Musculoskeletal disorders analyzing of air cleaner assembly operators using nordic body map in excavator manufacturer in Indonesia

Galih Prakoso[1], Hardianto Iridiastadi[2], Euis Nina Saparina[3]
[1] Production Improvement Engineer, PT Sandvik Indonesia
[2]Industrial Engineering Department, Institute Technology of Bandung,
[3]Industrial Engineering Department, Universitas Mercu Buana, Jakarta
Corresponding author: galih.prakoso3003@gmail.com

Abstract. *Musculoskeletal disorders often occur in non-ergonomic work postures. In this study an assessment of operator disorders was carried out on the installation of air cleaner components in a heavy equipment manufacturer. The purpose of this study was to determine the extent to which operator disorders and which body parts needed to improve work posture. The assessment method uses a standard Nordic Body Map questionnaire that is often used to assess musculoskeletal disorders. From the results of the assessment, the main disorders were in the right and left elbow body parts at 93%. Second, 87% of the body's right knee and left knee, third, right and left forearm, 80% right and left wrist, fourth on the second upper arm and 73% on the palm. The fifth is on the right shoulder, back and calf 60%. Therefore in these body parts, it is necessary to improve work posture to reduce the risk of musculoskeletal injury. An installation tool is needed for the process to make it easier for operators to work.*

Keywords: nordic body map, musculoskeletal disorders, work postural body assessment

1. Introduction

The manufacturing industry in Indonesia still involves a lot of operator physical activity. Assembling work is often done manually by the operator by using limbs. This research was conducted at a heavy equipment manufacturer in the Cibitung area, West Java, Indonesia. The company produces medium excavators with 10 tons, 20 tons and 30 tons in weight. The factory in the Cibitung area has three main production processes that are done to make the final product of the excavator there are welding or fabrication process, then assembling process and finally painting process.

The welding process in this company has used a lot of welding robots so that the operator only needs to put the components on the robotic welding machine table then the welding robot automatically does the welding work. Painting process is carried out using a conveyor and continuously enters into the Electro Deposit Painting room which automatically coating the components with the paint. Operator's involvement in this line is also very small, only just monitoring the painting process in the chamber and checking the quality of the paint thickness.

The chosen production line is line assembling where the manual installation process is still carried out by many operators. One of the installation processes without tools help such as cranes in this company is air cleaner installation. Therefore the operator is required to lift, hold and install the components weighing 8 kg using the limbs manually without any tools, as shown in figure 1.

Based on the description that has been explained above, it is necessary to conduct an assessment of the operator's postural body work in the process of air cleaner assembly. The purpose of the assessment was to find out which body parts of the operator were perceived to have musculoskeletal disorders. By knowing the body parts that are felt to have musculoskeletal disorders, the company can consider making improvements to the postural body work based on the assessment. This research is limited to the assessment of musculoskeletal disorders using the Nordic Body Map.

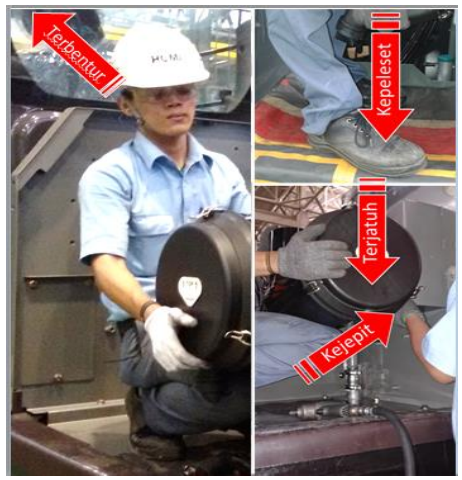

Figure 1 Manual process Air Cleaner assembly

The application of the Nordic Body Map to assess musculoskeletal disorders is used very often. Several previous studies can be used as references for the basis of research. Kuorinka et al. (1987) made and tested this Nordic Body Map standard questionnaire to analyze musculoskeletal symptoms in the context of ergonomic health. Reliability of the questionnaire has been proven to be acceptable. Specific characteristics of work strain are reflected in the frequency of responses to the questionnaire.

Examples of Nordic applications for assessing daily activities are driving activities. Chen, et al. (2004) identified disorders on the knee of the taxi driver using a Nordic questionnaire. Abledu et al. (2014) used the Nordic Body Map to find out musculoskeletal disorders in taxi drivers in Ghana. Mansfield and Marshall (2001) used a nordic questionnaire to assess which body parts of sports rally drivers experienced musculoskeletal injuries.

Another study uses the nordic questionnaire for work activities in the room as done by Mota et al. (2014) applied a nordic questionnaire to analyze musculoskeletal disorders on staff at a university in Brazil. Gavgani et al. (2013) determine ergonomic factors that affect operator health at Tabriz University of Medical Sciences, Iran using a Nordic questionnaire.

