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Ergonomics Risk Assessment Methods to Minimise Musculoskeletal Disorders: Barecore Workers in Indonesia

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Small and medium enterprises (SMEs) of bare-core making in Indonesia are still done manually, exerting a lot of human effort, repeatedly with awkward postures, bending and turning bodies, sitting or standing positions for long periods of time and the hands' reaching things too far away. This condition is very detrimental to health and is at risk for the occurrence of musculoskeletal disorders (MSDs). This research aims to evaluate and analyse the postures performed by bare-core workers, and to compare the results of the JS Index, ART Tool, and OCRA Checklist methods. The highest total score for each workstation is then proposed for improvements in the form of workstation design so that the total score can be reduced, this will reduce the risk of MSDs. The research was carried out both quantitatively and qualitatively including literature studies, field studies, and distributing Nordic Body Map (NBM) questionnaires to 30 workers. The research method used is the Job Strain Index (JS Index), the Assessment of Repetitive Task (ART) Tool, and the Occupational Repetitive Action (OCRA) Checklist. The method is to determine the risk of muscle injury caused by work posture on work activities carried out. The results showed that work risk was caused by effort per minute, repetition of work, length of rest, and arm posture. The redesign of the workstation resulted in a decrease in the highest exposure score of 48% (12 points) on the right-hand activity inserting wood into the SP 1 machine, while the lowest exposure decrease of 19% (4 points) on the right-hand activity inserting wood into the GangRip machine. The implication is that workers allocate rest time appropriately and the interaction of workers with machines is using the results of the redesign of the workstation.

Keywords: Job Strain Index; ART Tool; OCRA Checklist; Barecore workers

I. INTRODUCTION

Repetitive and awkward manual material handling (MMH) activities can increase the risk of ergonomics and can cause work-related musculoskeletal disorders (WMSDs) (Daruis *et al.*, 2017) that will have an impact on work productivity (Bidiawati & Suryani, 2015). WMSDs is one of the work-related disorders caused by improper work (Roman-Liu, 2014). Musculoskeletal disorders (MSDs) are an injury of the body's joints, ligaments, tendons, muscles, nerves, and structures that support the limbs, neck, and back (Nurmianto *et al.*, 2015). MSDS is one of the most chronic disorders that can develop from repeated micro-trauma (Kim, Chun & Hong, 2013). Accumulation of minor injuries caused by long-term and repetitive workloads is the main cause of MSDs (Roman-Liu, 2014).

Research using JS Index is conducted by (Chiasson *et al.*, 2012) used to assess 224 workstations involving 567 tasks in various industrial sectors, the result is that the Hand Activity Level (HAL) method is at a 37% low-risk level for wrist fan

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hands compared to the JS index with a value 9%. (Pratiwi & Yunita, 2018) conducted research in the batik industry, the result is that the 11 activities are at the medium-risk level and 5 activities are at the medium-risk level. JS Index is an assessment of risk for Distal Upper Extremity (DUE) disorders (Salvendy, 2012).

ART Tool method (Shokri, Varmazyar & Varyani, 2015) showed that 16% work stations are at a high-risk level, namely in stations of manual handling and repetitive movements are carried out, ratings of the two techniques are different. Research using OCRA Checklist is carried out by (Stradioto *et al.*, 2020) for civil construction with the result that the OCRA Checklist is the best method among the other ergonomic evaluation methods, in line with (Dias *et al.*, 2021) the result is rest time of 6 breaks of 10 minutes is better than 3 breaks of 20 minutes can reduce Upper Limb-WMSDs risk of workers at the chicken slaughterhouse, and from the research of (Suhardi, Maharani & Astuti, 2020) the result is Eliminate, Combine, Re-Arrange and Simplify (ECRS) application and the proposed design of work facilities can reduce OCRA index to 0.95 for the right hand and 0.85 for the left hand where the conditions were optimal.

