D. D. I. Daruis, D. Mohamad, N. K. Khamis*

RISK FACTORS AND PREVALENCE OF MUSCULOSKELETAL DISORDERS OF BATIK ARTISANS FROM BODY POSTURE AND HAND MUSCLE ACTIVATION

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SUMMARY: The batik industry as one of Malaysian cultural heritage is mainly located on the East Coast of Malaysia, particularly in the states of Kelantan and Terengganu. Most of the industry is home-based. Hence, the traditional batik work environment and tasks impose threats to the well-being of the artisans. This study investigates ergonomic issues and the prevalence of musculoskeletal disorders in two of Kelantan's batik industries. The artisans' natural working postures and the environments of the two places were observed and video recorded. Muscle activations on the wrist of the artisan doing the paint (canting) were imitated. Surface electromyography (sEMG) investigations were performed in the laboratory. A questionnaire survey was also distributed among craftsmen and artisans involved in the batik industry in Kelantan. Results illustrate evidence of the need to educate batik industries on ergonomic risk factors. According to the survey of 33 respondents, the most affected body parts are the waist (60%), back and feet (57%). The walkthroughs and site visits showed that batik making process demands awkward postures which include standing, precision handling of hand tools, trunk bending & rotating and overreaching repetitively between 4 to 8 hours. The Rapid Upper Limb Assessment (RULA) index obtained from the assessments ranges from 7-8. It was also shown from the sEMG data that trunk bending affects muscle contraction of the wrist during painting movement. Therefore, immediate interventions are required to improve batik artisans' postural working conditions, especially on the neck, trunk, legs, wrists and arms.

Key words: *Carpal Tunnel Syndrome, posture analysis, surface electromyography, RULA, muscle contraction, ergonomic, batik*

INTRODUCTION

These Javanese terms; ambatik or tritik, are said to be the origin of the word batik with a meaning of 'a cloth with little dots' *(Sunarya, 2016)*. Batik is a process of dyeing fabric by making use of a resist technique and currently, Malaysia is one of the leading countries in producing batik in Southeast Asia besides Indonesia *(Shaharuddin et al., 2021)*. Listed among the most preferred handicrafts in Malaysia, batik has grown in popularity among both residents and tourists. It is well-recognized that Terengganu and Kelantan have a large number of batik small-medium enterprises *(Nawi et al., 2020)*.

However, the industry is facing a few challenges and the biggest is the lack of interest among the younger generation to continue to grow the business *(Razali et al., 2021)*. One of the challenges includes the tasks demanded from batik productions that are all very manual and traditional *(Affanti and Hidayat, 2018)*. It is reported that the tasks induce musculoskeletal disorders *(Musa et al. 2000, Shaharuddin et al., 2021)* and the proce-

*Assoc. prof. dr. Dian D. I. Daruis, (dian@upnm.edu.my), Faculty of Engineering, National Defence University of Malaysia, Sg. Besi Camp, Kuala Lumpur, dr. Darliana Mohamad, Faculty of Creative Technology and Heritage, Universiti Malaysia Kelantan, Kota Bharu, Kelantan, dr. Nor Kamaliana Khamis, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Bangi, Selangor.

ss harms the environment *(Daud et al., 2022)* and the workers' skin *(Febriana et al., 2023)* from the use of chemicals in dyes and detergents. However, this paper will only focus on the physical risk factors and prevalence of musculoskeletal disorders at the batik-making sites.

If there are two or more ergonomics risk factors that may be present at one time, the higher the prevalence of Musculoskeletal Disorder (MSD). One has to understand the process of batik-making to understand the ergonomic risk factors faced by the artisan. In hand-drawn or canting batik making, before the canting process, the cloth which is usually 2 or 4 meters long, is stretched across frames with a fixed height. Canting or *'tjanting'* is the hand tool that is used to apply wax in lines and fine dots on the cloth to create batik designs. The cloth is tacked periodically along a wooden or metal frame to keep the material firm *(Yusof et al., 2013)*. The Malaysian batik artisan is known to perform the canting process while standing as opposed to the Indonesian artisan. The Indonesians make batik while sitting. According to a survey conducted in Kelantan, 60.2% of batik workers had reported experiencing musculoskeletal complaints, of which 41.0% expressed shoulder pain, 34.4% indicated lower back discomfort, and the remainder reported ankle pain *(Musa et al. 2000)*. A study in Terengganu suggested 64.5% MSD complaints came from the shoulders followed by sole 61.3% and upper back, hand & legs 51.6% *(Yusof et al., 2013)*. A study even concluded that all the batik crafters are in an urgent situation where MSDs are concerned and they all need ergonomic workstations immediately *(Arini and Haqi, 2021)*. Pramesti and Arini *(2022)* suggested that the significant factor that causes musculoskeletal complaints among batik craftsmen is the working period factor.

