Musculoskeletal and Postural Stress Evaluation as a Basic for Ergonomic Work Attitudes on Welding Workers

Wahyu Susihono[1], Yuri Selviani[2]
[1,2]Industrial Engineering Department, Faculty of Engineering
University of Sultan Ageng Tirtayasa,
Cilegon, Indonesia
[1]susihono@untirta.ac.id; [2]pmy_wahyu@yahoo.co.id

Ida Ayu Kade Arisanthi Dewi[3], Ni Luh Gede Liswahyuningsih[4]
[3, 4]IKIP PGRI Bali
Denpasar, Indonesia

Abstract—**Production process in the construction industry is mostly done by human labour in many manual material handling activities ranging from transportation, machine set-up, and workpiece arrangement. At our subject company, 33 workers have complaints about muscle parts, which are commonly referred to musculoskeletal complaints. NBM questionnaire is used to subjectively assess musculoskeletal muscle disorders. The method used is RULA, which targets upper body posture. The results shows that musculoskeletal complaints of the workers vary from low to high, mostly in the upper body parts. Whereas with the RULA method, it needs to improve the activities that have high scores of 7, that is when welding wire is lifted, and when the welding position is 3G and is 4G. Moreover, activities that need to be improved are those with high scores of 6, which when setting up the welding machine, and during the welding process 2G.**

Keywords—*musculoskeletal complaints; postural stress; work attitude.*

I. INTRODUCTION

Some companies are engaged in fabrication. One sub-field of fabrication is the welding process. In some welding process activities, there are found unnatural work attitudes, uncomfortable body movements, bad working conditions, and bent and squatted working posture within eight hours per day. This condition will accelerate fatigue and cause many complaints, pain and injury to the operator's limbs in the short and long term [1]. It is better to reduce bending, as stated by [2], bending activity at work should be designed minimally, even eliminated because it can cause interference with the musculoskeletal system.

Musculoskeletal complaints are complaints on the parts of the skeletal muscles that are felt by someone ranging from very mild to very painful. If the muscle receives a static load repeatedly and for a long time, it can cause complaints in the form of damage to the joints, ligaments and tendons. These complaints are usually termed as complaints of musculoskeletal disorders (MSDs) or injury to the musculoskeletal system [4]. Complaints of skeletal muscles generally occur due to excessive muscle contraction from giving too much workload with a long duration of loading. These complaints are caused by an uncomfortable lifting load [4], thus it is necessary to improve work to reduce musculoskeletal complaints [5, 6]. The discomfort of working, apart from being caused by musculoskeletal complaints, is also caused by unnatural work postures [7], thus ergonomic design is needed [8].

Working posture is the position of the body in doing activities. There are three factors influencing posture when working, namely: personal factors, located in the design of the workplace and factors of work characteristics; normal working posture (good working posture); and abnormal working posture (awkward working posture). The factor that generally can cause musculoskeletal complaints is abnormal work postures, which do not follow the natural movements in accordance with the anatomy of the worker's body. Workers who are in the welding process generally have high risk of disruption of the musculoskeletal system. Generally, disorders occur in the upper limbs felt in, among others, the presence of repetitive movements, the use of excess strength, and static muscle activity in the musculoskeletal system. Methods are needed to be able to investigate work attitudes so that it can be recommended to work more comfortably.

Up to this moment, the Rapid Upper Limb Assessment (RULA) method has been used to assess the posture, style and movement of a working activity related to the upper limbs. The RULA method is the most complex method developed by several experts to assess the potential for work injury [9]. Whereas, the method used for subjective investigation of muscle disorders is using the Nordic Body Map questionnaire. By using RULA method, it is hoped that musculoskeletal and postural stress complaints from workers can be identified and then used as a basis for improving the improvement of working attitudes. During this time, the RULA method approach has been used to base work improvement, but some studies, with dynamic subjects, have specific characteristics, so research on welder activity varies greatly. This study has differences in the stages of activity of each product completion; hence this study has a specific goal of improving the work on welder activity in the subject under study. In one

of the companies as the subject of research in Cilegon, 33 welder workers have complaints about muscle parts.