Research at the bare-core is done by (Pratiwi *et al.*, 2019) using JS Index and ART Tool with the result of a redesign of workstations can reduce ART score by up to 48%, further research is done by (Raymond & Felecia, 2014) by using 53,76% bare-core waste and trash to create new bare-core.

OCRA Checklist (Stradioto *et al.*, 2020) consists of five parts that focus on the four main risk factors (lack of recovery time, frequency, force, awkward posture/stereotyped movement) and several additional risk factors (vibration, low temperatures, precision work, repeated impacts). Also, factor in the net duration of repetitive jobs on the final estimate of risk. Integrated assessment scores for various types of jobs (Salvendy, 2012). OCRA Checklist, JS Index, and Upper Limb Repetitive Assessment (ULRA) methods assess the burden and risks associated with repetitive tasks involving the upper extremities (Roman-Liu, 2014). JS Index method is a semiquantitative job analysis method that generates a numerical score (SI score) that correlates with the risk of developing DUE Disorder (Bao *et al.*, 2009). Meanwhile, the ART Tool is a method designed to assess the risk of tasks that require repetitive motion of the upper limbs (arms and hands) (Executive, 2010). This method is suitable for some tasks involving the upper body, repetitive work every few minutes, and work lasting at least 1-2 hours per day or shift (Executive, 2010). OCRA Checklist method was founded by Occhipinti and Colombini. This method is one of the ergonomic tools used as research, namely by looking at the presence or absence of risk in a particular job in the upper body parts of the body that are carried out repeatedly or repetitively (Colombini & Occhipinti, 2018). The study evaluated this problem using the ART Tool, JS Index, and OCRA Checklist methods, where the three methods can be used to assess the risk of repetitive work activities in the upper body posture.

Barecore is the main material for making blockboard. Barecore is a small piece of sengon wood that is arranged and glued to form a rectangular board (Raymond & Felecia, 2014) 250cm long, 126cm wide, and 10.5cm thick. The bare-core fabrication process still uses traditional and simple human labour and machinery technology (Pratiwi & Ningrum, 2021). The bare-core fabrication process consists of 10 workstations, of which six workstations still apply the MMH work system, and work activities are carried out repeatedly. Work activities at each workstation involve upper body postures, namely: hands, arms, neck, and back.

The purpose of this study is to describe the risk level of MSDs in bare-core workers based on the ART Tool, JS Index, and OCRA Checklist methods. What is the risk level of MSDs after recommendations for improvement are made through the redesign of work equipment at each workstation?

