ORIGINAL ARTICLE

The Association between Batik Making Process with Electrocardiogram, Pulmonary Function, and Musculoskeletal Disorder in Batik Artisan

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ABSTRACT

Background: Batik making process produces smoke inhaled by batik artisans that may cause damage to cardiorespiratory function. Furthermore, it is performed in sitting position for a long period which can lead to musculoskeletal disorders. This study was designed to determine the association between the batik making process with an electrocardiogram, pulmonary function, and musculoskeletal disorder in batik artisan.

Methods: An observational study with cross-sectional design was conducted in Semarang between February-March 2015. Two groups each having 16 people, batik artisans exposed to smoke and unexposed subjects as control, were taken. Subjects' characteristics, exposure's characteristics, ECG test, and pulmonary function test were taken from each subject. While in 26 batik artisans, working position was assessed using RULA and musculoskeletal disorders by interview based on Nordic Body Map questionnaire.

Results: The analysis showed significant QT interval prolongation (p=0.037), but no significant PR interval prolongation (p=0.53) on batik artisans as compared to unexposed subjects. Therefore, batik artisans were at an eight-fold risk of having ECG abnormalities. The mean percentages of FVC (p=0.016), FEV_1 (p=0.038), and PEFR (p=0.037) were lower and impaired lung functions were higher (p=0.002) in batik artisan. Musculoskeletal disorder of batik artisans had a significant association with their working position (p=0.008) but insignificant with their working period (p=0,354).

Conclusion: Batik making process is associated with cardiorespiratory function and musculoskeletal disorder in batik artisan. Further studies are necessary to elaborate the mechanism of these associations.

Keywords: batik, electrocardiogram, pulmonary function, musculoskeletal disorders

INTRODUCTION

Batik is one of Indonesia heritage that gains interest from both domestic and abroad. Batik is unique due to its various patterns and colors, one of them is batik from Central Java. Batik industry is growing very rapidly. It is an art of cloth painting with batik wax melting. The process of making batik takes a long time, even for months[1]. Batik wax must be heated first on the stove until become liquid hot wax, then paint it with a pen-like tool called canting[2].

A study conducted by Balai Besar Teknik Kesehatan Lingkungan (BBTKL) Bantul demonstrated that the dominant gas in the batik wax melting smoke was carbon monoxide (CO)[3]. In addition, this smoke also contained NO_2, SO_2, CO_2, HC, H_2S, and particles[4]. These pollutants may cause disorder in biochemical and physiological processes in the human body[5]. Some of the pollutants in batik wax burning smoke are known to be cardiotoxic and affect the cardiac work. Exposure to CO, which is one of the gases with the highest concentration in the batik wax burning smoke, causes carboxyhemoglobinemia and hypoxemia leading to tissue hypoxia including the myocardium. Thus, the heart must pump more blood by increasing heart rate and stroke volume as compensation. In addition, CO also inhibits the enzyme cytochrome A3 mitochondrial oxidase, causing myocytes fail to extract ATP[6,7,8]. Another cardiotoxic gas, SO_2, modulates the calcium and potassium channel voltage in the myocytes and known to have a negative inotropic effect[9]. NO_2 and the particles are known to cause myocardial ischemia[10,11].

When the pollutant is inhaled by the artisan, it can cause acute or chronic damage to the lung tissue depending on the concentration of the pollutant, the length of exposure, and body susceptibility. If this process lasts long, it can cause occupational disease. Study of Anindyajati et al stated that 50% workers in batik industry "Melati" in Tegalayu Laweyan, Solo, who had worked for a long time and contacted directly with wax smoke, had respiratory problems. Workers in batik industry "Fatimah" in Songgalan, Solo also had the same problems, such as shortness of breath and their body is thin like a heavy smoker[3].

High concentration of pollutants cause an inflammatory response to the respiratory system characterized by decreased Forced Vital Capacity (FVC), forced expiratory volume in the first second (FEV1), and inspiratory and expiratory flow rates.[5] Cross-sectional study examining the effects of these substances on adult lung function showed that every 10µg/m^3 increase in SO_2 and NO_2 per year caused a 0.7% decrease in FEV1 in healthy subjects[12].

Batik making process is done while sitting for a long period and sometimes with hunched back. This kind of working position can lead to muscle tension which tends to cause a musculoskeletal problem either if it is done repeatedly or for a long period. Based on a study conducted by Indonesian Ministry of Health in 2005, the

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work-related disease was as much as 40,5% and from 482 workers in 12 districts in Indonesia, the musculoskeletal disorder was found to be the most common work-related disease (16%)[13]. One of the most common complains is Low Back Pain (LBP) that can be caused by several musculoskeletal abnormality, psychological disturbance, and inappropriate mobilization. Low back pain happens because the spine supports three times our weight when sitting compared to standing. Nowadays, most low back pain cases (90%) are caused by improper working position[14].

