November-December 2019
ISSN: 0193-4120 Page No. 2191 - 2200

Posture Analysis of Workers in Bare Core Production Workers using the Index and Job Strain Method Assessment of Repetitive Task Tool

Indah Pratiwi*, Muhammad Huda Al Addin, Much. Djunaidi, Ratnanto Fitriadi
Department of Industrial Engineering, Universitas Muhammadiyah Surakarta, Indonesia
*Corresponding author: Indah.Pratiwi@ums.ac.id

Article Info
Volume 81
Page Number:2191 - 2200
Publication Issue:
November-December 2019

Abstract:
The study was conducted using the Job Strain Index (JSI) method and the Assessment of Repetitive Task (ART) tool to determine the risk of muscle injury arising from work activities carried out.The objects of this study were six workers at six work stations, namely: (1) cutting 1 workstation, (2) removal and cutting work station, (3) surface planner 1 work station, (4) surface planner 2 work station, (5) gang rip workstation, and (6) conveyor workstation. The stages in the JSI method are collecting 6 task variable data, namely: intensity of effort, duration of effort, effort per minute, hand/wrist position, work speed, and work duration per day. The stages in the ART Tool are (1) frequency and repetition, (2) hand strength, (3) awkward postures, (4) additional factors, (5) task score and exposure score, (6) presentation of the results.The results of calculations using the JSI method, from 11 work activities there are 5 work activities with the low-risk level and 6 work activities with the moderate risk level. The results of calculations using the ART Tool method, there are 6 work activities with the moderate risk level and 5 work activities with the high-risk level. Proposed improvements made are adding a table for surface planner 1 workstation and changing the chair design by adding chair height, adding footrests, and backrests for the body for surface planner 1 and surface planner 2 workstation. The results of the redesign of the workstation can reduce the score ART Tool up to 48%.

Article History
Article Received: *5 March 2019*
Revised: *18 May 2019*
Accepted: *24 September 2019*
Publication: *12 December 2019*

Keywords: *JSI Method, ART Tool, MSDs,Barecore Product*

1. INTRODUCTION

Musculoskeletal disorders (MSDs) are related to work and public health problems. MSDs begin to spread widely on workers in developing countries. The prevalence of MSDs varies from 15 to 42% (Meksawi et al. 2012) highest in informal workers. MSDs that occur around 65% of workplace accidents and have significant economic and social impacts (M.-ève Chiasson et al. 2012) result in reduced quality and work productivity. According to findings in some studies, the prevalence of MSDs is 10%; it is as high as 80% in others. MSDs are more common among women than among men. Although men and women may have the same job title, they still don't perform the same type of work tasks. Today, women are probably more often exposed to monotonous repetitive, and heavy work tasks than men, e.g. health care personnel, cashiers, cleaners, and sewing machine operators (Öztürk & Esin 2011). Ergonomic exposures cited commonly as risk factors for MSDs include

November-December 2019
ISSN: 0193-4120 Page No. 2191 - 2200

forceful and repetitive use of the hands and arms, and extreme postures (Marcus et al. 2002), movement repetitions, heavy workloads, vibrations, and awkward postures (M.-ève Chiasson et al. 2012), manual material handling (Meksawi et al. 2012), improper lifting methods (Lei et al. 2005), poor posture, repetitive and excessive force, lifting and carrying (Khandan et al. 2018).

According to (Choobineh et al. 2007) the understanding of ergonomic risk factors initially includes work stations, tools, equipment, work methods, work environment, individual characteristics of workers, metabolic needs (Balasubramanian et al. 2009), physical stress (Choobineh et al. 2011), and emotional stress (Westgaard 2000). Understanding ergonomic risk factors is important because there are indications of MSDs in the upper and lower limbs of the legs and arms (Roman-liu et al. 2014). Workers who have MSDs problems are advised by researchers to replace the manual work method using a load lifting aid. The role of this WMSDs study is to minimize the impact of musculoskeletal symptoms. Risk factors of musculoskeletal symptoms are known to include workplace activities such as heavy load lifting, repetitive tasks, awkward working postures and seated static postures (Choobineh et al. 2009) while individual characteristics, psychosocial and organizational factors are also known to be important predictive variables.