II. METHODOLOGY

A. Criteria for Choosing Studies

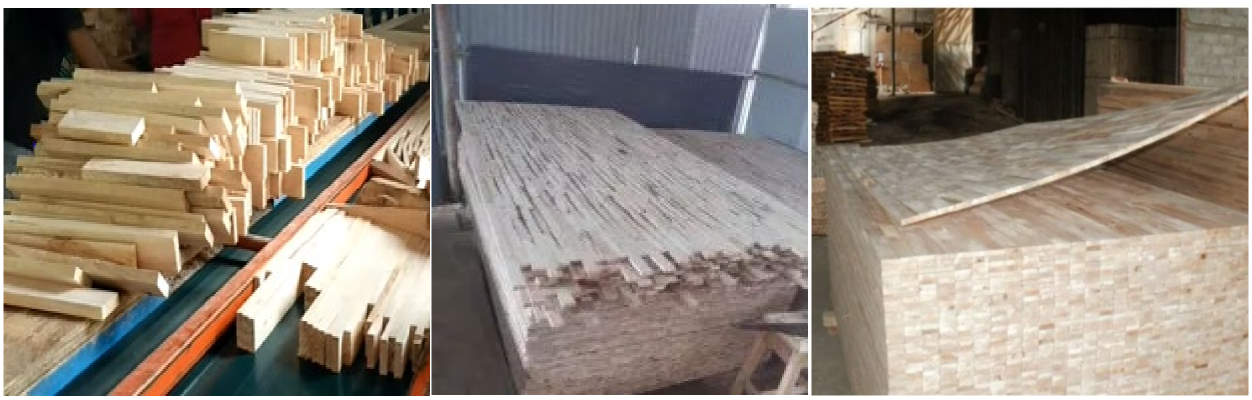
The selection of the method to be applied in this study was based on the results of the Standardised Nordic Questionnaire (SNQ) (Palmer *et al.*, 1999) and direct observation by looking at the production process of making bare-core (Pratiwi & Ningrum, 2021) as well as taking pictures of workers with their activities using video cameras. The result of SNQ observations shows that the body parts that feel pain are: the left wrist, right wrist, right upper arm, left upper arm, lower neck, back, right hand, and left hand (Pratiwi *et al.*, 2019). The body part that feels pain is part of the posture assessment factor in the JS Index and ART Tool methods. The results of direct observations on the production process are workers performing repetitive movements on wood cutting, wood smoothing, and core piece sorting activities, which are included in the measurement factors on the OCRA Checklist. It also takes into account other risk factors, namely: exertion of force, awkward postures, and movements, lack of recovery methods, other factors including precision movements, use of gloves, and mechanical compression (Lasota, 2015). The data collection process follows the rules of the OCRA Checklist, JS Index, and ART Tool methods, as well as the data analysis, follows technical criteria according to the characteristics of the three methods. (Stradioto *et al.*, 2020). The use of the three ergonomic evaluation methods is cheaper and easier to develop in the bare-core fabrication process. These three methods can evaluate the condition of the risk of injury to the upper body as well as repetitive movements, depending on the activity carried out, and propose practical solutions for each workstation (Stradioto *et al.*, 2020).

B. Participants and Collecting Data

The first step is to observe ergonomically bare-core workers with an exploratory character based on a quantitative approach through field research and case studies. Collecting data is carried out by conducting direct observations, interviewing workers and company owners, and documenting work activities using video cameras. Primary data was collected through survey research with interviews and SNQ questionnaires distributed to 50 bare-core workers in Klaten – Indonesia. Working time in one day for 7 working hours for 6 working days in one week. Primary data consists of data on body posture, working time, pulse, and duration of work, while secondary data is in the form of sources of information that are obtained from scientific articles, books, and research reports.

The total number of workers is 50 people who make up the population, with details on the sex of 21 men and 29 women. The working-age of workers (mean±SD) was 45.82±0.70 years, work experience (mean±SD) was 11.22±7.07 years, and body mass index (mean±SD) was 23.68±33.09.

The fabrication of bare-core is carried out through various stages of the process, namely: preparation of raw materials in the form of small pieces of used sengon wood from a furniture fabrication factory, all grade sengon wood with a length of 130 cm, a width of 8 cm, and a minimum thickness of 6.2 cm. The oven process is sengon wood pieces in the oven for 4 days to reduce the moisture content in the wood to less than 6% so that it does not experience changes in dimensions or cracks when processed further (Karyono, Darmono & Endarwati, 2012). The next process is cutting wood using a cross-cutting machine into three parts each with a size of 42 x 15.8 x 5.5 cm, then the wood grinding process using a surface planner machine. The next process is cutting the wood into smaller pieces with a size of 42 x 1.33 x 5.5 cm which is called the core. This core is then glued and the next process is pressing to unite the cores so that the sizes of the width and thickness are changed to 42 x 5.5 x 1.33 cm using a hydraulic press from the top and the sides. The last process is the glue drying process for 24 hours so that the glue becomes even and the bare-core is stored in the warehouse (see Figure 1).