A study conducted by Bergquist-Ullman and Larsson stated that 217 workers who suffered from acute attack of low back pain had a chance of recurrent episode as much as 62% in a year and 18% in two years[15]. There is no accurate percentage of low back pain case in most countries, including Indonesia. As estimated, around 40% people above 65 years old in Central Java have suffered from low back pain (male: 18,2%, female: 13,6%)[16]. Low back pain affects the productivity of workers in this case batik artisans. A study conducted in 2003 stated that workers with low back pain had decreased productivity up to 60%[14].

Physical ergonomy is one study about working postures. As the working position being assessed, hopefully, it can lower the number of musculoskeletal disorders so that it can improve workers' productivity. The previous study by Ikrimah and Soleha assessed the association between working period and musculoskeletal disorders which didn't show a significant association[17,18]. While the study about working position and musculoskeletal disorders haven't been done.

The aims of the present study were to determine the association between the batik making process with electrocardiogram, pulmonary function, and musculoskeletal disorder in batik artisan.

MATERIALS AND METHODS

An observational study with the cross sectional design was conducted in two batik factories in Semarang, Jawa Tengah between February-March 2015. Study subjects were batik artisans as exposed group (n=26). The batik artisans included in this study had criteria of female, making batik cloth with canting in open space, aged between 20-60 years, the duration of work more than two hours in one day with a minimum working period of two years. Housewife that not exposed to any batik making process, aged between 20-60 years became control group (n=16). Subjects who had another job that might cause chronic smoke exposure, history and symptoms of cardiorespiratory disorder or trauma causing musculoskeletal disorders, smoking, alcohol consumption, or with congenital disorders were excluded from this study. The samples were selected by purposive random sampling. Ethical approval was obtained from the ethics review committee, Komisi Etik Penelitian Kesehatan Fakultas Kedokteran Universitas Diponegoro/ RSUP Dr. Kariadi Semarang. Written informed consent was taken before we did the interview and measurement.

Study variables: Subject's characteristics were collected using an interviewer-administered structured questionnaire. Exposures characteristic consisted of working position and period became the independent variable. The working position was assessed using RULA *Employee Assessment Worksheet* and the result was categorized as low risk (RULA 1-2), moderate risk (RULA 3-4), high risk (RULA 5-6), and very high risk (RULA 7). The dependent variables were pulmonary function, electrocardiogram, and musculoskeletal disorder. Pulmonary function consisted of Forced Vital Capacity (FVC), forced expiratory volume in the first second (FEV1), and Peak Expiratory Flow (PEF). FVC and FEV1 were measured by autospiro MIR spirolab II, while PEF by mini wright peak flow meter. The results were expressed in percentage (%). Electrocardiogram features, including mean PR intervals and QT interval measured by electrocardiograph. The results were expressed in milliseconds (ms). Musculoskeletal disorders were assessed with *Nordic Body Map* questionnaire. This questionnaire specifically marks the body from the upper neck down to the soles.

Statistical analysis: The mean difference between FVC, FEV1, PEF and the ECG image (PR interval and QT interval) of batik artisan with the control group were analyzed by unpaired t-test because the data was normally distributed. The correlation between exposure of batik wax burning smoke and lung function category of batik artisan, working position and musculoskeletal disorders, also working period and musculoskeletal disorders were analyzed by Chi-square test. The risk of moderate to severe lung function impairment was expressed as a prevalence ratio. While the association between the working period with lung function and musculoskeletal disorder were analyzed by Spearman correlation test because the data were not normally distributed. The p-value was considered significant if $p < 0.05$. Data were analyzed using SPSS version 21.

RESULTS

This study had been done to the batik artisans in UKM Batik Kanfer and Kampung Batik Semarang 16. There were only 26 out of 36 batik artisans eligible to be the subject. As a control group taken 16 people from the housewives who never exposed by batik wax burning smoke with adjustment of age. 16 out of 26 exposed batik artisans were compared with the unexposed control group in case of their cardiorespiratory function.