II. METHOD

The subjects of this study were 33 workers in one of the welding companies in Cilegon, Banten Province, who had reported complaints about muscle parts. The stages carried out in this research are literature study, field observations in collecting questionnaire data and recording working posture videos, processing the studied variables namely the musculoskeletal complaints using Nordic Body Map questionnaires, and processing work posture movements using CATIA V5R17 software. The investigation of working postures is approached by using the RULA (Rapid Upper Limb Assessment) method. The limitations in this study are: a) the data retrieval is only focused on workers welder section, and b) the retrieval of musculoskeletal complaints data coverage at the time after the workers finished their daily activities.

III. RESULTS AND DISCUSSION

A. Nordic Body Map Questionnaire

Nordic Body Map (NBM) is one of the subjective measurement methods to measure workers' muscle pain. NBM questionnaire is one the form of ergonomics checklist questionnaire. In the Nordic Body Map (NBM), the questionnaire is divided into three parts, namely the trunk muscle (upper neck, lower neck, back, waist, and buttocks), the upper limb muscles or upper extremities (left shoulder, right shoulder, left and right upper arms, left and right elbows, left and right forearms, left and right wrists, left and right hands), and the lower extremity muscle parts or lower extremities (left and right thigh, left and right knee, left and right foot). Musculoskeletal complaints were assessed with 28 items describing the part of the body complaining of pain by filling in the Nordic Body Map questionnaire [10].

Nordic Body Map (NBM) questionnaire is a questionnaire to see complaints from body parts felt by respondents. It is the most common questionnaire used to find out the inconvenience of workers, since it is standardized and neatly arranged. This questionnaire has 28 body parts indexes under study. The answers to this questionnaire are in several versions, some are using a *Likert* scale and others are using yes or no answers. Based on the design of this research, the main assessment is to use scoring for example 4 Likert scale. If the scoring uses *Likert* scale, then each score or value must have a clear operational definition and easily understood by respondents. Thus, in this study, the questionnaire used applied a *Likert* scale with a scale of one to four.

As can be observed in Fig. 1, respondents who have reported complaints are in the categories of very sick, sick, to rather sick. The information showed that there were twelve complaints on the parts of the body that crossed the average line of complaints of pain, including the upper neck, lower neck, left shoulder, right shoulder, waist, buttocks, right wrist, right hand, left knee, right knee, left calf, and right calf. After

calculating the body complaints, dominant complaints were found, and then the percentage of complaint categories was calculated.

RULA analysis approach is used for basic ergonomic design, so that the complaints section can be reduced, the design generally uses an anthropometric approach [11], several proposals to provide alternative design solutions to reduce the risk of complaints are needed [12], there is a relationship between work posture and musculoskeletal complaints [13].
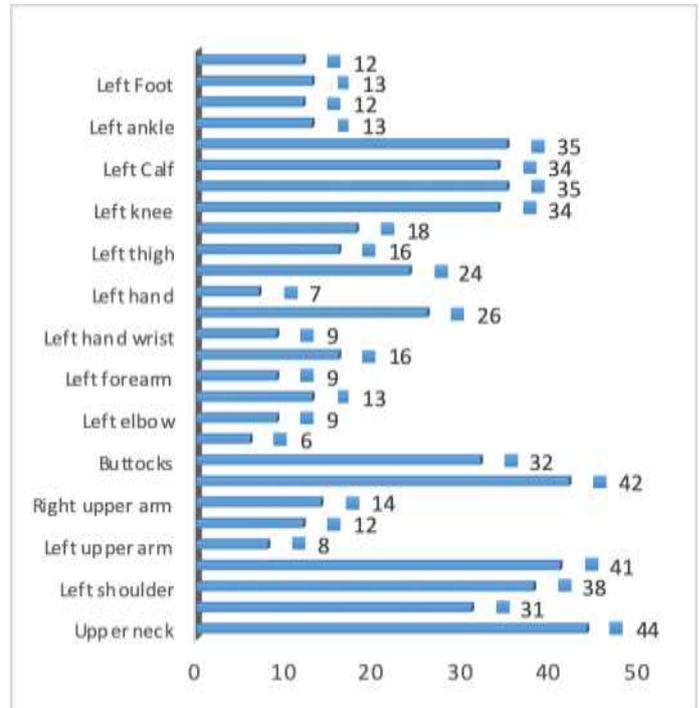

Fig. 1. Musculoskeletal complaints of welder workers (n = 33)