MSDs are among the most serious consequences of improper work-related musculoskeletal load (Roman-liu 2013). Symptoms of MSDs are defined as pain in one or more regions of the body. Accumulated minor injuries that result from repeated long-term work-related load can be considered the main cause of MSDs (Khandan et al. 2017). Research confirms a relationship between musculoskeletal load expressed as a function of parameters that describe posture, force and time sequences, and the incidence of MSDs (Roman-liu 2013).This means that a suitable work load can reduce the risk of developing MSDs. Biomechanical factors, posture and exerted force are the most important documented factors related to the workstation. Time sequences of load are important. That is why it is so important to correctly assess that load on the basis ofbiomechanical factors and the methods this can be done with (Roman-liu 2013).

CiptaMandiri is a plywood company with barecore production, with a production capacity of 100 pieces per day. Barecore is a rectangular piece of sengon wood with a thickness of 10.5 mm which is glued and arranged into a wooden board measuring 2500 mm long and 1260 mm wide. The company still applies the manual material handling (MMH) system and is repetitive. Work activities involve the work of the upper body, namely the hands, arms, neck, and back. Researchers evaluated the problem using the method of JSI method and ART tool, where both methods can be used to assess the risk of work activities for repetitive work in upper body posture.

JSI Method is a work evaluation method developed in 1995 by J. Steven Moore and ArunGrag, used to evaluate work that has the potential for musculoskeletal disorders in the Distal Upper Extremity (DUE) section (Kilbom 1994). According to (Moore & Grag 1995), this index is based on multiplication interactions between task variables, consistent with physiological, biomechanical, and epidemiological principles. Parts of his body are elbows, wrists, forearms, and hands. To describe and assess the level of risk experienced, there are 6 task variables used, namely: intensity of effort, duration of effort, effort per minute, hand/wrist position, duration of work per day, and speed of work.

Research on JSI has been carried out by (Pratiwi & Yunita, 2018) in the Batik Supiyarso industry, the results of the study show that

TEST Engineering & Management
November-December 2019
ISSN: 0193-4120 Page No. 2191 - 2200

ergonomic risk assessment based on the JSI method shows that 11 work activities are at a low-risk level or the work is safe and 5 work activities are at moderate risk level. (M.-È. Chiasson et al. 2012) conducted research in various industrial sectors in Finland using eight different methods to determine risk factors for work-related musculoskeletal disorders. The results of his research are the Hand Activity Level (HAL) method classifying 37% of workstations as low risk for hands and wrists compared to JSI with 9%. The highest correlation between Rapid Ulnar Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA), and between JSI and HAL.

The Assessment of Repetitive Tasks (ART) tool is a method developed by the Health and Safety Executive (HSE) in England, where this method is designed to assess the risk of work that requires repetitive movements of upper limbs. ART tool is suitable for some jobs involving upper body parts, work that is done repeatedly every few minutes, and work lasts at least 1-2 hours per shift (HSE 2010). Repeated work in question is a work activity that has a work cycle time or performs the same movement patterns in less than 30 seconds (Ferreira et al. 2009).

Research on ART Tool has been carried out by (Khandan et al. 2017) relating to complaints from MSDs of Opal Arc plate manufacturing companies in Kashan, the result is data analysis illustrating that 85.8% of workers stated that workers felt pain in one of their limbs. There was a significant relationship between pain position numbers and sex of workers ($p < 0.05$). The total exposure value based on the ART method is equal to 30.07 ± 12.43. The results of the ART method score indicate that 74.6% of the tasks are at a high level of risk. Other research by (Shokri et al. 2015) the presence of ergonomic disturbances due to repetitive manual work, the result is the MAC method score is 16% has a high-risk level and 44% is a moderate risk level.

From the background description above, the purpose of this study is to find out the level of risk of muscle injury based on the ART Tool and JSI method and how to recommend improvements to workers in the CiptaMandiribarecore company.

2. METHODOLOGY

2.1 Research Object

The object of this study was workers at six workstations making barecore in Klaten - Indonesia. This study looked at six work stations that use MMH, namely: (1) cutting workstation 1, (2) removal and cutting workstation, (3) surface planner 1 workstation, (4) surface planner 2 workstation, (5) gang rip workstation, and (6) conveyor workstation. The data needed for the JSI method are body posture data, work time data, work duration data, heart rate data. While the data needed on the ART Tool, namely: body posture data, work time data, work duration data, other factor data.