Subjects' characteristics: Subjects' characteristics including age, body mass index and working period can be seen in Table 1and Table 2

Cardiorespiratory Function: Based on the result of the unpaired t-test, there was a significant difference of percentage of FVC, FEV1, and PEF on batik artisan and control group (p = 0.016, 0.038, 0.037, respectively) (table 3). Based on chi-square test, there was a significant relationship between the exposure to batik wax burning smoke and subject's lung function categories (p= 0.002) with the prevalence ratio= 9 (table 4). It indicated that batik artisan (the exposed group) had 9 times the incidence risk of lung function abnormalities of moderate to severe. There was a significant negative correlation with moderate degree between working period and FEV1 percentage. Meanwhile, the correlation between the working period with the percentage of FVC and PEF was not significant (table 5). QT interval of batik artisan was significantly longer than the control group (p = 0.037) but there was no elongation of batik artisan's PR interval compared to control group (p = 0.53) (table 6).

Musculoskeletal disorder: Based on RULA *Employee Assessment Worksheet*, 22 subjects 84(62%) were categorized as workers with moderate risk and probably need correction (RULA 3-4). On the other hand, there were only 4 subjects 15(38%) categorized as workers with high risk and need immediate correction. The result of musculoskeletal assessment using Nordic Body Map questionnaire reported that more than half of the subjects had complained their lower back, followed by the left shoulder, left knee, and back correspondingly.

Musculoskeletal disorder which was assessed using Nordic Body Map questionnaire was then categorized into 2, ≤2 complains dan >2 complains. There were 22 subjects 84(62%) having complaint on more than 2 sites and on the other hand only 4 subjects 15(38%) having complaint on one or two sites.

Based on the chi-square test, there was a significant association between working position and sites of complaint with a prevalence ratio of 1.22 (p=0.008) (table 7). It means that subjects in high-risk group had 1.22 times the risk of having musculoskeletal disorders compared to moderate risk group.

There was an insignificant negative association between working period and musculoskeletal disorders in batik artisans (p=0.354). In addition, the correlation degree between working period and musculoskeletal disorders (r= -0.189) is categorized as very low degree correlation (table 8).

Table 1: Batik artisan's characteristic (n=26)

Characteristic	n	Median (Min-Max)	Mean ± SD (Min-Max)
Age	-		41,50 ± 12,26 (17-62)
Body Mass Index	-		25,73 ± 5,11 (17,2-34,1)
Working period	-	2 (1-10)	2,8 ± 2,05(1-10)

Table 2: Control group's characteristic (n=15)

Characteristic	n	Median (Min-Max)	Mean ± SD (Min-Max)
Age	-		43.0 ± 6.42(31-52)
Body Mass Index	-		25,9(20,8-44,6)

Table 3: Mean difference in lung function of batik artisan and control group

	Batik Artisan	Control group	p
FVC (%)	63.1 ± 10.18	70.9 ± 6.90	0.016*
FEV_1 (%)	68.8 ± 9.83	75.2 ± 6.43	0.038*
PEF (%)	88.0 ± 14.63	97.5 ± 9.52	0.037*

*p<0.05; unpaired t-test

Table 4: The relationship between exposure to batik wax burning smoke to the subject's category of lung function

Subject	Lung Function Category		p	PR (95%CI)
	Moderate Severe	Mild Normal		
Batik artisan	9(56.2%)	7(43.8%)	0.002	9(1.3-63.0)
Control group	1(6.2%)	15(93.8)		

P<0.05; n=number of subject; PR=prevalence ratio; CI: *confidence interval*

Table 5: The relationship between the working period and the lung function of the batik artisan

	Working Period	FVC	FEV_1	PEF
Working period	1.0 (p=1.0)	-0.36 (p=0.174)	-0.50* (p=0.047)	-0.04 (p=0.877)
FVC	-	1.0(p=1.0)	0.76(p=0.001)	0.20(p=0.449)
FEV_1	-	-	1.0(p=1.0)	0.25(p=0.353)
PEF	-	-	-	1.0(p=1.0)

*r=correlation coeficient; p=significant value (<0.05); spearman correlation test

Table 6: Differences between PR interval and QT interval of batik artisan and control group

Mean±SD (milisecond)	Subject		p
	Batik artisan	Control group	
PR interval	153.1±13.78	156.8±18.06	0.53
QT interval	393.8±22.4	377±18.59	0.037*

*p<0.05; unpaired t-test

Table 7: The association between working position and musculoskeletal disorder

Working position	Sites of complain		Total	*p*	PR (95%CI)
	>2	≤2			
High risk	4(15.4%)	0	4(15.4%)	0.008*	1,22 (1,004-1,488)
Moderate risk	18(69.2%)	4(15.4%)	22(84.6%)		
Total	22(84.6%)	4(15.4%)	26(100%)		