(a) (b) (c)

Figure 1. The process of making bare-core is a course (a) the result of the cutting process (b) the result of the gluing process, (c) the result of the pressing process

The barecore manufacturing process that applies MMH method was carried out at 6 work stations, namely: (1) wood cutting work stations, with activities (1.1) picking up the wood from the floor to the cutting table, (1.2) cutting the wood using mitter saw, (2) the first grinding wood workstations, with the activity (2.1) picking up pieces of wood from the cutting workstation, (2.2) loading the wood into the surface planner machine 1, (3) the second wood grinding workstation, with the activity (3.1) picking up the wood pieces from the surface planner 1 machine, (3.2) loading the wood into the surface planner machine 2, (4) gangrip workstation, with activities (4.1) picking up pieces of wood on the table, (4.2) loading wood pieces into gangrip machines, (5) wood sorting workstation, with activities (5.1) picking up the corepiece from the gangrip machine, (5.2) sorting the good core piece, (6) the wood setting workstation, with activities (6.1) taking the core piece from the table to the conveyer, (6.2) arranging the core piece on the conveyer.

In the JS Index method, the data collected are (Stanton *et al.*, 2005): (1) intensity of exertion, namely the percentage of maximum force required to perform one task. (2) duration of exertion is the percentage of exertion time or effort used in one work cycle. (3) effort per minute is the amount of exertion per minute or referred to as the frequency of work per minute. (4) hand/wrist posture is divided into 3 categories: wrist extension, wrist flexion, and wrist ulnar deviation. (5) speed of work is an estimate of the speed of workers in doing their subjective work. (6) duration of task per day is the total time a worker's work is carried out in a day. While the data collected in the ART Tool method are (Executive, 2010): data collected from 12 variables consisting of arm movement, repetition, strength, head/neck posture, back posture, arm posture, wrist posture, finger/handgrip, rest, work speed, other factors, and duration. Data collected in the OCRA Checklist (Colombini, Occhipinti and Álvarez-Casado, 2013) are cycle time, frequency of movement, duration of repetitive work, posture and body movements (shoulders, elbows, wrists, finger grips), and additional factors, including temperature, humidity, light, noise level, and anatomical pressure.

C. Data Processing

After the required data are collected, then the next step is data processing for ergonomic evaluation using the JS Index, ART Tool, and OCRA Checklist methods for bare-core workers in Klaten – Indonesia.

JS Index steps, namely (Stanton, 2004): (1) collecting data from 6 task variables, namely: intensity of exertion, duration of exertion, effort per minute, hand/wrist posture, speed of work, duration of task per day (2) providing rating for the 6 data variables that have been collected (3) determining the multiplier value for each task variable (4) calculating the strain index value (see Formula 1) (5) representing the results of the risk value (see Table 1).

$$SI\ Score = IE \times DE \times EM \times HWP \times SW \times DD \quad \ldots (1)$$

Where IE = Intensity of Exertion, DE = Duration of Exertion, EM = Effort per minute, HWP = Hand/Wrist Posture, SW = Speet of Work, DD = Duration of task per Day.

ART Tool steps, consist of (Executive, 2010): (1) the first stage, determining the frequency and repetition, consisting of two variables, namely A1 arm movement and A2 repetition. (2) the second stage, determining the strength of the hand by observing and measuring the level of strength and time required by the hand to perform the task. (3) the third stage, determining the awkward posture by observing and measuring the body posture of the head/neck, back of the body, and the elbows, consisting of 5 variables, namely: C1 head/neck posture, C2 back posture, C3 arm posture, C4 wrist posture, C5 hand/finger grip. (4) the fourth stage, determining additional factors by measuring and considering further aspects for repetitive tasks, consisting of 4 variables, namely: D1 breaks, D2 work pace, D3 other factors, D4 duration. (5) the fifth stage, calculating the task score and exposure score. The task score was obtained from the sum of each variable, namely: hand movement, repetition, hand strength, head/neck posture, back posture, arm posture, wrist posture, hand/finger grip, rest time, work speed, and other factors (see Formula 2). While the exposure score is obtained by multiplying the value of the task by the duration of work (see Formula 3). (6) The sixth stage, presents the results of the risk score (see Table 1).