One of the most frequently used instruments for assessing the ergonomic risk of work-related MSDs is the Rapid Upper Limb Assessment (RULA) index *(DOSH, 2017, Vignais et al., 2013, Meksawi et al., 2012)*. The upper half of the body, with special emphasis on the neck, trunk, and upper limbs, are the focus of the subjective observation approach known as RULA *(McAtamney & Corlett, 1993, Dockrell et al., 2012, Vignais et al., 2013)*.

Since this study focuses on the hand painting or canting batik-making process, another pertinent issue is to investigate risk factors for the potential of carpal tunnel syndrome (CTS). Up to the recent knowledge of the authors, no batik-related literature has reported anything on EMG analysis. The handling of the canting tool is very precise and it is interesting to see the activation of the muscles involved in the pinch hand grip and prolonged static arm tasks. The closest reference that could be made to batik painting is art painting. It was shown that certain grip/wrist positions are directly related to the increased prevalence of CTS *(Agostinos and McLinden, 2016, Laoopugsin and Laoopugsin, 2012)*, de Quervain's disease and trigger finger *(Ryzewicz and Wolf, 2006, Andreu et al., 2011)*. Surface Electromyography (sEMG) emerged as a diagnostic procedure to assess the health of muscles and the nerve cells that control them (motor neurons); *(Jarque-Bou et al., 2021)*. The main objective of this study is to perform ergonomics analyses at two batik workshops in Kelantan, evaluate the risk factors and the prevalence of MSDs. Other than that, to study the muscle patterns during grasping and hand stroking of the canting tool & painting brush.

METHODOLOGY

A site visit to two Batik operators was carried out in mid-September 2022. Both batik companies are situated at Kota Bharu, the capital city of Kelantan state. Observations were focused on: i) the batik craftsmen or artisans' postures, ii) their workspace design which might have been the risk factors that cause musculoskeletal disorders, and iii) other ergonomic issues. Subjective evaluation was done before the site visit. It was conducted online, using Google Forms to 33 respondents from Kelantan's batik makers. The survey consisted of three sections: i) demographic information, ii) body discomfort survey and iii) stool design preference survey. Only the first two sections are relevant for this study.

Besides, visual inspection and video recording were carried out during the site visits. Guidelines on Ergonomics Risk Assessment at Workplace (DOSH 2017) were used and the result from the checklist for awkward posture was not alarming (only 4 out of 13 *"Yes"* checkboxes ticked). Hence, it does not require any further advanced asse-

ssment (the Guidelines suggested a minimum of 6 "Yes" checkboxes ticked as the requirement). Nevertheless, the repetitive motion checklist which body parts involved were neck, shoulders, elbows and wrists, suggests further investigation. Therefore, rapid upper limb assessment (RULA) analysis was used. Data was collected by observing two types of working postures. The first posture was while the arm was close to the body (not extended); (Figure 1) and the second posture was while the arm was extended (Figure 2).

Figure 1. Batik painting Posture 1 for RULA Assessment
Slika 1. Batik slikanje Stav 1 za RULA ocjenjivanje

Figure 2. Batik painting Posture 2 for RULA Assessment
Slika 2. Batik slikanje Stav 2 za RULA procjenu

Next, the sEMG study was carried out in the laboratory with one female subject. It is important to simulate the task in a controlled environment as there is too much noise that will be captured by the sEMG device on-site. A curve was drawn on white paper as a guide for the subject to move the wrist/hand and imitate the batik drawing/painting movement. This was done to ensure consistent movement of the hand muscle throughout six intervals. Two channels were used from a four-channel MegaWin EMG to record upper limb muscle activity. The muscle groups where the electrodes were attached are those are those which are involved in painting activities which include grip, wrist stability, activity at the elbow and shoulder flexion *(Agostinucci & McLinden, 2016)*.