*p=significancy value (<0.05); PR=Prevalence Ratio; CI=*Confidence Interval*

Table 8: The association between working period and musculoskeletal disorders

	Work period	Musculoskeletal disorder
Work period	1.00 (p=1.0)	-0.189 (p=0.354)*
Musculoskeletal disorder	-	1.0 (p=1.0)

*r=correlation coeficient; p=significant value (<0.05); Spearman correlation test

DISCUSSION

The exposure of batik wax burning smoke caused impairment of lung function in batik artisan. It is shown by the lower of mean percentage of FVC, FEV1, and PEF in batik artisan compared to the control group. This was relevant with the study of Munthe et al in Kampung Batik Laweyan Solo which demonstrated that the mean value of lung function (FVC and FEV1) of the batik artisans who were exposed by batik wax burning smoke was lower significantly than the unexposed group[19].

Examination of lung function with autospiro and peak flow meter in this study showed that 9(56.2%) batik artisans suffered from moderate to severe abnormalities. It was significantly more than the control group which was only 1 subject (6.2%). Those who were categorized normal to mild abnormalities in batik artisans were less than the control group significantly 7(43.8%) and 15(93.8%), respectively. This was relevant with a study conducted by Agustina Lubis, et al, which stated that pulmonary function abnormalities were more common in women who worked in the batik industry (48%) than in the tanning industry (15.8%)[20]. Lam, et al in China also reported that there was a significant association between exposure to gas/fumes and dust in the workplace with an increased prevalence of chronic obstructive pulmonary disease (COPD) in Chinese adults who were not affected by smoking[21].

This study found the association between exposure to the batik wax burning smoke and lung function. Previous studies showed that the batik wax burning smoke containing acrolein and other products such as carbon monoxide, hydrogen cyanide, hydrogen chloride, formaldehyde, nitric oxide, hydrogen sulfide, and irritant gases. Inhalation of these materials may cause accumulation of gases and particles in the respiratory tract or lung parenchyma. In the respiratory tract, the diameter of the trachea would be smaller, tunica mucosa was thickened, edema and inflammation of epithel, mucus hypersecretion, and paralysis of the ciliary epithelium, causing accumulation of debris and airway constriction[3,4,19]. In the lung parenchyma, the accumulation of smoke caused thickening of the septum interalveolar, the diameter of the alveolar would be bigger, and damage of alveoli walls[22]. If both conditions occur chronically, it will lead to abnormalities in lung function that can manifest as a clinical disorder called occupational lung diseases such as asthma and bronchitis[19].

Spearman correlation test showed a significant negative correlation with medium degree between working period and FEV1 percentage. This demonstrated that the longer the work, the further decreasing of FEV1. Whereas, there were no significant correlation between working period with a percentage of FVC and PEF. Hence, the longer period of work wasn't always followed by a decrease of FVC and PEF.

Our findings are in contrast with the study of cement industry workers by S.A. Meo, et al in Pakistan. This study revealed that long period of work would increase the level of exposure to cement dust and further, it would cause abnormalities of lung function, such as FVC, FEV1, PEF, and MVV. The mean of FVC, FEV1, PEF, and MVV of cement industry workers who had worked for more than 10 years were lower significantly than the control group[23].

These contradictions are attributable to some factors. The batik artisans in this study had less variable working period. Thus, it was less represented the value of lung function over a certain period of work. In the study of S.A. Meo, et al, the number of workers for each category of working period were at least ten people.[23] Hulke, et al also showed that a decrease in airflow indicator such as PEF was only seen after workers at gas stations were exposed to gas pollutant for more than ten years[24]. While in this study, the decrease of PEF was less significant because the maximum period of work was only ten years.

In the cardiology function, changes in the duration of PR interval indicate an interruption of atrial depolarization. Extension of PR interval or AV block degree 1 is caused by delayed conduction in AV node or disturbance in His-Purkinje fiber. It is the marker of increased risk of atrial fibrillation[25].

This study didn't show the extension of PR interval on the batik artisan when compared with the control group. This was also reported by some previous studies. They stated that changes in PR interval were caused by several other factors including endothelial dysfunction and arterial wall stiffness, age, sex, heart rate, BMI, antihypertensive drugs, and autonomic nervous system[26,27].

On the contrary, there was an extension of QT interval on the batik artisan when compared with the control group. Similarly with this study, Baja E., et al. also stated that exposure to air pollution from vehicle fumes, which contained a wide variety of particulate pollutants, had a significant association with extension of QT intervals[28].

