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Application of Nordic Body Map and Rapid Upper Limb Assessment for Assessing Work-related Musculoskeletal Disorders: A case study in Small and Medium Enterprises

Okka Adiyanto[1,2], Effendi Mohamad[1*], Rosidah Jaafar[1], Farid Ma'ruf[2], Muhammad Faishal[1,2] , Anggi Anggraeni[2]

[1]Fakulti Kejuruteraan Pembuatan, Universiti Teknikal Malaysia Melaka, Melaka 76100, MALAYSIA.

[2]Teknik Industri, Fakultas Teknologi Industri, Universitas Ahmad Dahlan, Jalan Ring Road Selatan, Tamanan, Bantul Yogyakarta 55166, INDONESIA

*Corresponding Author

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Abstract: Small Medium Enterprise (SMEs) hold a strategic role in economic activities. Since SMEs contribute in enlivening businesses, it is important to assess the SMEs' performances. One of the most vital aspects in running SMEs is the workers' productivity which is very risky of declining performance. This study will assess Musculoskeletal Disorder (MSD), one of the workers' productivity problems. By applying Nordic Body Map (NBM) and Rapid Upper Limb Assessment (RULA), this study aims to assess work-related MSD in a SME. The NBM questionnaire was used to explore the prevalence of MSD and ergonomic risk factors perceived by the operator. Meanwhile RULA analysis was conducted to know the operator's work position score. The RULA assessment resulted 7 in initial score of employee's position. This score indicated that it immediately required an investigation, further implementation, and changes. From this result, it is necessary to improve a better working position by using a work desk and chair. After the improvement, the RULA score dropped to 3, a good number. The change of operator's body posture proved that RULA is very important to be further assessed. By doing so, it can be used to offer advice based on ergonomic risk evaluation and expected to increase productivity in SMEs.

Keywords: Ergonomic, Rapid Upper Limb Assessment, Nordic Body Map, Musculoskeletal Disorder

1. Introduction

Small and Medium Enterprises (SMEs) have a strategic role in national development as a driver of economic growth, exports, and innovation [1]. The growth and development of SMEs in Indonesia are very fast. SMEs currently play an essential role in improving the community's economy [2]. SMEs also play a very important role in job prospects [3]. Based on data from Indonesia's National Statistics Bureau (BPS), there are currently more than 65 million SMEs spread across Indonesia. In 2016, there were 61.7 million SMEs in Indonesia. The number keeps continuously increasing, in 2017 the number of SMEs reached 62.9 million and in 2018 the number of MSMEs reached 64.2 million. It is predicted that in 2019, 2020 to 2021 the number will continuously increase more. SMEs also contributed to 61.07 percent of total GDP, 14.37 percent of total exports, and absorb 97.30 percent of total employment[1].

SMEs are widespread throughout rural areas and potentially have considerable employment growth. Their development can be included as an influential element of policies to create jobs and make income. The production process, human resource capacities, raw materials, and marketing are common obstacles to SMEs development in

*Corresponding author: effendi@utem.edu.my

developing countries, including Indonesia [4]. Although SMEs are labor absorbers and are the backbone of the economy in developing countries, SMEs still face challenges. Some of the obstacles that are often found in SMEs are about worker productivity. Several studies have shown that there was a relationship between working conditions, employee health, and productivity [5].

A large number of workers in SMEs is at risk of causing occupational safety and health (OSH) problems. Minor injuries, ergonomic problems, and poor working conditions are OSH problems in SMEs [6]. The majority of SMEs in Indonesia employ workers who are primarily involved in the work process. It shows that the operator's role is the most important in the manufacture of a product [7]. Ergonomic Risk Factors encountered in SMEs are sitting in a low squat posture, with frequent and heavy manual material handling (MMH) in non-neutral postures, for example, lifting, carrying, pushing, and pulling [6], [8]. These factors can lead to injury or related problems involving tendons, muscles, or nerves most of which can progress to musculoskeletal disorders (MSD). MSD or musculoskeletal disorders are injuries and disorders of the soft tissues (muscles, tendons, ligaments, joints, and cartilage) and the nervous system [9].