$$\text{Task Score} = A1+A2+B1+C1+C2+C3+C4+C5+D1+D2+D3 \quad \dots (2)$$

$$\text{Exposure Score} = \text{Task Score} \times \text{Duration (D4)} \quad \dots (3)$$

OCRA steps, consist of (Colombini and Occhipinti, 2018): (1) calculating Actual Technical Actions (ATA), namely: calculating the Net Total Time of Cycle (NTC), calculating the frequency, determining the duration (D) of repetitive actions (2) calculating the Reference Technical Action (RTA) value, namely: determining the value of Constanta of Frequency (CF), calculate Force Multiplier (FoM), calculate Posture Multiplier (PoM), calculate Repetition Multiplier (ReM), calculate Addition Multiplier (AdM), calculate Recovery Multiplier (RcM), determine Duration Multiplier (DuM), calculate Repetitive Task Action (RTA) in one work shift (see Formula 4) (3) Calculating the OCRA index (see Formula 5). Based on the results obtained, the calculation of the OCRA Index. then the OCRA index risk classification can be determined (see Table 1).

$$RTA = [CF \times (FoM \times PoM \times ReM \times AdM) \times D] \times (RcM \times DuM) \quad \dots (4)$$

$$OCRA\ Index = \frac{\text{Sigma ATA}}{Sigma\ RTA} \quad \dots (5)$$

C. *Analysis and Improvement Recommendations*

From the results of the data processing, the final score is obtained to determine the level of ergonomic risk in each work activity carried out by bare-core fabrication workers. Then the final score is included in the action level or exposure level category to see the ergonomic risk level of the three methods (see Table 1).

Tabel 1. Checklist Score for JS Index, ART Tool, and OCRA Checklist (Stanton, 2004) (Executive, 2010) (Occhipinti & Colombini, 2006)

OCRA Checklist		**JS Index**		**ART Tool**	
Score	Exposure Level	Score	Action Level	Score	Action Level
≤ 1.5	Risk absent	<3	Low risk or the work is safe	0-11	Low-risk level
1.6-2.2	Not relevant risk	3-7	Medium risk	12-21	Medium risk level
2.3-3.5	Very low risk				
3.6-9.0	Medium risk	>7	High risk or the work is harmful	>22	High-risk level

≥9.1	High risk

The analysis was carried out by observing the risk factors, namely medium risk, and high risk. The OCRA Checklist scores >3.6, the JS Index scores >7, and the ART Tool scores >22. In-depth analysis was carried out by looking at what parameters can affect the total score can be high so that there is a high risk of MSDs. Identification and analysis of work, as well as the actions of six workstations, were studied in one work shift. Furthermore, improvements are made in the form of providing recommendations to reduce the level of ergonomic risk from the work. Proposed improvement by redesigning the workstation. The design of the workstations 3DMax software while the size of the work equipment uses anthropometric data taken from the Indonesian Ergonomics Association on the website www.pei.org.id.

III. RESULTS AND DISCUSSION

The results of the study in the form of scores and risk levels for each activity are using three ergonomic evaluation methods (see Table 2). Figure 2 shows an awkward posture. Figure 2(a) shows workers carrying out the activity of picking up wood from the floor to the cutting table. The worker's posture is too bent when picking up pieces of wood because it is on the floor, while the worker sits on a chair with a height of 60 cm. The worker's posture when picking up pieces of wood using his left hand from the surface planner 1 machine (Figure 2(b)) is twisting because the machine is behind the worker's body. Figure 2(c) is also an awkward posture because the worker takes the core piece, which is far from the reach of the hand, so that the worker's body experiences a pull that exceeds his body's threshold.