2.3. Data Processing using JSI Method

The steps taken in the JSI method are (Moore & Grag 1995): (1) Collecting data on 6 task variables in the strain index, namely: intensity of effort (formula 1), duration of effort (formula 2), effort per minute (formula 3) , hand position/wrist, work speed, and duration of work per day. (2) Determine the value of the multiplier by calculating the rating value, (3) Calculating the value of the Strain Index, all multiplier values obtained by each task variable are then multiplied to get the strain index value, (4) Presenting the risk value by analyzing the risk level of work based on the results of the value strain index.

TEST Engineering & Management

November-December 2019
ISSN: 0193-4120 Page No. 2191 - 2200

$$\%\text{Maximum Power } = 100\ x\ \frac{Required\ \ Strength}{Worker's\ Maximal\ \ Strength} \ldots \quad (1)$$

$$\%\text{Work Duration} = 100\ x \frac{Average\ \ Duration\ \ of\ Exertion\ \ per\ Cycle}{Average\ \ Exertional\ \ Cycle\ Time} \ldots \quad (2)$$

$$Effort\ per\ Minute = \frac{number\ \ of\ exertion}{total\ \ observation\ \ time} \ldots \quad (3)$$

2.4. Data Processing using *ART Tool*

There are six steps that must be done in implementing the ART Tool, table 1 where each variable in that stage is classified into 3 levels of risk (HSE 2010).

Table 1. Risk Level Classification (HSE 2010)

Color	Code	Explanation
Green	G	Low Risk Level
Amber	A	Moderate Risk Level
Red	R	High Risk Level

The stages in the ART Tool (HSE 2010) are: (1) Frequency and Repetition, consisting of 2 variables, namely: (a) A1-Arm Movement (b) A2-Repetition, (2) Hand Strength, by observing and measuring the level of strength and time needed by hand in carrying out a task, (3) Awkward postures, consisting of 5 variables, namely: (a) C1-Head / Neck Posture (b) C2-Back Posture (c) C3-Arm Posture (d) C4-Wrist Posture (e) C5-Hand / Finger Grip, (4) Additional Factor, consists of 4 variables, namely: (a) D1-Breaks (b) D2-Work Pace (c) D3-Other Factors, (d) D4-Duration , (5) Task Score and Exposure Score, obtained from the sum of 11 variables contained in frequency and repetition, hand strength, awkward postures, and additional factors (Formula 4 and Formula 5), and (6) Presenting Results (Risk Value) with analyze the level of Risk from work based on the results of the exposure value. There are three levels of risk, namely: (a) a low-risk level or safe work with an exposure value of 0-11, (b) a moderate risk level with an exposure value of 12-21, and (c) a high-risk level or hazardous work with an exposure value> 22.

Task Score = A1+A2+B1+C1+C2+C3+C4+C5+D1+D2+D3............. (4)
Exposure Score = *Task Score* x D4 .... (5)

3. RESEARCH RESULTS AND ANALYSIS

The production process is carried out on 11 work activities with six workstations and a total sample of workers of six people. The profiles of the six workers are: the first worker with a male sex, 174 cm in height, working at a cutting 1 workstation. The second to sixth worker is female with sequential height, namely: 147 cm, 150 cm, 144 cm, 140 cm, and 150 cm. Work in sequence for surface planner 1 workstation, surface planner 2 workstation, gangrip workstation, transfer and sorting workstation, and conveyor workstation.

A description of the workstation, work activities, body posture and pulse measured at the worker, can be seen in Table 2.

Table 2. Work Activities for Making Barecore and Pulse of Workers

No	Work station	Work Activities	Body Posture		Pulse (beat/minute)
			Right	Left	
1	Cutting 1	1.1 Taking wood from the floor	v	v	89
		1.2 Cutting wood using mitter saw machine	v	v	85
2	Surface Planner 1	2.1 Taking pieces of wood	-	v	97
		2.2 Inserting wood into the surface planner 1 machine	v	-	97

3	Surface Planner 2	3.1 Taking pieces of wood from surface planner 1 machine	-	v	92
		3.2 Inserting wood into the surface planner 2 machine	v	-	97
4	Gang Rip	4.1 Taking pieces of wood on the table	v	v	88
		4.2 Inserting wood into the gang rip machine	v	v	92
5	Removal and Sorting	5.1 Taking, sorting and removing core piece	v	v	93
6	Conveyor	6.1 Taking core piece from table to conveyor	v	v	87
		6.2 Organizing core piece in conveyor	v	v	85

Body posture is divided into two parts, namely right and left. The activity of taking pieces of wood and taking pieces of wood from surface planner 1 is not done by the right posture. The activity of inserting wood into surface planner 1 machine and inserting wood into a surface planner 2 machine is not carried out by the left body posture. The average pulse rate of workers is taken at 12.00 noon when workers will rest against six workers.