An ergonomic concern frequently found at the place of work, especially pertaining to human power and stamina to carry out the work, is a musculoskeletal disorder (MSD) [10]. The European Agency for Occupational Safety and Health (EU-OSHA), considers musculoskeletal disorders as a major disease. It affects millions of workers and means incurring huge costs of billions of euros for companies and for the public health system [11]. In ergonomics, the attitude and mobility of workers are the causes of MSD in the workplace. Various approaches and tools have been formulated to evaluate exposure to the risk aspects of work-related musculoskeletal disorders. Measurement of MSD can be divided into three: self-report approach (SR), direct measurement (DM), and observational method (OM) [12].

The self-report (SR) method commonly used is the Nordic Body Map (NBM). This NBM method aims to measure the complaints felt by operators [13]–[15]. Several studies using the Nordic Body map are [13], [15]–[17]. The limitation of this methodology is that the respondent's billing procedure is unreliable at all times and can lead to bias [18]. The OM methodology is very popular and involves paying close attention to the posture of the workers. Popular processes in this approach are Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA) [19]. There were previously several studies using the RULA method [12], [20]–[22].This limitation is apparent in the accuracy and evidentiary of the results depending on the input information collected, and therefore the results can be biased [23]. The objective of this work is to apply the Nordic Body Map (NBM) and Rapid Upper Limb Assessment (RULA) to small and medium enterprises in Indonesia.

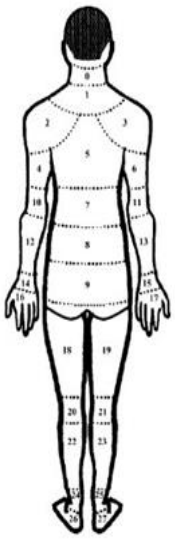
2. Methodology

This research intended applying Nordic Body Map (NBM) and Rapid Upper Limb Assessment (RULA) to assess operators working position in SMEs in Indonesia. The study was conducted in the TS Aluminum Yogyakarta in Indonesia. The required data for this research was in the manufacturing process plant. The workers have been found to have 7 hours of working per day. The work hours are from 8:30 am to 4:30 pm within one-hour break. Unfortunately, their sitting position is under bent and legs bent. It was predicted that the wrong work postures are often caused by the layout of work facilities that are not in accordance with anthropometry, so that it greatly affects the workers' performance. In short, this will have an impact on worker discomfort when carrying out the work as depicted in Fig. 1.

Fig. 1 - Posture of the operator

2.1. Nordic Body Map (NBM) Analysis

NBM questionnaire is a kind of ergonomics specification questionnaire which is frequently deployed for ascertaining the inconvenience of workforces. The distribution of the questionnaire was used to find out the inconvenience by the workers. The used questionnaire was the Nordic Body Map (NBM), the purpose of filling out the questionnaire was to find out which parts of the muscle experienced complaints [24]–[26]. The Nordic Body Map (NBM) has a standardized questionnaire which is followed by the rest of the world world [20], [25], [27]–[29]. There are 4 body parts (neck), upper limbs (forearm, shoulder, hand/wrist), lower leg (leg, leg), and trunk (lower and upper back) [30]. The questionnaire uses images of the human body which is divided into nine main segments: shoulders, neck, elbows, upper back, lower back, hips/buttocks, wrists/hands, knees, and ankles/feet. Individuals who answered the survey were asked to provide a sign of whether they had grievances in some parts of their body. In detail, the Nordic Body Map (NBM) questionnaire can be seen in the Fig. 2.



No	Location	Grade of complaints			
0	Pain/stiff in the upper neck	A	B	C	D
1	Pain in the lower neck				
2	Pain in the left shoulder				
3	Pain in the right shoulder				
4	Pain in the left upper arm				
5	Pain in the back				
6	Pain in the right upper arm				
7	Pain in the waist				
8	Pain in the buttock				
9	Pain in the bottom				
10	Pain in the left elbow				
11	Pain in the right elbow				
12	Pain in the left lower arm				
13	Pain in the right lower arm				
14	Pain in the left wrist				
15	Pain in the right wrist				
16	Pain in the left hand				
17	Pain in the right hand				
18	Pain in the left thigh				
19	Pain in the right thigh				
20	Pain in the left knee				
21	Pain in the right knee				
22	Pain in the left calf				
23	Pain in the right calf				
24	Pain in the left ankle				
25	Pain in the right ankle				
26	Pain in the left foot				
27	Pain in the right foot				