The experiment procedure and the usage of sEMG on subjects were approved by the University's board of research ethics (JKEP17/2022). The subject first received a thorough explanation of the experiment's objective and procedure. The subject was instructed to use her dominant hand and follow a drawn curve on white paper in front of her to imitate the batik painting movement. This procedure was conducted within a time range of 10 seconds of each movement. Different posture situations were assessed as shown in Table 1.

Table 1. Postures involved in measurement

Tablica 1. Položaji uključeni u mjerenje

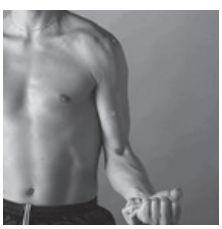
Trunk Bending 0°-45°	Arm Extension 0°-45°	Position 1
	Arm Extension 45°-90°	Position 2
Trunk Bending 45°-90°	Arm Extension 0°-45°	Position 3
	Arm Extension 45°-90°	Position 4

Both muscles were measured from the right side only, the dominant arm of the subject. The procedure for conducting the sEMG experiment was by the Surface Electromyography for the Non-Invasive Assessment of Muscles (SENIAM) recommendations. The identification of Biceps Brachii Long Head (BB) and Abductor Pollicis Brevis (APB) muscles and electrode placement position on the skin is depicted in Table 2.

Before the electrode placement, detailed skin preparation was done for the subject as shown in Figure 3. To prevent skin impedance and provide stable electrode contact, this procedure was required. Shaving was used to remove any extra hair from the skin, and then rubbing alcohol was used to clean the skin. The collected raw sEMG data were filtered through the band pass and notch filter process using MATLAB software. The bandpass filter consisted of two types that are the high pass and the low pass filter and for this experiment, the values were set at 20 Hz and 500 Hz respectively. While the notch filter cut-off frequency is set at 50 Hz (as according to SENIAM). After the process of data filtering, the filtered EMG signals were epoch according to segments. Epoch is a time window in a stipulated time used for analysis. In this study, epochs were taken for 10 seconds in every segment.

Table 2. Identification of muscle and electrode placement position

Table 2. Identifikacija položaja mišića i elektroda

Muscle	**Biceps Brachii Long Head**	**Abductor Pollicis Brevis**
Starting Posture	Sitting on a chair with the elbow flexed at a right angle and the dorsal side of the forearm in a horizontal downwards position.	Sitting or supine with the back of the hand stabilized on a table.
Electrode Placement	Electrodes need to be placed on the line between the medial acromion and the fossa cubit at 1/3 of the fossa cubit.	Slightly medial of the distal 1/4 of the 1st fossa metacarpi
Orientation		

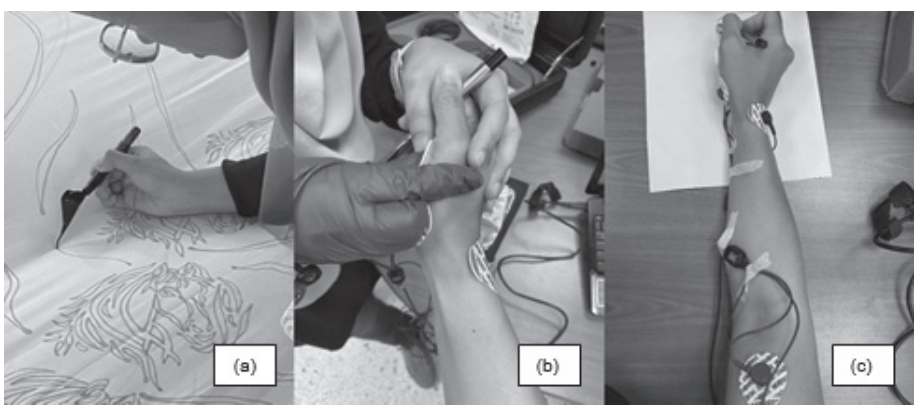


Figure 3. Imitating hand-wrist movement while painting as in (a), preparing the arm for sEMG in (b) and sEMG measurement in (c)

Slika 3. Imitacija pokreta šake i zgloba tijekom slikanja kao u (a), priprema ruke za sEMG u (b) i sEMG mjerenje u (c)

RESULTS AND DISCUSSION

Table 3 shows the demographics of the respondents for questions related to gender. The total number of female respondents who answered the questionnaire was 26 while the number of male respondents was 7, thus making the total number of 33 respondents. Most of the respondents are female and in the age range of 24 to 29 years. The nature of the batik industry is it is dominated by female workers. Besides that, the majority of the respondents had less than five years of experience working in the field of batik. More experienced workers are usually involved in guiding and teaching and not in production. From the survey, it is also shown that 60.6% of respondents are working in the batik painting sections.