Image 1 is a cutting work station 1 with the activity of picking up pieces of wood done manually, the position of the body sitting on a chair and the left hand taking wood on the 1st floor.

Figure 1. Posture Work Activity of Taking Wood Pieces

Body posture in work activities to take pieces of wood that is workers take pieces of wood in a sitting position on a chair with the body bent forward position back to form an angle of 56.63 ° from a neutral position. The position of the neck forms an angle of 27.48 ° from the neutral position. The position of the left arm forms an angle of 57.56 ° from the neutral position. The position of the left wrist forms an extension angle of 9.69 ° (see Figure 1).

Data processing using the JSI method is: the intensity of the work pulse value is 97 beats per minute and get a multiplier value of 1. The duration of effort from the measurement results is 190 seconds and 105 seconds with a percentage value of 55.26% with a multiplier value of 2. Work per minute from the observations with a total time of 3.17 minutes, measured work of 64 times the value of work per minute of 20.21 times per minute with a multiplier value of 3.The position of the wrist forms an extension angle of 9.23 °, so the multiplier value is 1.Working speed with normal speed, so the multiplier value of 1. The duration of work per day is from 8:00 to 16:00 hours with a break of 1 hour or for 7 hours per day, the multiplier is 1 (see Table 3).

Table 3. JSI Method Assessment Results on Left Handwork Activities Taking Wood Pieces

Job Strain Index Method- Left Hand			
Variables	**Measurement**	**Rating Score**	**Multiplier Value**
Intensity of Work (beats / min)	97	1	1
Work Duration (%)	55.26	4	2
Work per minute	20.21	5	3
Wrist (°)	9.69	1	1

Work Speed	Work with normal speed	3	1
Duration (hour)	7	4	1
Strain Index Score			6

Based on Table 3 it can be explained that the SI score from work activities picks up pieces of wood at 6. This means that the work activities are categorized as having a risk of moderate injury or the work activity requires corrective changes but no immediate handling is needed (Moore & Grag 1995).

Data processing using ART tools included variable arm movements, repetition, hand strength, head posture, rear body posture, arm posture, wrist posture, finger grip, rest, work speed, other factors, and duration.

Table 4. ART Tool Assessment Results on Left Handwork Activities Taking Wood Pieces

Metode ART Tool – Kiri			
Variables	**Measurement**	**Color**	**Value**
Arm Movement	Frequently (for example regular movements with several pauses)	3	3
Repeating	More than 20 times per minute	6	6
Arm Force	There is no indication of any special effort	0	0
Head Posture	Bent or rotated during the half-time / more (> 40%)	2	2
Rear Posture	Bend forward, sideways or rotate for half time / more (> 40%)	2	2
Arm Posture	Far from body or not sticking to table for half-time or more (>40%)	4	4
Wrist Posture	Almost straight / in neutral position	0	0
Finger / Hand Grips	Wide finger grip or grip for some time (15–40%)	1	1
Break	3 jam hinggakurangdari 4 jam	0	6
Work Speed	Not hard to keep up to work	0	0
Other Factors	No factors existed	0	0
Duration	4 - 8 hours		1
Score			**24**

Table 4 showing that exposure value from work activities of the left hand from picking up wood pieces is 24. It means that work activities can be categorized as having a high risk of injury or that work activities need a quick action so it can get corrective changes (HSE 2010).

Recapitulation of the measurement results using the JSI method and ART Tool can be seen in Table 5.