As can be observed in Fig. 2, 60% of respondents score between 28 and 49, which are in the category of low complaints, thus corrective action is not needed. There are 34% of respondents who score between 50 and 70 in the category of moderate complaints, so that corrective action is needed in the future. There are 4% of respondents who score between 71 and 91 in the category of high complaints, thus corrective action is needed immediately. There are 2% of respondents who score between 92 and 112, meaning that complaints are very high, thus corrective action is needed as soon as possible. Further research is needed to find out more about in-depth relationships between work attitudes, length of service and musculoskeletal complaints [14, 15], if it is possible, before the intervention is carried out by workers, it is necessary to design a development model. It is possible that musculoskeletal complaints are not only caused by lifting activities, but also because of the activities carried out repeatedly [16]. This research was focused on investigating the level of complaints welder.

Welder is a job that has a heavy workload, often working in extreme areas such as working at heights or working in a narrow area. The success application of this method really depends on the conditions and situations experienced by the workers at the time of the assessment and depends on the expertise and experience of the observer concerned. There are 12 body parts that have levels of complaints. They exceed the average of 88% workers who report complaints in the upper neck, 84% workers report complaints in the waist, 82% workers who report complaints on the right shoulder, 76% workers who report complaints on the left shoulder, 70% workers who report complaints on the right knee, 70% workers who report complaints on the right calf, 68% workers that report complaints on the left knee, 68% workers who report complaints on the left calf, 64% workers that report complaints on the buttocks, 62% workers that report complaints on the part lower neck, 52% workers that report complaints on the right wrist, and 48% workers that report complaints on the right hand. The complaints generally occur in certain muscles, especially dynamic muscles. Some appraisals could also be used by NIOSH [17], Lean Ergonomics [18], and the ultimate goal of which is to investigate work attitudes and reduce musculoskeletal complaints [19, 20].
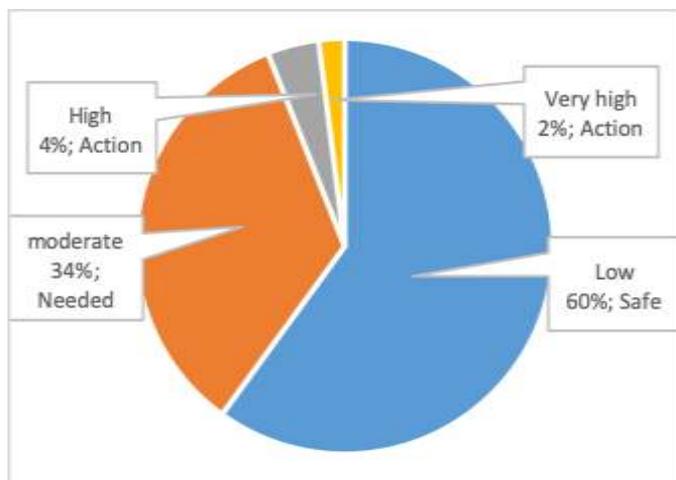

Fig. 2. Body Complaint Level (n = 33 workers)

In general, minor muscle complaints are found in those who have enough time to rest. On the other hand, for people who work continuously but without enough rest, they report having muscle fatigues. A low level of body freshness increases the risk of muscle complaints. Muscle complaints increase with increasing physical activity. The work that is carried out without an evaluation will cause health risks [21, 22].

There were 16 body parts with a low complaint level: 36% complaints on the right thigh, 32% complaints on the right forearm, 32% complaints on the left thigh, 28% complaints on the right upper arm, 26% complaints on the elbow right, 26% complaints on the left ankle, 26% complaints on the left foot, 24% complaints on the back, 24% complaints on the right

ankle, 24% complaints on the right foot, 18% complaints on the left elbow, 18% complaints on the left forearm, 18% complaints on the left wrist, 16% complaints on the left upper arm, and 14% complaints on the buttocks.

The high category level of musculoskeletal complaints must be done to improve work attitude. The low category complaints level of Musculoskeletal Disorders (MSDs) have total NBM score 28 to 49. In this study, MSDs complaints resulted from 33 welders experiencing complaints in the low category do not need corrective action. As many as 17 people have moderate complaints, which means remedial action is needed in the future. As many as 2 people report high category complaints, which means corrective actions were needed immediately. Moreover, 1 person experiences very high category complaints, meaning that corrective actions needed as soon as possible. Complaints reported by workers aged 35 years and above are generally caused by less resting period, which is less than 7 hours. Lack of time to rest will cause an increased risk of musculoskeletal complaints [23].