Fig. 2 - NBM questionnaire

2.2. Rapid Upper Limb Assessment (RULA) analysis

RULA is a screening application that focuses on the observatory evaluation of the operator's working position [12]. RULA is also a survey method developed to evaluate ergonomics in a workplace to find out inconvenience from workers. This method does not require special equipment in providing a rapid assessment of the posture of the neck, trunk, and upper limbs along with muscle function and external loads experienced by the body. A coding system was used to generate a list of actions indicating the level of intervention required to reduce the risk of injury due to physical loading on the operator [31]. RULA consists of three steps, namely the development of recording work postures, the development of an assessment system, and the development of an action level scale that provides risk level results

1. Step 1 development of work posture recording
   Body segments are divided into two groups, they are A and B. Group A includes the upper and lower arms and wrists, while group B includes the neck, trunk, and legs. This ensures that all body postures are recorded so that awkward or restricted leg, trunk, or neck postures that may affect upper limb posture are included in the assessment.
2. Step 2 Development of the assessment system
   A single score is used as an assessment of group A. On the other side, group B was used to represent the level of complaints on posture felt by the operator. The scale ranking of nine was used on the postures. A score of 1 is defined as the posture in which the least musculoskeletal load occurs. Where score differences occur, the load on the musculoskeletal system is discussed and scores are agreed upon. This produces a body segment posture score table called the A and B posture scores.
3. Step 3 Development of the action level scale
   This third stage is to determine the activity level based on the number of scores that have been assessed. Lynn, McAtamney, and Corlett, Nigel divided the action into 4 levels [31]. In detail, those four levels are presented under the Table 1.

Table 1- RULA action level

Action Level	Score	The level of risk	Implications and risk posture employment issues
1	1-2	posture accepted	acceptable posture if it is not minted or repeated for long periods
2	3-4	low risk	Needed further investigation and changes may be required
3	5-6	intermediate risk	Needs further investigation and changes are required soon
4	7	Very high risk	Investigation and implement the necessary changes immediately

3. Result and Discussion

3.1. Nordic Body Map Analysis

The information about the operators was collected through interviews with the workers as details depicted in Table 2. The purpose of the interviews was to understand the problems related to ergonomics in the workplace. Only one operator was judged because he was the only one doing the job and had a work posture that could cause MSD. The health check uses the NBM questionnaire that has been presented so that the operator can mention the body part that feels uncomfortable while working. The operator's posture during the installation procedure is sitting on the floor and bending the body and head posture. Unfortunately, this position is not recommended as it is at risk and can cause MSD if the work takes place every day. Based on the results of the NBM questionnaire Table 3, several complaints were captured on some parts. They are the right shoulder, back, waist, right hand, right ankle, and right foot. While the results of the NBM score are depicted in Fig. 3. Based on the NBM score, it can be seen that there are 6 body points that have pain categories and 4 body parts that characterize moderate pain. This result implies that workers' bending performance during work hours can affect pain in several parts of the body.

3.2. RULA Analysis

Rapid Upper Limb Assessment (RULA) analysis was design by scaling a risk score between 1 to 7, in which the higher the score, the greater the risk of MSDs. Thus, the operator position data is needed to make simulations using mannequins in CATIA. The position of the operator can be seen in Fig. 4. Mannequin design using CATIA software was used to illustrate and adjust the operator's position in real-time. The percentile used in this design is the 50th percentile which corresponds to the average population of Indonesia [32]. Based on the results of the questionnaire, there were complaints on the upper and lower neck because workers worked at an angle of 36° with their heads down. Complaints of back pain because the operator has to work on his side. Pains in the buttocks and hips are felt when the operator persists seated on the floor. Pain in the right and left arms due to the absence of a table or work tool to support it. The operator must hold the product at a height of less than 12-25 cm from the floor, and therefore he must bend his head and body. Complaints of normal pain occur in two parts of the body: the right and left shoulder. This complaint is triggered by the posture of the operator's head that is bent continuously. It also indirectly bends the shoulders at the same time. In detail, the RULA evaluation was carried out using CATIA software. The results of the RULA score can be furtherly seen in Fig. 5.