Table 5. Recapitulation of Data Processing Results of JSI Method and ART Tool

Work Activities	**Type of Hand**	**Strain Index**		**ART tool**	
		Value	**Risk**	**Value**	**Risk**
1.1 Taking wood from the floor	Right	0.75	Low	14	Moderate
	Left	0.5	Low	14	Moderate
1.2 Cutting wood using mitter saw machine	Right	2.25	Low	21	Moderate
	Left	4	Moderate	20	Moderate

November-December 2019
ISSN: 0193-4120 Page No. 2191 - 2200

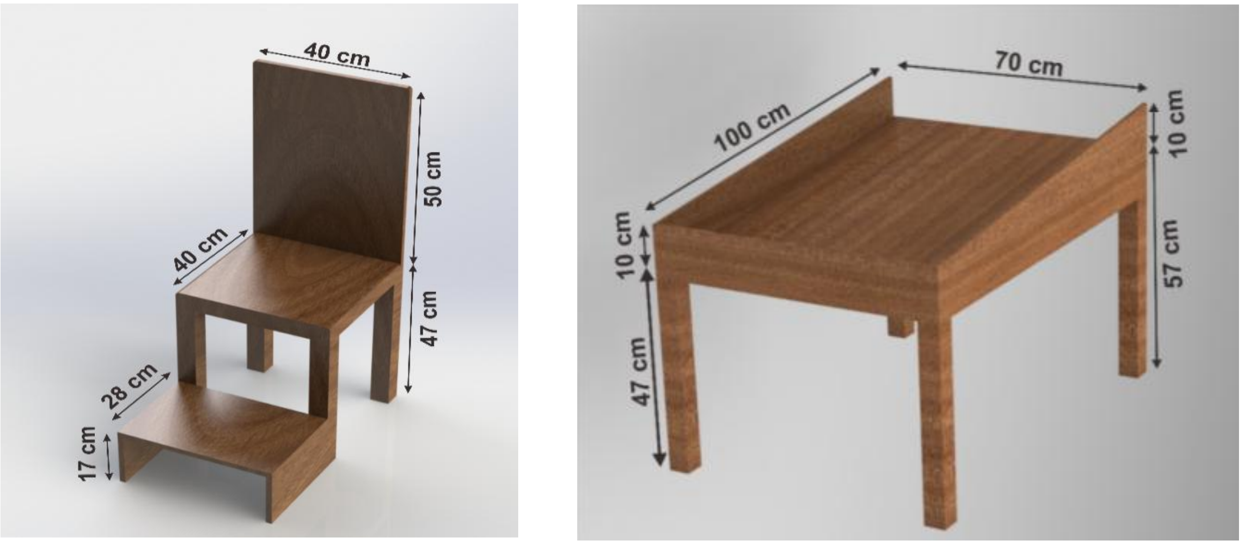
2.1 Taking pieces of wood	Left	6	Moderate	24	High
2.2 Inserting wood into the surface planner 1 machine	Right	6	Moderate	25	High
3.1 Taking pieces of wood from surface planner 1 machine	Left	4.5	Moderate	23	High
3.2 Inserting wood into the surface planner 2 machine	Right	3	Low	23	High
4.1 Taking pieces of wood on the table	Right	1	Low	13	Moderate
	Left	1	Low	13	Moderate
4.2 Inserting wood into the gang rip machine	Right	6	Moderate	21	Moderate
	Left	4	Moderate	16	Moderate
5.1 Taking, sorting and removing core piece	Right	6	Moderate	24	High
	Left	1	Low	16	Moderate
6.1 Taking core piece from table to conveyor	Right	1	Low	19	Moderate
	Left	1	Low	19	Moderate
6.2 Organizing core piece on conveyor	Right	1	Low	15	Moderate
	Left	1	Low	15	Moderate

Table 5 shows that there are 11 low risks with a score of 0.5-3.0 and seven moderate risks with a score of 4.0-6.0 using the JSI method. In the ART Tool, there are 13 moderate risks with a score of 13.0-21.0 and five high risks with a score of 23.0-25.0.

The highest score for the JSI method and ART Tool on the work station surface planner 1. Left-hand activity ie picking up pieces of wood with an SI score of 6 is in the medium category that requires corrective changes but does not need immediate treatment. An ART Tool score of 24 indicates a high level of risk or requires immediate treatment for corrective changes. The second highest score is for the JSI method and ART Tool on the work station surface planner 1. Right-hand activity ie inserting wood into surface planner 1 with an SI score of 6 is in the medium category that requires corrective changes but does not need immediate handling. An ART score of 25 indicates a high level of risk or requires immediate treatment for corrective changes.

In the JSI method has a moderate risk caused by the variable duration of effort and effort per minute to get a higher score than other variables, while the ART Tool has a high risk due to the variable repetition, neck posture, back posture, rest and arm posture get a high score than other variables.