(a) (b) (c)

Figure 2. Work posture of the bare-core maker (a) picking up wood from floor to table (b) picking up pieces of wood from surface planner machine 1 (c) sorting the good core piece

Table 2. Assessment results using OCRA, JSI dan ART Tool methods

Workstation	OCRA Checklist		Activity	Hand	JS Index		ART Tool	
	Right	Left			Score	Risk	Score	Risk
1. Wood Cutting	30.72	7.90	1.1. Picking up wood from floor to table	Right	0.75	Low	14	Medium
				Left	0.5	Low	14	Medium
			1.2. Cutting the wood using a miter saw	Right	2.25	Low	21	Medium
				Left	4	Medium	20	Medium
2. Wood Grinding 1	21.66	21.66	2.1. Picking up pieces of wood from the cutting workstation	Left	6	Medium	24	High
			2.2. Loading the wood into the surface planner (SP) machine 1	Right	6	Medium	25	High

3. Wood Grinding 2	10.97	14.62	3.1. Picking up the wood pieces from the SP 1 machine	Right	4.5	Medium	23	High
				Left	3	Low	23	High
			3.2. Loading the wood machine SP 2	Right	1	Low	13	Medium
				Left	1	Low	13	Medium
4. GangRip	31.63	11.94	4.1. Picking up pieces of wood on the table	Right	6	Medium	21	Medium
				Left	4	Low	16	Medium
			4.2. Loading wood pieces into GangRip machine	Right	6	Medium	24	High
				Left	1	Low	16	Medium
5. Core piece	19.43	20.10	5.1. Picking up the core piece from the GangRip machine	Right	1	Low	19	Medium
				Left	1	Low	19	Medium
			core piece	Right	6	Medium	21	Medium
6. piece	10.36	6.77	6.1. Taking the core piece from the table to the conveyor	Right	1	Low	15	Medium
				Left	1	Low	15	Medium
			6.2. Arranging the core piece on the conveyor	Right	1	Low	15	Medium
				Left	1	Low	15	Medium

The results of assessments using the OCRA Checklist, JS Index and ART Tool methods can be seen in Table 2. These results show the score and risk of injury for each workstation and activity for bare-core workers. The colour in Table 1 shows the level of risk of injury for each method, high-risk of injury is red ( ), medium-risk of injury is yellow ( ) as well as low-risk of injury is green ( ).

A. *JSI Method*

In the JS Index method, the cause of the high-risk score is due to the variable duration of exertion and effort per minute. The duration of exertion reflects the physiological and biomechanical effects related to how long the exertion is sustained (Bao *et al.*, 2009). Duration of exertion is the percentage of exertion time used in one work cycle. Duration of exertion is obtained by calculating the duration of all exertions divided by the total observation time, then multiplied by 100. The measured effort during observation and the total observation time is measured in seconds. Based on measurements of the activity of picking up wood from the floor, the total observation time is 190 seconds, and the duration of the effort is 105 seconds, the percentage value is 55.26%, so the multiplier value of business duration is 2.

Effort per minute is the number of exertions per minute or the frequency of work per minute (Bao *et al.*, 2009). Effort per minute is obtained from the amount of exertion during the observation period divided by the total observation time in minutes. Based on measurements of the activity of picking up wood from the floor, the total observation time is 2.6 minutes, the measured effort is 8 times, the value of effort per minute is 3.08 times per minute, then the multiplier value of effort per minute is 3.