Table 2- Data information about the operator

No.	Item inquiry	Result
1.	Sex	Men
2.	Age (years)	50
3.	Weight (kg)	60
4.	Height (cm)	165
5.	Experience (years)	7
6.	Marital status	Married
7.	Duration of action (hours / day)	7
8	BMI	22

Table 3- Results of the NBM questionnaire

No	Location Pain	Not Pain	Moderate pain	Pain	Very Painful
0	upper neck		√		
1	Lower neck		√		
2	Left shoulder	√			
3	Right shoulder			√	
4	Left upper arm	√			
5	In the back			√	
6	Right upper arm	√			
7	Waist			√	
8	Buttock		√		
9	Bottom	√			
10	Left elbow	√			
11	Right elbow	√			
12	Left lower arm	√			
13	Right lower arm	√			
14	Left wrist	√			
15	Right wrist	√			
16	Left hand	√			
17	Right hand			√	
18	Left thigh	√			
19	Right thing	√			
20	Left knee	√			
21	Right knee	√			
22	Left calf	√			
23	Right calf	√			
24	Left ankle	√			
25	Right ankle			√	
26	Left foot		√		
27	Right foot			√	

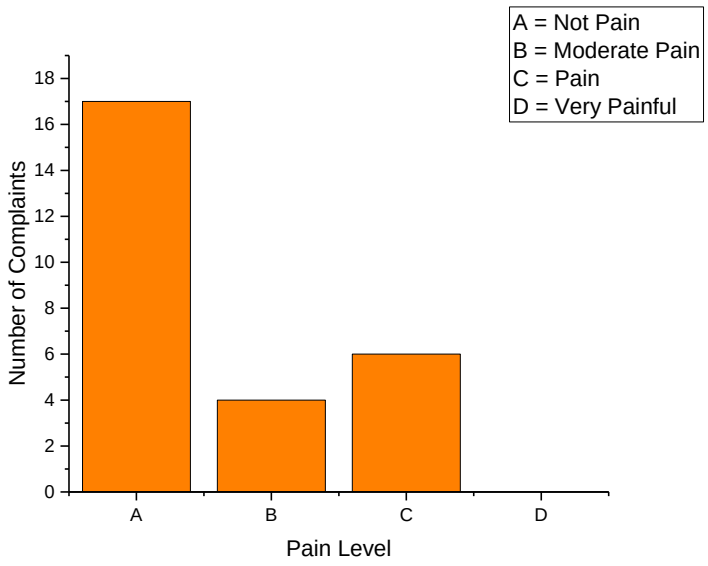


Fig. 3- Results of Nordic Body Map score

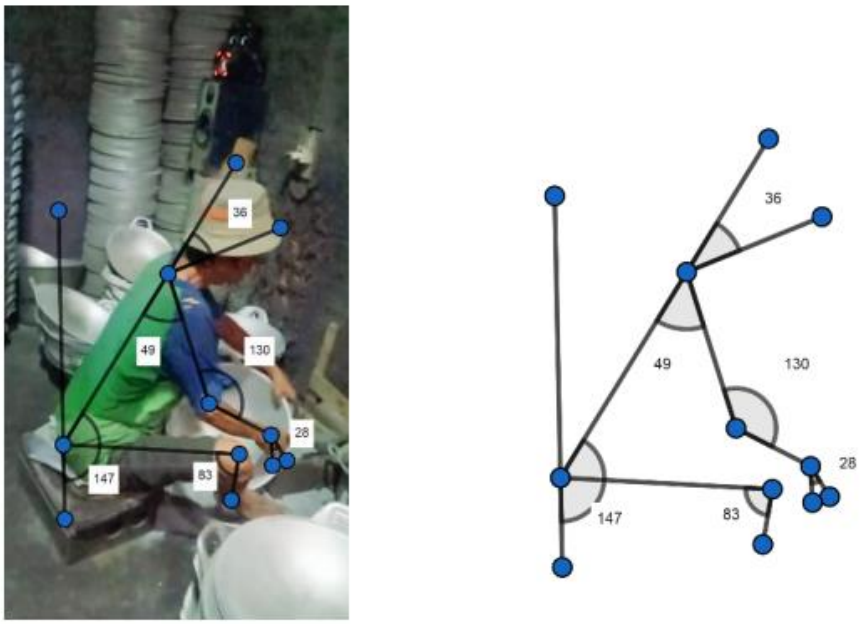


Fig. 4 - Position of an operator

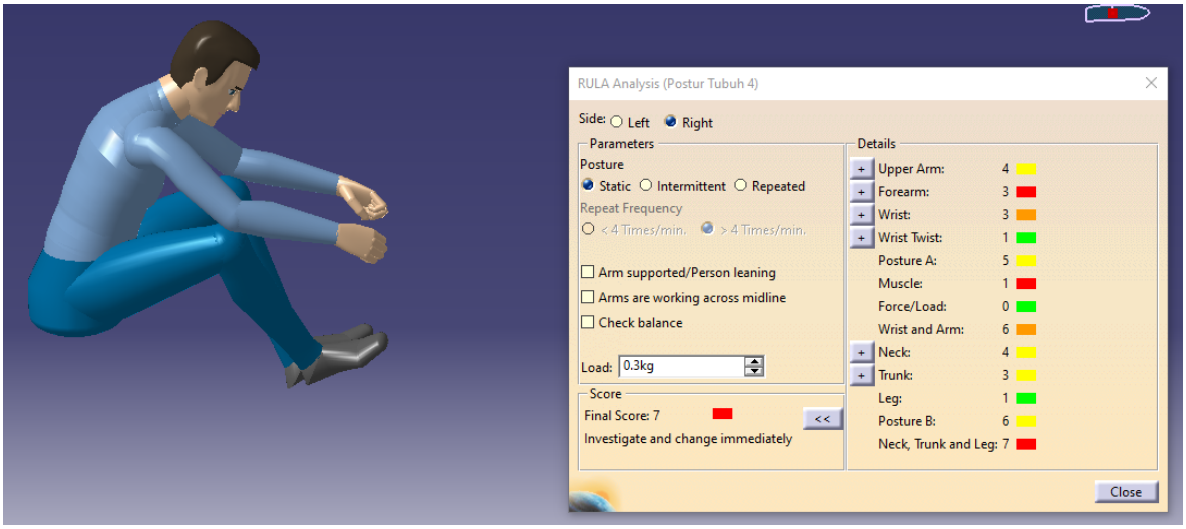


Fig. 5 - RULA score right side

Based on the results of the RULA evaluation, it was found that the value obtained based on the operator's work position was 7 as shown in **Table 4**. Based on the score, it is necessary to investigate and implement the necessary changes immediately.

Table 4 - RULA Final Score

Tool	Color code	The final result	Action
RULA		7	Investigation and implement the necessary changes immediately

3.3. Modification of body posture

Based on the complaints experienced by the operators, the highest risk is in the waist and legs. Therefore, the designed improvement of working facilities was carried out by focusing on the waist and legs. One of these was by improving the sitting position at work. The appropriate work position can be seen in Fig. 6. It interprets that the back position is at an angle of 0° and the worker's back is not twisted or bent. The position of the neck is known that the head is in a bent position with a large angle of 35°, the angle of the legs is 90°.