Proposed improvements are made to reduce the risk of MSDs complaints. This requires a redesign of the work station by increasing the height of the chair and adding a table for a place to take pieces of wood. The initial height of the chair is 32 cm, the height of the machine surface planner 1 is 70 cm and the operator's height is 147 cm. The proposed improvements are: make a chair with a length of 40 cm, width 40 cm, and height 97 cm, the height of the seat mat 47 cm and height of the body rest 50 cm. Then, at the bottom of the chair is a footrest for foot length 40 cm, width 28 cm, and height 17 cm (see Figure 2 (a)).



(a) **(b)**

Figure 2. Design proposals on work station surface planner 1 (a) chairs and seating pads (b) tables where pieces of wood are placed

The next improvement proposal is to make a table to place pieces of wood with a slope angle of 6 degrees. The dimensions of the table are length 100 cm, width 70 cm, the height of the front leg 47 cm and height of the rear leg 57 cm. At the edge of the tabletop, a barrier is provided so that the piece of wood does not fall to the floor with a height of 10 cm (see Figure 2 (b)). The design of the proposed improvements will then be reassessed using the ART Tool method (see Table 6).

Table 6. Recapitulation of ART Tool assessment results after improvement

Work Activities	**Type of Hand**	**ART Tool Value**		**Reduction**	
		Before	**After**	**Value**	**Percentage (%)**
1.1 Taking wood from the floor	Right	14	10	4	28.57
	Left	14	10	4	28.57
1.2 Cutting wood using mitter saw machine	Right	21	17	4	19.05
	Left	20	16	4	20.00
2.1 Taking pieces of wood	Left	24	14	10	41.67
2.2 Inserting wood into the surface planner 1 machine	Right	25	13	12	48.00
3.1 Taking pieces of wood from surface planner 1 machine	Left	23	13	10	43.48
3.2 Inserting wood into the surface planner 2 machine	Right	23	13	10	43.48
4.1 Taking pieces of wood on the table	Right	13	9	4	30.77
	Left	13	9	4	30.77
4.2 Inserting wood into the gang rip machine	Right	21	17	4	19.05
	Left	16	12	4	25.00
5.1 Taking, sorting and removing core piece	Right	24	16	8	33.33
	Left	16	9	7	43.75
6.1 Taking core piece from table to conveyor	Right	19	15	4	21.05
	Left	19	15	4	21.05
6.2 Organizing core piece on conveyor	Right	15	11	4	26.67
	Left	15	11	4	26.67

November-December 2019
ISSN: 0193-4120 Page No. 2191 - 2200

Based on table 6 it can be explained that the highest reduction in ART Tool score is by 48% (12 points) in right hand work activities inserting wood in surface planner work station 1, while the smallest ART Tool score is by 19.05% (4 points) in right hand activity work to put the wood into the Rip Gang. The results of the redesign of the work station can reduce the highest ART Tool score by 48%.

4. CONCLUSION

The rresults of the MSDs assessment using the JSI method note that out of the 11 work activities studied there are five work activities that have a low or safe risk level and six work activities have a moderate risk level or require corrective changes but do not need immediate handling, while using ART Tool method there are five work activities that have a high level of risk or require immediate treatment for corrective changes and six work activities that have a moderate level of risk or require corrective changes but do not need immediate treatment.Proposed improvement is to add a table for surface planner work station 1 and change the chair design by adding chair height, adding footrests, and backrest for the body for surface planner 1 workstation and surface planner 2 workstation.

REFERENCES

[1] Balasubramanian, V., Adalarasu, K. & Regulapati, R., 2009. Comparing dynamic and stationary standing postures in an assembly task. *International Journal of Industrial Ergonomics*, 39(5), pp.649–654. Available at: http://dx.doi.org/10.1016/j.ergon.2008.10.017.

[2] Chiasson, M.-È. et al., 2012. Comparing the results of eight methods used to evaluate risk factors associated with musculoskeletal disorders. *International Journal of Industrial Ergonomics*, 42(5), pp.478–488.

[3] Chiasson, M.-ève et al., 2012. Comparing the results of eight methods used to evaluate risk factors associated with musculoskeletal disorders. *International Journal of Industrial Ergonomics*, 42(5), pp.478–488. Available at: http://dx.doi.org/10.1016/j.ergon.2012.07.003.

[4] Choobineh, A. et al., 2007. Musculoskeletal problems in Iranian hand-woven carpet industry : Guidelines for workstation design. *Applied Ergonomics*, 38, pp.617–624.