Table 3. Demographics of the survey respondents

Tablica 3. Demografija ispitanika ankete

	Respondents	Frequency
Gender	Male	21.2%
	Female	78.8%
Age	18-23 years	18.2%
	24-29 years	54.5%
	30-35 years	18.2%
	36-41 years	3%
	42 years and above	6.1%
Working Experience	Less than 5 years	78.8%
	6-10 years	3%
	More than 11 years	18.2%
Work type	Batik stamping	21.2%
	Batik painting	60.6%
	Others	18%

Results from section B of the survey showed more than 50% of respondents worked between 4 to 8 hours and 18% worked for more than 8 hours. They also responded to the body pain and discomfort questions as illustrated in Figure 4.

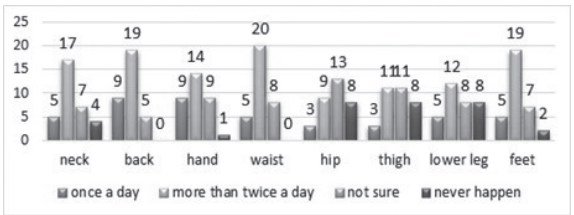


Figure 4. Discomfort as reported by the batik craftsmen and artisans

Slika 4. Neudobnost prema izvješćima obrtnika batika

Batik canting and painting require a lot of patience to produce good quality work. From the survey and interview during the walkthrough, each 2 to 4 meters of batik piece needed around 4-8 hours to complete. This explains Figure 4 finding where many respondents experienced discomfort in several parts of the body more than twice. It shows that batik workers in Malaysia are exposed to body discomfort while working due to the awkward posture and long hours (and usually continuous) working duration. The finding is almost similar to Yusof et al. *(2013)* in that the commonly affected area according to their respondents were shoulders, followed closely by the sole and the same response for back, hand and leg discomforts. Also, the working hours (more than 6 hours per day) were found to be contributing to their MSD symptoms. Thus, this proves that ergonomic intervention in batik industries is needed to prevent injuries and accidents in the future.

The RULA scores for each posture were calculated using the manual assessment worksheet by McAtamney and Corlett *(1993)* as shown in Figure 5(a) and (b).

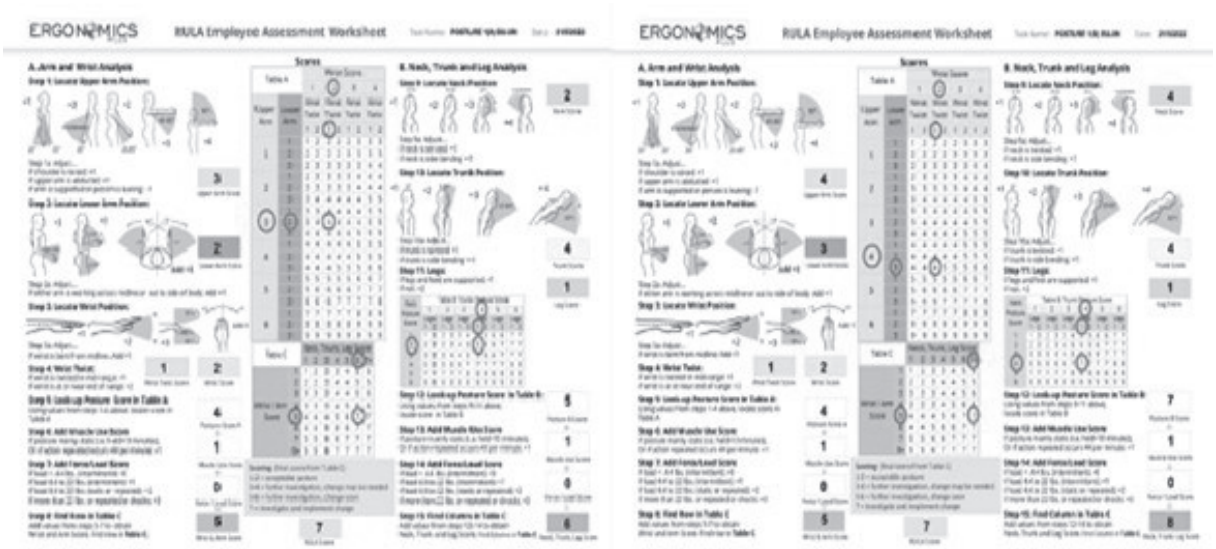


Figure 5. RULA Assessment Worksheet (a) Posture 1; (b) Posture 2
Slika 5. Radni list za procjenu RULA (a) Stav 1; (b) Stav 2