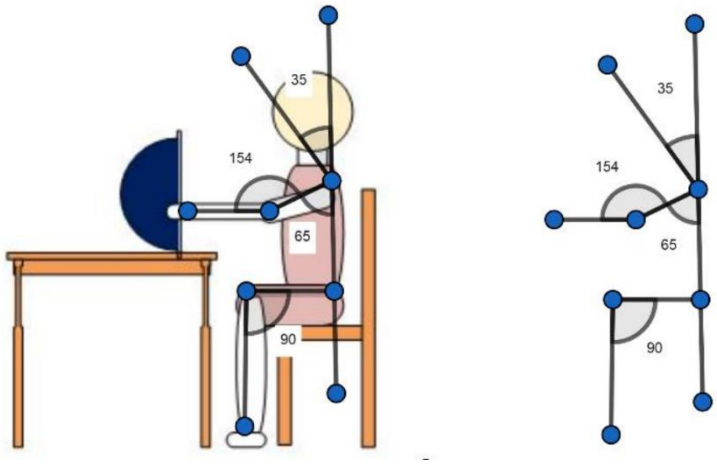


Fig. 6 - Proposed solution

Concerning that prior explanation, the proposed solution is to use a work desk and chair. Precisely, the size of the table and chairs is adjusted to the size of the operator's ergonomic body. The length of the workbench is based on the dimension of the length of the elbow, so that workers can reach all work pieces beside or in front of the workbench easily with a 5th percentile value with the result of 81.6 cm. It is for the sake of the workers who have a larger body posture to remain comfortable with the designed size. For the seat height, the design uses a popliteal height aspect. Its height is about 43 cm. The width of the seatback is 41 cm. The height of the back is 59 cm. The width of the designed seat is based on the dimensions of the hip width of 40 cm, and the length of the seat of 45 cm according to the popliteal features of the buttocks. After getting the design of the proposed tools to find out the design that properly reduces the risk of MSD, an analysis using CATIA was carried out to get the RULA score. Simulations were carried out using mannequins and making work tools. The tool used during the simulation was a tool that is in accordance with the specified design size using anthropometric measurement data carriers. Furthermore, the results of the RULA score analysis using the RULA evaluation can be seen in Fig. 7. As the result, the right upper arm, wrist twist, forearm, neck, torso, and leg were classified as green. The green indicates that the operator has a comfortable posture that is acceptable for work. Differently, the wrist, arm, and wrist segments were indicated by yellow which illustrates that the operator is working on a table and classifies the position as less risky. The parts marked in red are understood to be in a dangerous position, namely the muscle.