[5] Choobineh, A. et al., 2011. The impact of ergonomics intervention on psychosocial factors and musculoskeletal symptoms among office workers. *International Journal of Industrial Ergonomics*, 41(6), pp.671–676. Available at: http://dx.doi.org/10.1016/j.ergon.2011.08.007.

[6] Choobineh, A., Peyvandi, G. & Sharif, M., 2009. International Journal of Industrial Ergonomics Perceived demands and musculoskeletal symptoms among employees of an Iranian petrochemical industry. *International Journal of Industrial Ergonomics*, 39(5), pp.766–770. Available at: http://dx.doi.org/10.1016/j.ergon.2009.01.001.

[7] Ferreira, J. et al., 2009. *Development of an assessment tool for repetitive tasks of the upper limbs (ART) RR707 Development of an assessment tool for repetitive tasks of the upper limbs (ART)*, Health and Safety Execution (HSE).

[8] HSE, 2010. *Assessment Of Repetitive Tasks Of The Upper Limbs (The ART Tool) Guidance for Employers*, England: Health and Safety Execution (HSE).

[9] Khandan, M. et al., 2018. Ergonomic Assessment of Posture Risk Factors Among Iranian Workers: An Alternative to Conventional Methods. *Iranian Rehabilitation Journal*, 16(1), pp.11–16.

[10] Khandan, M., Mosaferchi, S. & Koohpaei, A., 2017. Assessing Exposure to Risk Factors for Work- related Musculoskeletal Disorders Using ART method in a Manufacturing Company. *Archives of Hygiene Sciences*, 6(3), pp.259–267.

[11] Kilbom, A., 1994. Assessment of physical exposure in relation to work-related musculoskeletal disorders--what information can be obtained from systematic observations?

Safety Science, 20(special issue).

[12] Lei, L. et al., 2005. Risk factors for the prevalence of musculoskeletal disorders among chinese foundry workers. *International Journal of Industrial Ergonomics*, 35, pp.197–204.

[13] Marcus, M. et al., 2002. A Prospective Study of Computer users: Postural Risks factors for Musculoskeletal symptoms and disorders. *American Journal of Industrial Medicine*, 41(January), pp.236–249. Available at: http://eurooffice.se/download/a prospective study of computer users II.pdf.

[14] Meksawi, S., Tangtrakulwanich, B. & Chongsuvivatwong, V., 2012. Musculoskeletal problems and ergonomic risk assessment in rubber tappers : A community-based study in southern Thailand. *International Journal of Industrial Ergonomics*, 42(1), pp.129–135. Available at: http://dx.doi.org/10.1016/j.ergon.2011.08.006.

[15] Moore, J.S. & Grag, A., 1995. The strain index : A proposed method to analyze jobs for risk of digital upper extremity disorders. *American Industrial Hygiene Association Journal*, 56, pp.443–458.

[16] Öztürk, N. & Esin, M.N., 2011. Investigation of musculoskeletal symptoms and ergonomic risk factors among female sewing machine operators in Turkey. *International Journal of Industrial Ergonomics*, 41(6), pp.585–591. Available at: http://dx.doi.org/10.1016/j.ergon.2011.07.001.

[17] Pratiwi, I. & Yunita, D.R., 2018. Analisis Postur Kerja Pengrajin Batik Menggunakan Metode Job Strain Index dan Loading on the Upper Body Assessment. In *Seminar Nasional IENACO 2018*. pp. 77–83.

[18] Roman-liu, D., 2013. Comparison of concepts in easy-to-use methods for MSD risk assessment. *Applied Ergonomics*, pp.1–8. Available at: http://dx.doi.org/10.1016/j.apergo.2013.05.010.

[19] Roman-liu, D., Bugajska, J. & Tokarski, T., 2014. Comparative Study of Upper Limb Load Assessment and Occurrence of Musculoskeletal Disorders at Repetitive Task Workstations. *Industrial Health*, 52, pp.461–470.

[20] Shokri, S., Varmazyar, S. & Varyani, A.S., 2015. Manual material handling assessment and repetitive tasks with two methods MAC and ART in a subsidiary of a manufacturer of cleaning products. *Scientific Journal of Review*, 4(8), pp.116–123.

[21] Westgaard, R.H., 2000. Work-related musculoskeletal complaints : some ergonomics challenges upon the start of a new century. *Applied ergonomics*, 31, pp.569–580.