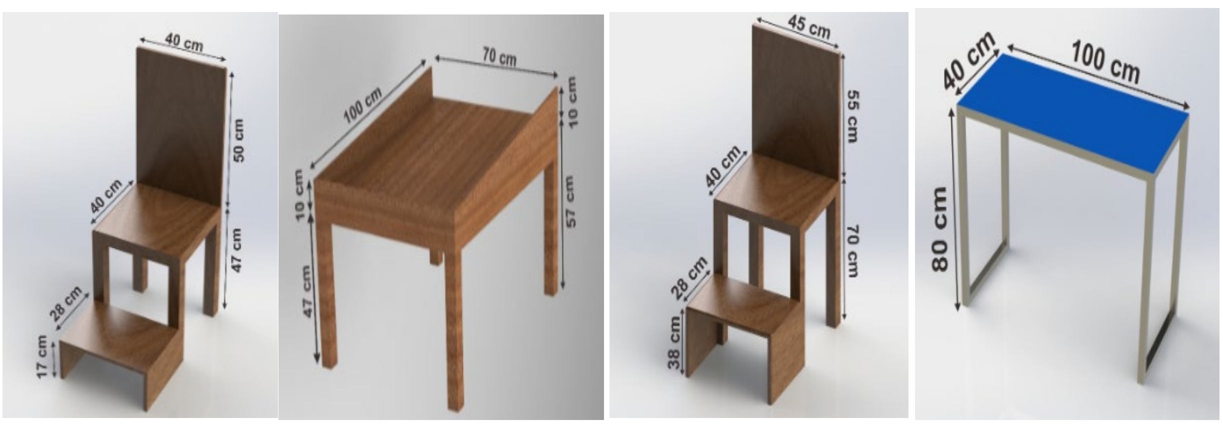
B. *ART Tool Method*

In the ART Tool method, the cause of the high score is the repetition, rest, and arm posture variables. Variable A2 Repetition by observing arm and hand movements but not fingers, then counting how many times the same movement pattern is repeated over a certain period. The results of observations on the activity of picking up wood from the floor, the repetition movement is carried out more than 20 times per minute, resulting in a score of 6 so that it is red. Variable C3 Arm posture, by observing and measuring the risk of arm posture, is considered an awkward posture if the elbow is raised high around the chest and is not attached to the work table while performing the task. The results of observations on the activity of taking wood from the SP 1 machine, the arm posture

>40% resulted in a red score of 4. Variable D1 Breaks: observing and measuring the maximum amount of time a worker performs a repetitive task without taking a break. The term 'rest' means the time lag in doing repetitive tasks using the hands or arms. The rest also includes time spent doing other tasks without involving the arms or hands (Executive, 2010). The results of observations on the activity of picking up wood from the SP 1 machine are 3 hours to less than 4 hours, getting a score of 6 in red.

C. OCRA Checklist Method

The results of the calculation using the OCRA Checklist method is that the six workstations get high-risk, namely the total score >3.6. Factors that influence the risk of MSDs are a repetition of movements and the unbalanced use of the right and left hands in work. At the wood grinding workstation 1, the frequency of right (F_{Right}) hand movements is 29 actions/minute and left hand (left) 17 is actions/minute. After performing repetitive movements, workers need a rest period that is proportional to the length of time they work. One work shift is 470 minutes with a working duration of 420 minutes without recovery. The result of RTA_{Right} is 399.17 actions and RTA_{Left} is 887.04 actions. The OCRA $Index_{Right}$ result is 30,720 (high risk) and the OCRA $Index_{Left}$ is 7.89 (medium-risk).



(a) (b) (c) (d)

Figure 3. Proposed design (a) chairs at wood grinding workstation 1 (b) table at wood cutting workstation (c) chairs at wood grinding workstation 2 (d) table at core piece sorting workstation

D. Improvement Recommendations

Recommendations for improvement are made to reduce the occurrence of MSDs in workers, namely by using both hands to work with a balanced capacity, both from the energy given or the repetition of the movements performed. If this is not possible, the worker will do the work by changing hands, so that one of the hands can rest alternately. Workers use the right hand dominantly, and the placement of wood is too far from the reach of the worker's hand so that the left-hand does not act optimally. It's best to place the wood close to the hand so that the hands can act in a balanced way. The position of the hands reaching forward for the determination of the width of the table and the span of the hands for the length of the table (Rejeki, Rahman & Achiraeniwati, 2014). At the wood grinding workstation, the process can be improved by adding height to the chair and adding an iron roll to the cutting table so that workers can easily pick up the pieces of wood.