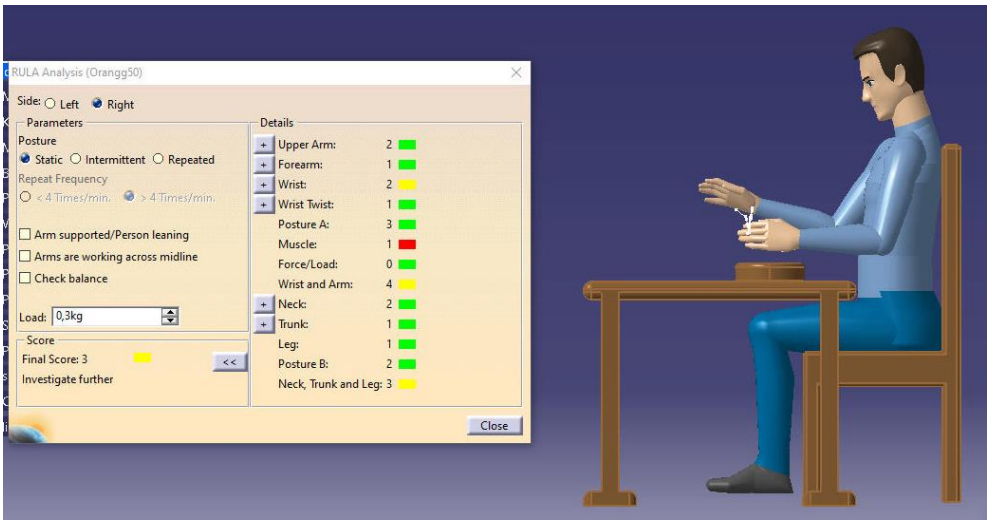


Fig. 7 - Posture analysis by RULA when operators do their jobs and viewed from left side

Based on the results of the RULA analysis, there was a decrease in the score for RULA. It happens as the improvement was made by the operator about the working position. Furtherly, Table 5 shows how the comparison results after and before the improvements.

Table 5 - Comparison of RULA score before and after solution

Tool	Before		After	
	Color code	RULA Score	Color code	RULA Score
RULA		7		3

This study employs a combination of two methods namely self-report and observational report. It is important to do as its objective is to assess the operator's working position properly [33], [34]. Self-reports are generally done using the NBM method. Differently, the observational reports can use RULA. The NBM measurement uses a questionnaire that is filled out by the operator according to how the operator reflects their working position. The RULA assessment is done by assessing the condition of the body. RULA posture considers static postures and cannot consider for dynamic postures [12]. This analysis is expected to help SMEs to reduce complaints to operators, especially to prevent the occurrence of MSD.

4. Conclusions

There are high complexity problems in assessing MSD risk factors in SMEs. In order to determine level of complaints from operators in SMEs, there are various assessment methods have been developed, but this study used the common one which is Nordic Body Map (NBM). After assessing the operator's complaints, an evaluation was conducted to determine the RULA score with the help of CATIA. Before the improvement was achieved, the RULA score was 7. A desk and chair were added to improve the operator's posture. After improving the work position, the RULA analysis with CATIA resulted score of 3, which is a good number. From this study, it can be concluded that ergonomic intervention such as designing new tools is a practical approach to control musculoskeletal risk factors. Furthermore, at the same time, it can also provide a safe and healthy workplace for operators in SMEs.

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References

[1] H. N. Saturwa, S. Suharno, and A. A. Ahmad, "The impact of Covid-19 pandemic on MSMEs," *Jurnal Ekonomi dan Bisnis*, vol. 24, no. 1, pp. 65–82, 2021.

[2] L. Mahmudova, "Definitining the Performance of Small and Medium Enterprises," *Network Intelligence Studies*, vol. VI, no. 12 (2/2018), pp. 111–120, 2018.