Muscle complaints generally occur due to excessive muscle contraction of workloads that are too heavy, for long periods of time. Muscle complaints can occur if muscle contractions exceed 20%, then blood circulation to the muscles decreases according to the degree of contraction, which is affected by the amount of energy needed. If the oxygen supply to the muscles decreases and the process of carbohydrate metabolism is inhibited, the result is a buildup of lactic acid, which causes muscle pain. Besides, the factors that can affect MSDs complaints can be influenced by the age of the worker, since age is the main cause that can affect performance. Optimal age to work for maximum muscle strength is between 20-29 years, at the age of 60 years the average muscle strength decreases to 20%. The first complaint is usually felt at the age of 35 years and the level of complaints will continue to increase along with the age. For middle age, the strength and endurance of muscles begin, so the risk of muscle complaints increases. Work posture analysis is needed to see the physiological impact or even the impact on work stress [24]. Technological redesign is needed in order to reduce the value of postural stress and work boredom [25], especially in lifting activities [26, 27].

Environmental factors or work facilities contribute to musculoskeletal complaints. Some manual material handling workers need stretching exercises to reduce musculoskeletal complaints [28, 29], so that productivity and occupational health could increase [30]. Smoking habit factors have a significant relationship with waist muscles complaints, especially for work that requires muscle mobilization. Smoking can reduce the capacity of the lungs so that oxygen consumption is reduced and can cause decreased body freshness and cause pain in the muscles. Physical fitness greatly affects muscle complaints, when the body does not have enough rest there will be muscle complaints.

B. Work Posture with the RULA (Rapid Upper Limb Assessment) Method

Rapid Upper Limb Assessment (RULA) is a method developed in the field of ergonomics that investigates and

evaluates work positions carried out by the upper body. This equipment does not carry out special tools in measuring the posture of the neck, back, and body parts. Assessment using the RULA method takes a little time. RULA is intended and used in the field of ergonomics with a broad scope of fields. In several studies, work posture analysis can be used with several approaches, including work posture analysis using the OWAS Method (Ovako Working Posture Analysis System), RULA and REBA (Rapid Entire Body Assessment) [31,32,33]. In this assessment, body posture images were analyzed using RULA through the help of the CATIA V5R17 software.

Fig. 3. RULA Score when Taking Welding Wires (a) Right side, score 3 (b) Left section, score 3

Fig. 4. RULA Score when Lifting Welding Wire (a) Right side, score 7 (b) Left section, score 7

Fig 5. RULA Score when Set Up the Welding Machine (a) Right, score 6 (b) Left, Score of 6.

Fig 6. RULA Score during the 1G Welding Process (a) Right, score 4 (b) Left, score 3.

Fig. 7. RULA Score during the 2G Welding Process. (a) Right side, score 6 (b) Left section, score 6.

Fig. 8. RULA Score during the 3G Welding Process. (a) Right, evening 7 (b) Left, score 7.

The results of this RTA score could be used as a basis for work improvement [34, 35, 36]. In this study, the work postures observed were seven work postures from the start to the welding process. It started from the operator when taking the welding wire, lifting the welding wire, setting up the welding machine, to the welding process. In the welding process, there are many positions, namely: 1) the position of 1G (Groove), where the welding position of 1G is welding when the operator welds flat or horizontally under his view; 2) 2G welding is a welding when the operator welds in a horizontal position parallel to his view; 3) 3G welding is a welding when the operator welds in a vertical position; whereas 4) 4G welding is when the operator welds with an

overhead position or welding position above his head. In carrying out welding activities, the operator moves statically in a quite long time, with a limited range of differences in work postures. The operator conducts welding in various positions such as sitting, squatting, looking down, or looking up. In this case, if the welding left for too long and continuously, it can cause the risk of disruption of the musculoskeletal system in workers, especially in the upper body. So using the RULA (Rapid Upper Limb Assessment) method can determine work priorities based on injury risk factors. This is done by comparing the values of the different tasks that are evaluated. This method can be used to find the most effective actions for jobs that have a relatively high risk. Some other studies can also use the RULA, REBA, OWAS methods. However the results are not different. Other methods have an investigative approach with a different focus [37-40].