The results of RULA analysis are shown in Table 4 for every posture involved. It displays the wrist and arm scores along with the results for the neck, trunk, and legs. Table 1 lists the final results and necessary actions for each posture. The level of investigation or adjustments that must be made for each posture will be specified in the needed action for each posture.

Table 4. RULA Scores for Batik worker

Tablica 4. RULA rezultati za radnika batika

Posture	1	2
Wrist and arm score	5	5
Neck, trunk and leg score	6	8
Final score	7	7
Action	Investigation and changes are required immediately	

From Table 4, it is obvious that all postures require immediate action. To provide safe and comfortable working conditions for canting batik artisans, all working postures need to be improved. Based on the observation, the main causes of posture problems are the awkward outstretched hand position and the extreme trunk bending due to the position of the cloth that was too low and the long hours, continuous repetitive work. These could cause muscle and nerve discomfort to the craftsmen and artisans.

The muscle activity recorded can be depicted in Figure 6(a)-6(d) of both positions for muscle BB and muscle APB respectively. It could be seen that there are differences in muscle contraction when the work was done at different angles for trunk bending hip flexion-extension and arm extension posture. The peaks are formed when the wrist is extended and flexed to the maximum. The sEMG data showed consistent muscle contraction for BB muscle during the painting activity. A study suggested that although muscle damage-induced characteristics (pain, swelling, range of motion) were not correlated with neuromuscular impairments (muscle activation, force output), disruption of excitation-contraction coupling may have contributed to decrements in fatigue *(Behm et al., 2001)*. These results imply that muscle fatigue could interfere with grasping stability by altering the coordination and the control of force *(Hu et al., 2018)*.

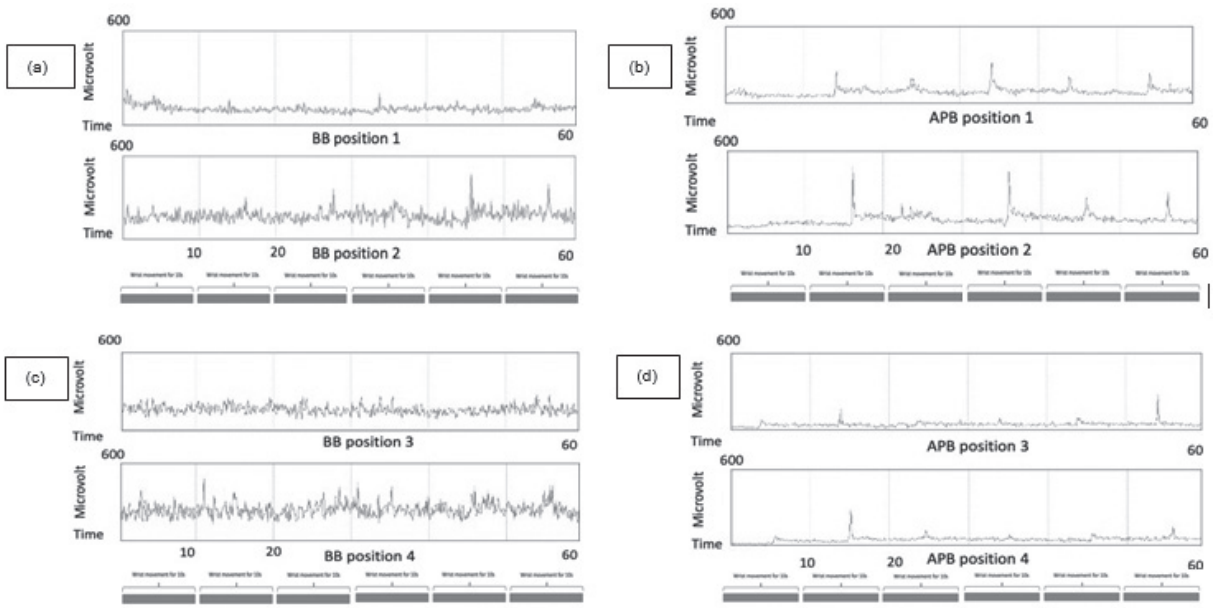


Figure 6. Schematic Representation of EMG for (a) BB muscle positions 1 & 2 (b) APB muscle positions 1 & 2 muscle (c) BB muscle positions 3 & 4 (d) APB muscle positions 3 & 4