[3] H. Herr and Z. M. Nettekoven, "The role of small and medium-sized enterprises in development: What can be learned from the German experience?," *Global Labour University Working Paper*, no. 53, p. 32, 2018.

[4] I. R. Maksum, A. Y. Sri Rahayu, and D. Kusumawardhani, "A social enterprise approach to empowering micro, small and medium enterprises (SMEs) in Indonesia," *Journal of Open Innovation: Technology, Market, and Complexity*, vol. 6, no. 3, 2020.

[5] S. Vinberg, "Occupational safety and health challenges in small-scale enterprises," *Industrial Health*, vol. 58, no. 4, pp. 303–305, 2020.

[6] S. P. Tarigan, D. H. Ramdhan, and D. Z. Nuridzin, "Ability to Identify Occupational Health and Safety (OHS) Hazards in Small Sized Enterprises Workers in Cimanggis District , Depok City , West Java," *National Journal of Occupational Health and Safety*, vol. 1, no. 1, 2020.

[7] N. Vignais, M. Miezal, G. Bleser, K. Mura, D. Gorecky, and F. Marin, "Innovative system for real-time ergonomic feedback in industrial manufacturing," *Applied Ergonomics*, vol. 44, no. 4, pp. 566–574, 2013.

[8] A. A. Acquah *et al.*, "Musculoskeletal disorder symptoms among workers at an informal electronic-waste recycling site in agbogbloshie, ghana," *International Journal of Environmental Research and Public Health*, vol. 18, no. 4, pp. 1–20, 2021.