From the results of this study, information related to assessment of work posture by using the CATIA software when taking the welding wire to get a right score of 3 and a left score of 3 is obtained. It reveals the level of risk experienced as moderate. The action requires further investigation, such as changes for improving work attitude. Assessment of work posture at the time of lifting the welding wire reports a right score of 7 and a left score of 7. It implies that the higher the level of risks experienced, the more urgent the action required for further investigation and improvement will be. The factors that cause a very high level of risk at the time of removal of this welding wire shows that the welded wire had a load of 15 kg. Category 7 requires evaluation of work attitude in a short time. Work improvement can be done with an ergonomic work design [41, 42, 43]. The assessment of work posture, when setting up the welding machine, was to get a right score of 6 results and a left score of 6. It implies that the higher the risk experienced, the more urgent it is to conduct further investigation and immediate improvement. The cause of the high level of risk can be seen from the picture of the observation result of the operator setting up the welding machine with the bending position at an angle of 90º.

The assessment of work posture when welding with 1G position are 4 for the right score and 3 for the left score. This shows that the level of risk experienced is moderate, so the action needed is further investigation, including changes to improve work attitude. In addition to the risks posed in terms of musculoskeletal complaints, there are other hazards during the welding process, such as safety problems when the operator standing with one left foot on the used material and the operator's right foot stepping on the part or work piece being welded.

The assessment of work posture when welding 2G i.e. for the right score obtains a result of 6 and a left score of 6, this shows that the level of risk experienced is high, so the actions required are further investigation and immediate improvement. The cause of the high level of risk can be seen from the picture that workers do the welding process with a bent body position, while his head is looking up. The assessment of work posture when 3G welding that is for the right score obtained a result of 7 and a left score of 7. This shows that the level of risk

experienced is very high, then the actions required are immediate further investigation and improvement. Factors that cause a very high level of risk can be seen from the picture that workers do the welding process with the position of the body squatting while the body half rotate to the right.

The assessment of work posture at 4G welding, that is, for the right score the result is 7 and the left score is 7. This shows that the level of risk experienced is very high, so the action required for further investigation and improvement as soon as possible. Factors that cause a very high level of risk, can be seen from the picture that workers do the welding process with a squat body position while the head is looking up with extreme tilting up because he was of welding above the head. The difference in the value of the work posture is influenced by the presence of different work attitudes [44], so it is necessary to evaluate the work posture and the position of the worker when completing work activities [45,46].

From the results of the assessment of body posture using the RULA (Rapid Upper Limb Assessment) method, it is found that the position that has a very high score is 3 positions, including when lifting the welding wire, when welding 3G, and when welding 4G. There are 2 positions that have high scores, including when setting up the welding machine, and during the 2G welding process. The positions that have a moderate score are 2 positions, including when taking the welding wire, and the 1G welding process. There is a strong relationship between work posture and musculoskeletal complaints [47]. This is caused by the factor of work equipment that is not appropriate so that it affects the work posture of workers, which then also affects the musculoskeletal complaints. Work posture with the principle of manual material handling has a fairly high risk of injury compared to using assistance. However, the use of machines that do not consider human anatomy will also contribute to the occurrence of musculoskeletal complaints. Generally complaints are felt in terms of muscles and bones, thus RULA analysis is needed to obtain appropriate recommendations [48-51]

IV. CONCLUSION

Based on the analysis and discussion previously described, it can be concluded as follows:

a. Musculoskeletal complaints: 2% of workers experience very high complaints, 4% high complaint rates, 34% moderate complaints, and 60% low complaint rates.

b. The most dominant part of the body that experiences musculoskeletal complaints is the upper neck by 88%

c. Attributes that need to get improvement are activities that have a very high score of 7, namely when lifting the welding wire, and at the 3G welding position and 4G welding position

d. Activities that need improvement have a high score of 6, when setting up welding machines, and during the 2G welding process. Further research is needed to design 2G welding activities in the form of improved work attitude and evaluation of Ergonomic-based Standard Operating Procedures

REFERENCES

[1] S. R. Wignjosoebroto and E. A. Jovianto, Ergonomics Study in the Design of Tools for the Adjustment and Welding of Travo Tank Products. *Journal of Industrial Engineering*, Surabaya: FTI IT, 2010.

[2] W. Susihono and E. Rubiati, "Improvement of Work Methods Based on Rapid Upper Limb Assessment (RULA) in Construction and Fabrication Companies," Journal of Industrial Spectrum, vol. 11 (1), pp. 101-110, 2013.