Slika 6. Shematski prikaz EMG-a za (a) položaje BB mišića 1 i 2, (b) položaje mišića APB 1 i 2 mišića, (c) položaje mišića BB 3 i 4, (d) položaje mišića APB 3 i 4

It was also reported that hand rest and wrist support can successfully reduce specific upper limb muscle fatigue during prolonged typing. This leads to a muscle-selective reduction in the occurrence of fatigue. Which also provides direct evidence that they may prevent work-related musculoskeletal disorders *(Callegari et al. 2017)*. However, the recommendations might not be accurate for batik artisans. Mainly because they work with pliable and soft clothes that are unlike steady static surfaces like drawing canvas or keyboards.

Nevertheless, it is envisioned that with more ergonomic awareness, practices and recommendations, the occupational ergonomics among batik artisans could be enhanced. More importantly, designing an ergonomic workstation may prevent awkward postures and provide maximum comfort to the batik workers and consequently enhance productivity *(Yusof et al. 2013)*. Based on the observation and findings, the artisans need to reduce bending position by ensuring the cloth is not placed too far down. The cloth should be placed around the waist level of workers and this is dependent on the anthropometry of the specific batik organization.

CONCLUSION

Findings shows that awkward postures & prolonged standing and performing the canting & painting tasks are the risk factors identified at the two batik operators. The survey questionnaire found that more than 50% of the prevalence of MSD complaints were high at the upper and lower backs, including the feet. The result from the ergonomics risk assessment found that the final score for RULA is 7 which indicates high risk and needs immediate change. Muscle activation of the sEMG showed that the pinching grip of the canting tool and paint brushes was also a risk factor for MSD and CTS. Based on the findings, ergonomic awareness and intervention are urgently required for the batik industries in Malaysia.

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ČIMBENICI RIZIKA I UČESTALOST MIŠIĆNO-KOŠTANIH TEGOBA RADNIKA PRI RADU U TEHNICI BATIKA UZROKOVANIH POLOŽAJEM TIJELA I RADA MIŠIĆA RUKU

SAŽETAK: Industrija izrade batika dio je malezijskog kulturnog naslijeđa a pretežno je povezana sa istočnom obalom Malezije, i to države Kelantan i Terengganu. Većina rada obavlja se od kuće. Upravo zato, tradicionalni radni uvjeti i zadatci predstavljaju ugrozu za dobrobit majstora izrade batika. Istraživanje se bavi ergonomskim pitanjima i učestalošću mišićno-koštanih tegoba u dvije industrije batika u državi Kelantan. Položaji tijela pri radu i radna okolina na ta dva mjesta promatrani su i zabilježeni video snimkama. Imitirane su mišićne radnje ručnih zglobova radnika bojadisara tkanina. Površinska elektromiografska mjerenja (sEMG) provedena su u laboratoriju. Također je korišten i upitnik podijeljen radnicima u industriji batika u Kelantanu. Rezultati ukazuju na potrebu upoznavanja radnika u industriji batika s čimbenicima nastanka ergonomskih rizika. Kod 33 sudionika, najugroženiji dijelovi tijela bili su struk (60 %), leđa i stopala (57 %). Promatranje rada na samome mjestu pokazalo je da process izrade batika zahtijeva nespretne položaje tijela uključujući stajanje, precizno rukovanje ručnim alatima, savijanje i zakretanje trupa i istezanje na daljinu, i to u ponavljajućem ritmu tijekom 4 do 8 sati. Indeks brze procjene gornjih udova (RULA) dobiven iz opće procjene kreće se između 7 i 8. Također je vidljivo iz podataka sEMG-a da savijanje trupa uzrokuje kontrakcije mišića zapešća tijekom bojenja. Stoga je potrebno hitno provesti mjere kojima bi se smanjili napori pri naprezanju tijela, naročito vrata, trupa, leđa, zapešća i cijele ruke.

Ključne riječi: *sindrom karpalnog kanala, analiza položaja tijela, površinska elektromiografija, RULA, kontrakcija mišića, ergonomija, batik*

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