[9] N. Jaffar, A. H. Abdul-Tharim, I. F. Mohd-Kamar, and N. S. Lop, "A literature review of ergonomics risk factors in construction industry," *Procedia Engineering*, vol. 20, pp. 89–97, 2011.
[10] S. Oliv, E. Gustafsson, A. N. Baloch, M. Hagberg, and H. Sandén, "The Quick Exposure Check (QEC) — Inter-rater reliability in total score and individual items," *Applied Ergonomics*, vol. 76, no. December 2018, pp. 32–37, 2019.
[11] P. Fuchs, "Musculoskeletal disorders caused by the most common job demands and ergonomic risks," 2018.
[12] C. S. Moriguchi *et al.*, "Impact of experience when using the Rapid Upper Limb Assessment to assess postural risk in children using information and communication technologies," *International Journal of Industrial Ergonomics*, vol. 70, no. December 2018, pp. 398–405, 2019.
[13] H. R. Zadry, P. Fithri, U. Triyanti, and D. Meilani, "An ergonomic evaluation of mountaineering backpacks," *ARPN Journal of Engineering and Applied Sciences*, vol. 12, no. 18, pp. 5333–5338, 2017.
[14] A. Thetkathuek, P. Meepradit, and T. Sa-ngiamsak, "A Cross-sectional Study of Musculoskeletal Symptoms and Risk Factors in Cambodian Fruit Farm Workers in Eastern Region, Thailand," *Safety and Health at Work*, vol. 9, no. 2, pp. 192–202, 2018.
[15] L. Widodo, F. J. Daywin, and M. Nadya, "Ergonomic risk and work load analysis on material handling of PT. XYZ," *IOP Conference Series: Materials Science and Engineering*, vol. 528, no. 1, 2019.
[16] Y. L. Chen and Y. S. Ou, "A case study of Taiwanese custom-beverage workers for their musculoskeletal disorders symptoms and wrist movements during shaking task," *International Journal of Industrial Ergonomics*, vol. 80, no. September, p. 103018, 2020.
[17] J. Chin, Herlina, H. Iridiastadi, L. Shu-Chiang, and S. Fadil Persada, "Workload Analysis by Using Nordic Body Map, Borg RPE and NIOSH Manual Lifting Equation Analyses: A Case Study in Sheet Metal Industry," *Journal of Physics: Conference Series*, vol. 1424, no. 1, pp. 4–10, 2019.
[18] A. Burdorf, J. Derksen, B. Naaktgeboren, and M. van Riel, "Measurement of trunk bending during work by direct observation and continuous measurement," *Applied Ergonomics*, vol. 23, no. 4, pp. 263–267, 1992.
[19] J. D. Chen, T. Falkmer, R. Parsons, J. Buzzard, and M. Ciccarelli, "Impact of experience when using the Rapid Upper Limb Assessment to assess postural risk in children using information and communication technologies," *Applied Ergonomics*, vol. 45, no. 3, pp. 398–405, 2014.
[20] A. K. Singh, M. L. Meena, H. Chaudhary, and G. S. Dangayach, "Ergonomic assessment and prevalence of musculoskeletal disorders among washer-men during carpet washing: Guidelines to an effective sustainability in workstation design," *International Journal of Human Factors and Ergonomics*, vol. 5, no. 1, pp. 22–43, 2017.
[21] M. Joshi and V. Deshpande, "A systematic review of comparative studies on ergonomic assessment techniques," *International Journal of Industrial Ergonomics*, vol. 74, no. August, p. 102865, 2019.
[22] R. Sebti, A. Boulila, and S. Hamza, "Ergonomics risk assessment among maintenance operators in a Tunisian railway company: A case study," *Human Factors and Ergonomics In Manufacturing*, vol. 30, no. 2, pp. 124–139, 2020.
[23] M. Fagarasanu and S. Kumar, "Measurement instruments and data collection: A consideration of constructs and biases in ergonomics research," *International Journal of Industrial Ergonomics*, vol. 30, no. 6, pp. 355–369, 2002.
[24] A. Widyanti, A. Ramadhiar, B. Fista, and N. Rahmawati, "The ergonomics of mothering and child care activities (ErgoMOMics) in Indonesia: Individual and social factors influencing musculoskeletal symptoms," *Work*, vol. 65, no. 3, pp. 625–633, 2020.
[25] I. Dianat and M. A. Karimi, "Musculoskeletal symptoms among handicraft workers engaged in hand sewing tasks," *Journal of Occupational Health*, vol. 58, no. 6, pp. 644–652, 2016.
[26] Y. Thamrin, S. Pasinringi, A. M. Darwis, and I. S. Putra, "Relation of body mass index and work posture to musculoskeletal disorders among fishermen," *Gaceta Sanitaria*, vol. 35, pp. S79–S82, 2021.
[27] J. Heinrich, B. M. Blatter, and P. M. Bongers, "A comparison of methods for the assessment of postural load and duration of computer use," *Occupational and Environmental Medicine*, vol. 61, no. 12, pp. 1027–1031, 2004.
[28] H. Ospina-Mateus and L. A. Quintana Jiménez, "Understanding the impact of physical fatigue and postural comfort experienced during motorcycling: A systematic review," *Journal of Transport and Health*, vol. 12, no. February, pp. 290–318, 2019.
[29] J. Sanjog, T. Patel, and S. Karmakar, "Occupational ergonomics research and applied contextual design implementation for an industrial shop-floor workstation," *International Journal of Industrial Ergonomics*, vol. 72, no. February 2018, pp. 188–198, 2019.
[30] S. Chaiklieng, "Health risk assessment on musculoskeletal disorders among potato-chip processing workers," *PLoS ONE*, vol. 14, no. 12, pp. 1–8, 2019.
[31] M. Lynn and N. Corlett, "RULA: A survey method for the investigation of work-related upper limb disorders," *Applied Ergonomics*, vol. 24, no. 2, pp. 91–99, 1993.
[32] M. Hartono, "Indonesian anthropometry update for special populations incorporating Drillis and Contini revisited," *International Journal of Industrial Ergonomics*, vol. 64, pp. 89–101, 2018.
[33] A. R. Tualeka, J. Jalaludin, F. Salesman, A. Wahyu, and N. Daika, "Correlation between age, working period

and work-related musculoskeletal complaints with nordic body map among fishermen," *Iranian Journal of Public Health*, vol. 49, no. 3, pp. 601–602, 2020.

[34] D. Dane, M. Feuerstein, G. D. Huang, L. Dimberg, D. Ali, and A. Lincoln, "Measurement properties of a self-report index of ergonomic exposures for use in an office work environment," *Journal of Occupational and Environmental Medicine*, vol. 44, no. 1, pp. 73–81, 2002.

[35] S. C. Peres, R. K. Mehta, and P. Ritchey, "Assessing ergonomic risks of software: Development of the SEAT," *Applied Ergonomics*, vol. 59, pp. 377–386, 2017.

[36] B. M. Deros, D. D. I. Daruis, and I. M. Basir, "A Study on Ergonomic Awareness among Workers Performing Manual Material Handling Activities," *Procedia - Social and Behavioral Sciences*, vol. 195, pp. 1666–1673, 2015.