[3] Tarwaka, Industrial Ergonomics: *Ergonomics Knowledge Basics and Application at Work* (2nd Ed), Solo:Harapan Press Solo, 2015.

[4] R. D. Astuti, "Analysis of the Effect of Work Activities and Lift Load on Musculoskeletal Fatigue," Journal of Echoes of Engineering, vol.1 (2), pp. 27-32, 2017.

[5] I. Mindhayani and H. Purnomo, "Work System Improvement to Increase Employee Productivity," Journal PASTI, vol. X (1), pp. 98-107, 2016.

[6] K. Sundari, "Work attitude that causes musculoskeletal complaints and increases productivity in ceramics builders," Industrial engineering scientific journal, vol 10 (1), pp. 42-47, 2014.

[7] K. Istighfaniar and Mulyono, "Evaluation of Work Posture and Musculoskeletal Complaints in Pharmacy Installation Workers," The Indonesian Journal of Occupational Safety and Health, vol. 5(1.), pp. 81–90, 2016.

[8] L. Widodo, S. Wow, Y. Kevin, "Design Work Facilities on the Controller Assembling Process in PT. Multitanaka Suryatama Based on Ergonomic Principles," Scientific Journal of Industrial Engineering, vol. 6(2.), pp. 124-137, 2018.

[9] W. Susihono, "Analysis of Work Posture with the Rappid Upper Limb Assessment (RULA) Method as a Basis for Recommendations for Work Facility Redesign," Journal of Industrial Services, vol. 1(2), pp. 266-271, 2016.

[10] A. A. Darojatul, "Mapping of Musculoskeletal Complaints Based on Risk Factors of Workers of Meatball Production Workers," Thesis, Jakarta: Faculty of Medicine and Health Sciences of UIN Syarif Hidyatullah, 2017.

[11] D. Rosyanti, A. Hawan, Nelfiyanti, "Ergonomic Design of Circumcision Sites to Reduce Musculoskeletal Complaints by the Rapid Entire Body Assessment (REBA) Method and Anthropometric Measurements" Bina Teknika, vol. 15(1), pp. 69-76, 2019.

[12] W. Sarvia E., "Proposal for Designing Alternative Material Handling to Reduce the Risk of Pain Complaints and Determination of Rest Time for Lifting Gallons (Case Study of Distribution of Water Gallons to "X" Distributor Stores)," Journal of Industrial Engineering, vol. 4(1), pp. 7-17, 2019.

[13] Pegi, T. Kawatu, P. A., J. Kaunang W. P., "Relationship between work posture with musculoskeletal complaints on aviation security (avsec) workers at the Samratulang airport," KESMAS Journal, vol 7(4), 2018.

[14] Oley, R, A. Suoth, L, F. Asrifuddin, A. 2018. "Relationship between Work Attitude and Work Period with Musculoskeletal Complaints in Fishermen in Batkota Sub-District, North Lembeh District, Bitung City in 201," KESMAS Journal, vol. 7(5).

[15] A. Silviana N., "Assessment of Workers' Work Postures Using the REBA and Biomechanics Methods (Case Study of PT. XY in the Packing Section)," Journal of Industrial Engineering, vol. 1(1) pp. 10-16, 2018.

[16] M. D. Habibie and J. Suroto, "Analysis of work postures and repetitive movements for complaints of musculoskeletal disorders in tempe-making workers in bandung rejo village mranggen sub-district demak," Journal of Community Health, vol. 5(5), pp. 245-254, 2018.

[17] D. B. Leksonowati T. Dahniar, "Employee Posture Analysis of the Pick Up Section at PT Lintas Nugraha Ekakurir (JNE) Kayon Branch, Cinere with the NIOSH Method," Journal of Technology, vol. 1(2), pp. 103-113, 2018.

[18] L. N. Matondang R. Huda, "The Lean Ergonomics in Green Design of Crude Palm Oil Plant," Journal of IOP Conf. Series: Materials Science and Engineering, vol. 1(1), pp. 1-7, 2018.

[19] T. H. Sulistiyo, R. J. Sitorus, Ngudiantoro, "Analysis of ergonomic risk factors and musculoskeletal disorders in radiologists in hospital radiology installations in Palembang," Journal of Health Medicine, vol. 5, (1), pp. 26-37, 2018.