QT interval represents ventricular repolarization, a marker of ventricular arrhythmias, and associated with blood carboxyhemoglobin level. Exposure to these pollutants causes abnormal ventricular repolarization, defined as impaired ion channel function in myocytes. Chronic exposure of CO pollutants, in particular, increases the activation of the inflow (or decreases the inactivation of the inflow) or reduces the outflow of repolarization resulting in extension of the duration of ventricular repolarization which may continue as a ventricular arrhythmia[29,30,31]. Subjects with QT interval extension had an 8-fold higher risk for arrhythmias and cardiac arrest[32].

Another theory suggested that chronic exposure to these pollutants will lead to accumulation of pollutants in the airway and trigger oxidative stress and activate the reactive oxygen species (ROS) mechanism. Furthermore, it will release the proinflammatory cytokines that cause endothelial damage and myocardial inflammation. These cause a change in the function of the sodium and calcium channels which leads to the accumulation of positively charged ions within the myocytes which will further lead to extension of the duration of ventricular repolarization[28].

This study assessed working positions with RULA and assessed complaints of the musculoskeletal system with the Nordic Body Map questionnaire. All subjects in this study were 26 batik artisans in Semarang. The assessment of working position with RULA showed that 22 subjects (84,62%) categorized in moderate risk group and the other 4(15,38%) in high risk. This is similar to the previous study by Titin Isna Oesman on batik artisans in Sleman, where the biggest percentage belongs to moderate risk group (56%)[33]. As for the assessment of musculoskeletal disorder using Nordic Body Map questionnaire showed that the most complaint was on the lower back by 57,7%. This is also similar to the previous study saying that 9 out of 12 batik artisans (75%) complained about their low back pain[34]. Lower back pain is a pain syndrome in the lower back and is one of the work-related musculoskeletal disorders. Currently, 90% of low back pain cases are caused by abnormal working position[35].

There was a significant association between working position and category of musculoskeletal disorders. It is appropriate to the theory saying that working posture affected musculoskeletal disorders. There was no previous study that analyzed the association of working position and musculoskeletal disorders in general.

Working in a sitting position will provide more comfort. In addition to moving body weight, greater stability is achieved and energy expenditure will be minimal. The discomfort experienced by the worker in this sitting position is because of the tendency to lean forward. It will cause problems in the respiratory and gastrointestinal system[36].

The International Labor Organization (ILO) mentioned several postures that are categorized as odd postures, such as sitting without a back support, sitting without a lumbar support, sitting bending, and sitting with too much back lean forward. In addition to odd posture, there was also a static posture. Static posture was a fixed physical posture with minimal movement. This awkward and static position was found in batik artisan and caused disruption of the musculoskeletal system[36].

This study demonstrated an insignificant negative correlation between working period and musculoskeletal disorder complained by batik artisans. It can be concluded that the longer working period of an artisan would not always follow by the more sites of musculoskeletal disorders. The previous study by Ikrimah stated that there was no significant association between working period and musculoskeletal disorders (p =0.313)[17]. Besides, a study by Soleha also stated that there was also no significant association (p=0.439)[18]. The result of this study was not similar to the theory by Guo in his study. It stated that the longer period would be followed by more musculoskeletal disorders[37]. It was allegedly because the occupation of subjects from the previous study was different from this recent study. In addition, the batik artisans' working position had been through adaptation to be a comfortable position so that the musculoskeletal disorders were also minimal.

Our study had some limitations. For instance, the method used was cross-sectional method, which the data only included a small number of subjects with a minimum working period and conducted in a single time. The content of pollutants in batik wax burning smoke and exposure levels on batik artisan cannot be measured by researchers because of the limited budget.

CONCLUSION

In conclusion, batik making process can cause musculoskeletal disorder in batik artisan due to the improper working position. The exposure of batik wax burning smoke in batik artisan can cause abnormalities in their cardiorespiratory function. Batik artisans are more likely to have lower FVC, FEV1, and PEF; also an extension of QT interval than the unexposed control group. However, we didn't find an extension of PR interval of the batik artisan compared to the control group. Our findings were important to develop a standardized working position to repair the improper posture and prevent musculoskeletal disorders in batik artisans; also a universal precaution equipment and environmentally friendly batik candles for batik artisans. Health checks should be routinely performed to the batik artisans in order to detect organ function disorder and perform the early treatment. In addition, further comprehensive research is needed with larger samples, more similar working period among the workers, also measurements of content in batik wax burning smoke and the exposure of the subjects.

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