearson Chi-Square (p-value)	0.000
Likelihood Ratio	38.240
Spearman correlation	0.703
N	**58**

DISCUSSION

The results of this research descriptively indicate that there are non-ergonomic work stations and require immediate improvements. Based on the results of measuring WMSDs risk using the PLIBEL instrument shows that 63.8% workers need immediate action and the rest of 27.6% need urgent action, while the measurement of work posture using the QEC instrument shows that all respondents need an immediate improvement thorough investigation of working conditions. The findings in this study are very important as a management reviews to determine work stations improvements.

The neck and the back is the body region most exposed to MSDs risk. It might correlated to the frequently bending position in e long duration while working on making crafts. Wijayanti's (24) research also shows that handcraft workers experience severe neck complaints due to being in a bent position for too long while working. Schibye et a1 (25) studied the lack adjustment of sitting position is a risk factor highly correlated with subjective neck symptoms. Bernard (26) proved some evidence that repetitive hand or arms movements and static postures involving the neck or shoulder muscles contributed to the neck pain and disorders.

The high risk of musculoskeletal disorders among woven bamboo workers is also described in Sriagustini's research (27) which shows that the main ergonomic hazards for workers is non-ergonomic work station and lack of individual adjustment for ergonomic. Nugroho (28) conducted a similar study aimed at reducing WMSDs risk in the rattan weaving process at the Anggun Rattan UKM. One of the results of this research is that the weaving process in Anggun Rattan UKM has a high risk and needs to be improved. The results of the Nordic Body Map also indicate that the operator has musculoskeletal disorders, especially in the neck, shoulders, back and thighs.

The results of observations in this study indicate that all workers work in a static position with a narrow range of motion and perform repetitive movements continuously for approximately 5 hours. According to Carter (29) , if the muscles receive static loads repeatedly for a long period of time, it can cause complaints in the form of damage to joints, ligaments and tendons. These complaints are usually referred to as MSDs or injuries to the musculoskeletal system. Based on the study results which analyzed the posture variable as the only factor affecting WMSDs, it showed that the correlation between posture and WMSDs risk was strong (r = 0.70). WHO (x) determine main factors that are directly associated with MSDs among workers including: heavy loads, high force exertion, working in unfavorable body postures, monotonous repetitive movements, long-lasting loading and physical environmental conditions (7).

High muscle strength exertion affect in overstretching of used muscle tissue. High-intensity exertion are active within the body tissues particularly during lifting or carrying heavy objects (30). In addition, pushing, pulling, holding or lifting excess weight causes high-intensity muscle stretching problems. Handling heavy materials for over a long duration caused musculoskeletal failures if performed for several years (31). WMSDs risk in this study may also caused by frequently-repeated movements for a long work duration and long period, even if the weight of the objects handled or the forces produced are low (7). Under such condition, the same muscle region are strained for long periods or with a high frequency. Early fatigue, pain and possible injuries are the consequences.

Muscle load in a static posture is a condition in which muscles are tensed continuously for a long time to hold a certain posture. A characteristic of static muscle loads is that the muscles contract without the appropriate joint

movement being followed. If the muscles do not have the opportunity to rest during the condition, muscle fatigue can occur even at low strength levels. In addition, the static load causes a lack of blood circulation in the muscles (32). Monotonous repetitive movements with or without lifting for long periods of time can cause musculoskeletal disorders. Repetitive work occurs when the same body part is repeatedly activated and there is no possibility of at least a brief period of relaxation, or movement variation is impossible (33). Physical environmental factors such as temperature and climatic conditions can exacerbate the risk of musculoskeletal disorders. Furthermore, psychosocial influences such as unfavorable work demands, facilities, and support from coworkers can add to the effect of physical and psychological tension (34). A risk for disorders of the musculoskeletal system appears if the load and the functional capacity of the worker are not balanced (7). However, MSDs is known to be multifactorial which is difficult to determine overal factors in a single study. It is important to integrate data from different studies on factors that contribute to WMSD. In this way, the risk factors and level of evidence of their association with each WMSD can be evaluated.

This research might be represent condition among woven bamboo craftmens that needs a further study in another factors, since the various work condition in every working environments. The basic principle of ergonomic is to create an appropriate balance between the requirements of the work and the capacity of the working person, by either adapting the work to the workers by design of the respective work.

CONCLUSION

The result of this study prove that the most of the workers of woven bamboo packaging in Mojorejo Village, Jetis District, Ponorogo Regency experienced musculoskeletal complaints and need an immediate improvements. The neck is the region most exposed to the MSDs risk (score 15.5/very high level risk). Based on the result, work stations need to be redesigned adjusted to the workers posture and position. The finding in this research also proved that there are several occupational problems in the SMEs. Occupational health and safety management system policies should be rearranged so it could cover the entire working community, including workers in the SME

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