[20] C. E. Revaldi, C. S. Gunawan, G. J. Rakasiwi, "Prevalence and Factors Causing Musculoskeletal Disorders in the Tire Warehouse Operator PT X Tangerang Indonesia," Indonesian Ergonomics Journal, vol. 05 (01) pp. 10-15, 2019.

[21] R. Fahmi, "167 images of fatigue and musculoskeletal complaints in long-distance night bus drivers po. Restu mulya," The Indonesian Journal of Occupational Safety and Health, vol. 4(2) pp. 167-176, 2015.

[22] Sumardiyono, R. Wijayanti, E. Probandani, G. Larasati, "Occupational health risk factors for written batik workers," SNST proceedings, vol. 1(1), pp. 7-12, 2018.

[23] A. Nurliah, "Musculoskeletal Disorders (MSDs) Risk Analysis in Forklift Operators at PT LLI," Thesis, Depok; University of Indonesia, pp. 71–74, 2012.

[24] B. Das and S. Gangopadhyay, "Prevalence of Musculoskeletal Disorders and Physiological Stress Among Adult, Male Potato Cultivators of West Bengal, India," Asia-Pacific Journal of Public Health, vol. 20 (9), pp. 1 – 14, 2015.

[25] W. Susihono, L. Lady, F. R. Sari, "Redesign of Rice Thresher Technology Based on Ergonomic Rules Reduces Postural Value of Stress and Work Boredom," Proceeding on the IENACO National Seminar-2019, pp. 40-47, 2019.

[26] K. N. Sanjaya, N. H. Wirawan, B. Adenan, "Manual Material Handling Work Posture Analysis Using Biomechanics and NIOSH," Journal of UNIQUE JATI," vol. 1(1), pp. 61-71, 2017.

[27] F. Novariyanto, E. Suparti, "Analysis of Gallon Water Lifting with Physiology and Biomechanics Approaches (Case Study: In Surakarta Prosperous Stores)," Scientific Journal of Industrial and Information Engineering, vol. 5(1), pp. 42-51, 2016.

[28] S. Harwanti, N. Ulfah, B. Aji, "Effect of workplace stretching exercise on decreasing complaints of musculoskeletal disorders in batik workers in the sokaraja district," Indonesian Public Health Journal, vol. 9(1), pp. 49-59, 2017.

[29] A. R. R. Mabilehi, L. P. Ruliati, N. C. L. P. Berek, "Analysis of Risk Factors for Musculoskeletal Complaints in Blacksmiths in Alak District, Kupang City," Timorese Journal of Public Health, vol. 01(1), pp. 31-41, 2019.

[30] M. Andriani and E. Dewiyana Erfani, "Ergonomic Egrek Redesign to increase worker productivity when harvesting oil palm," Journal of Industrial Systems Integration, vol. 4(2), pp.119-128, 2017.

[31] H. M. Afif and W. A. Y. Endang, "Analysis of Work Posture Using OWAS Method (Ovako Working Posture Analysis System), RULA (Rapid Upper Limb Assessment) and REBA (Rapid Entire Body Assessment) (Case Study of DI PT Adi Satria Abadi)," RECEPTION Journal, vol. 5(1), pp. 44-50, 2018.

[32] S. Patriyono and Bethriza, "Work Posture Analysis with RULA Method on the FR and RR D30D Masking Process Operators at PT. SC Plant 2," PASTI Journal, vol. 7(1), pp. 79-92, 2018.

[33] B. Pratiwi, A. Miftachurrohman, D. Much, "Work Prosture Analysis with the Manual Task Risk Assessment (ManTRA) Method in Making Vermicelli Noodle," Scientific Journal of Industrial Engineering, vol. 7(1), pp. 71-82, 2018.

[34] Y. Mutiarasari, A. Rino, N. D. A. Yusuf, "Proposed Improvement of Assist Tool Specifications at the Stamping Tool Stamp Work Station by using the Rapid Upper Limb Assessment (RULA) Case Study (Case Study of the Batik Komar house)," E-Proceeding of Engineering, vol. 2(2), pp. 4738, 2015.

[35] B. Son and A. Ary, "Proposed Improvement of Worker's Body Posture in Assembling Activities at PT. Hitachi Construction Machiner Indonesia using the Rapid Upper Limb Assessment (RULA) Method," Undip Ejurnal, vol. 6(4), 2017.