The initial height of the small chair is 32 cm, the height of the SP 1 machine is 70 cm and the operator's height is 147 cm. The improvement recommendations are, (1) to make a chair with a length of 40 cm, a width of 40 cm and a height of 97 cm where the height from the bottom to the seat is 47 cm and the height for the back of the body is 50 cm. The bottom of the chair is provided with a footrest with a length of 40 cm, a width of 28 cm, and a height of 17 cm. Sitting comfort at work is increasingly important because it affects MSDs. (**Figure 3 (a))** is a recommendation design of a chair for a wood smoothing place. (2) to make a table for wood cuttings with an angle of 6 degrees. The dimensions of the table made are length 100 cm, width 70 cm, the height of the front leg 47 cm, and height of the back leg 57 cm. Anthropometric data to determine table height using elbow height dimensions (Rejeki, Rahman & Achiraeniwati, 2014). At the edge of the upper table, a skat or barrier is need to be provided so that the pieces of wood do not fall to the floor with a height of 10 cm **(Figure 3(b))** is a recommended design for the table for the place of wood pieces. Next is to make a chair with a length of 45 cm, a width of 40 cm and a height of 125 cm where the height from the bottom to the seat is 70 cm and the height for the back of the body is 55 cm. Then, at the bottom of the chair is given a footrest with a length of 45 cm, a width of 28 cm, and a height of 38 cm **(Figure 3 (c))** is a chair design for wood grinding workstation 2. Next is to make a table with a length of 100 cm, width 40 cm and 80 cm high **(Figure 3(d))** is a table design on a core piece sorting workstation. The risk of MSDs is also due to limited rest time, so adequate rest time is needed by allocating the right rest time. Improvement recommendations are made by allocating rest time for stretching and muscle recovery. The recommendation given is in one hour, there will be a recovery time of 10 minutes or 10 seconds every 1 minute for all workers, with a ratio of work time to rest that is 5:1. The meaning of allocation of rest time is to divide the rest time given evenly and not concentrate on one time only. Rest is very helpful, but it is what workers do during the break that is important to reduce musculoskeletal complaints (Gasibat, Bin Simbak & Abd Aziz, 2017).

After designing the workstation, there was a decrease in the exposure score, the highest was 48% (12 points) in the right-hand activity of inserting wood into the SP 1 machine, while the lowest exposure score decreased by 19.05% (4 points) in the right-hand activity of taking the wood into the GangRip machine. The implication of this research is that bare-core workers have a high risk of MSDs, especially in the following activities: cutting the wood using a miter saw, picking up pieces of wood from the cutting workstation, loading the wood into the SP 1 machine, picking up the wood pieces from the SP 1 machine, and loading wood pieces into GangRip machine. The high total score is caused by: repetition of work, workers' lack of rest time, awkward postures on the head, back of the body, and arms. After designing the workstation, there was a decrease in the exposure score, the highest was 48% (12 points) in the right-hand activity of inserting wood into the SP 1 machine, while the lowest exposure score decreased by 19.05% (4 points) in the right-hand activity of taking the wood into the GangRip machine.

IV. CONCLUSION

Bare-core SMEs' workers work manually, using simple machines, repeatedly, so it is necessary to carry out a risk assessment of work postures. The research was conducted using three methods, namely: JS Index, ART Tool, OCRA Checklist. The JS Index method for assessing working posture is only on wrist posture, while the ART method for assessing work posture includes: head posture, back of body, arms, and finger/hand grip. The ART Tool method is more suitable to be applied to bare-core workers, because this method is more comprehensive in measuring all observed activities so that the results can describe the actual conditions of the workers. Further consideration of the risks of working posture on manual bare-core workers should focus more not only on work postures but also on workers' health and safety standards. Furthermore, ergonomic risk measurements can be carried out by applying the redesign in real terms.

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