[36] S. Gorde and B. Atul, "The Ergonomic Assessment of Cycle Rickshaw Operators Using Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA) Tools," Sciendo, vol. 1, pp. 219-229, 2019.

[37] D. Correia, Y. F. Muhammad, A. S. Risma, "Work Posture Analysis Using the Rapid Upper Limb Assessment (RULA) Method and the Ovako Working Posture Analysis System (OWAS)" RECEPTION Journal, vol. 4(2), 2016.

[38] I. Pegiardi, Firdanis, Supriyadi, "Oparator Work Posture Analysis with RULA Method in the Gas Cutting Area. Oparator Work Posture Analysis with RULA Method in the Gas Cutting Area," INTECH Journal, vol. 3(2), pp. 73-33, 2017.

[39] D. Restuputi, W. P. Lukman, "REBA Method for the Prevention of Musculoskeletal Disorder in Labor," Journal of Industrial Engineering, vol. 18 (1), pp. 19-28, 2017.

[40] A. Dywer, H. Jeremy, K. Majid, D. Angela, D. Michelle, C. David, "Ergonomic assessment of robotic general surgeons: a pilot study," Journal of Robotic Surgery, vol. 3(2).

[41] D. Rosyanti, A. Hawan, Nelfiyanti, "Ergonomic Design of Circumcision Sites to Reduce Musculoskeletal Complaints by the Rapid Entire Body Assessment (REBA) Method and Anthropometric Measurements," Bina Teknika, vol. 15(1), pp.69-76, 2019.

[42] M. H. Behesti, A. J. Tajpour, J. Ameneh, S. Sajedeh, B. Maryam, R. Habebeh, "Evaluation of Ergonomic Risk Factors for Musculoskeletal Disorders among Kitchen Workers," Archives of Occupational Health, vol. 2(2), pp. 128-35, 2018.

[43] M. R. Ramadhani, P. Darul, A. Diajeng, "Assessment Analysis of Ergonomics Work Posture on Wheel Installation With Ovako Work Posture Analysis System (OWAS) Method AND Rapid Entire Body Assessment (REBA) Method Preventing Musculoskeleal Disorders AT PPD Jakarta," IOSR Journal of Humanities and Social Science," vol. 23(10), pp. 1-11, 2018.

[44] A. Widyanti, "The Agreement between Observation and Self-report Methods in Work Posture Analysis," JITI, vol. 12(2), pp. 186-191, 2018.

[45] P. Michal, R. Dariusz, W. Dorota, A. Alexander, "Ergonomic Evaluation of Working Position Using the REBA Method," Sciendo, vol. 1, pp. 61-68, 2019.

[46] K. Istighfaniar and Mulyono, "Evaluation of Work Posture and Musculoskeletal Complaints in Pharmacy Installation Workers," The Indonesian Journal of Occupational Safety and Health, vol. 5(1), pp. 81–90, 2016.

[47] A. Arfariari, "Relationship of Work Posture with Musculoskeletal Complaints and Work Productivity in Packing Workers," Thesis, Surakarta: Muhammadiyah University, 2014.

[48] M. Siska, And A. A. Septi, "Manual Material Handling Posture Analysis on Pallet Removal Activities Using Rappid Upper Limb Activity (RULA) at PT. Alam Permata Riau," Journal of Science, Technology and Industry, vol. 15(2), pp. 77-86, 2018.

[49] R. Ardiliansyah, H. R. Lukman, Wiediartini, "MSDs Injury Risk Level Analysis in Manual Material Handling Work with REBA and RULA Methods in the Work of Grain Production Area PT. Petrochemicals Like" Proceeding 1st Conference on Safety Engineering and Its Application, vol. 1(1), 2018.

[50] D. Correia, Y. F. Muhammad, A. S. Risma, "Work Posture Analysis Using the Rapid Upper Limb Assessment (RULA) Method and the Ovako Working Posture Analysis System (OWAS)," RECEPTION Journal, vol. 4(2), 2016.

[51] T. Dahniar and D. B. Leksonowati, "Employee Posture Analysis of the Pick Up Section at PT Lintas Nugraha Ekakurir (JNE) Kayon Branch, Cinere with the NIOSH Method," Journal of Technology, vol. 1(2), pp. 103-113, 2018.