The Field of Industry also has the application of the Nordic questionnaire as carried out by Hossain, et al. (2018) study musculoskeletal disorders in garment workers in Bangladesh. Still in the same industry, Wakjira and Tafese (2014) also examined disorders about the arms, elbows, and fingers of the operators in Ethiopia. Aghilinejad, et al. (2012) used the Nordic Body Map (NBM) questionnaire standard to assess musculoskeletal disorders in operators handling steel material in an automotive company in Iran. Salve (2015) determined musculoskeletal discomfort in a jewelry producing company in India.

In the field of medicine, several studies also use Nordic body maps to measure musculoskeletal disorders. Wong, et al. (2017) used this questionnaire to determine musculoskeletal disorders in otolaryngology patients. Ambarwati, et al. (2018) analyze the musculoskeletal risk suffered by dentists in tasikmalaya. Kumar, et al. (2013) also examined the risk of musculoskeletal in dentist activities in India.

All the research described above produces points of pain from parts of the body that experience musculoskeletal discomfort and can later become the basis of an improvement in work posture. In general, the body map nordic questionnaire is a tool that can be used to analyze any activity both in the scope of work and daily activities outside of work.

2. Literature Review

A simple ergonomic measuring tool that can be used to identify the source of the cause of musculoskeletal disorders is the Nordic body map. Through the Nordic body map, it can be seen parts of the muscles that experience pain with the level of pain ranging from discomfort (rather pain) to very sick (Corlett & Clark, 2003). Seeing and analyzing body maps as shown in Figure 2, can be estimated the type and level of pain of skeletal muscles felt by workers.

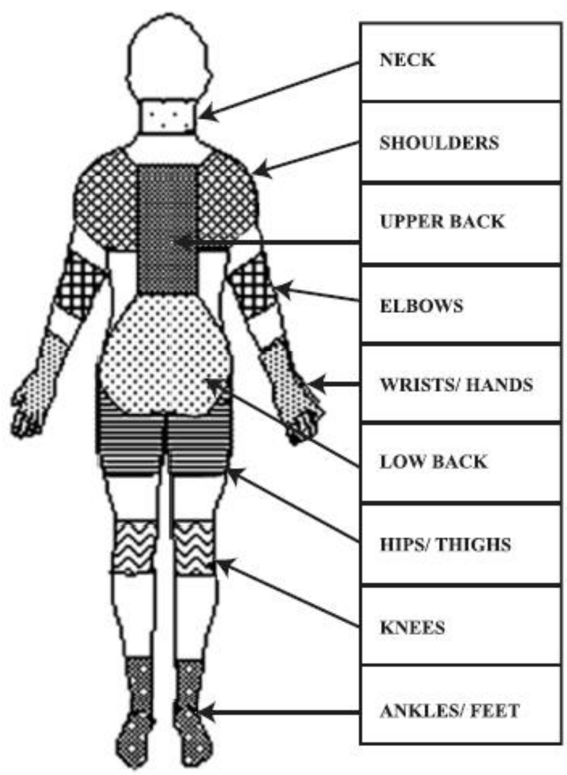

Figure 2 Nordic Body Map
Source: Iridiastadi dan Yassierli, 2015

Kuorinka, et al. (1987) compiled a Nordic body map questionnaire for computer analysis. Regular analysis of various statistical epidemiological programs can be applied. Alternative dichotomies of responses may require special consideration. The questionnaire provides useful and reliable information about musculoskeletal symptoms. This information is very good for improving in-depth investigations or providing guidance for decision making about preventive measures.

Various studies have shown that different response distributions for different occupational groups and differences are related to the estimated workload. In several studies, questionnaires have revealed a high prevalence of symptoms and pain in certain anatomic areas that clearly correlate with local physical demands.

Palmer, et al. (1999) examined the reuse of Nordic questionnaires and the validity of the questionnaire for pain of upper limbs and neck. The study was conducted in a population of 105 hospital outpatients with various upper and neck extremities (including cervical spondylosis, adhesive capsulitis, lateral epicondylitis, Carpal Tunnel Syndrome and Raynaud's phenomenon). Subjects were asked to fill in the modified Nordic questionnaire twice with a close time span. Repetition of their responses was assessed by calculating the kappa coefficient (K), and the sensitivity and specificity of component items in the questionnaire were determined for the specific diagnostic categories of upper limb and neck pain. Symptom reports for pain in the upper extremities and neck, pain interfering with physical activity, neurological symptoms and blanching were all found to be very recurrent (K = 0.63-0.90).

In the above studies it was also found in a number of pain reports in certain areas that proved the nordic questionnaire was very sensitive in relation to certain upper extremity disorders, but with the exception of finger blanching reported in patients with Raynaud's phenomenon, none proved to have good specificity (range = 0.33-0.38). The conclusion is that the modified Nordic Body Map questionnaire can be repeated, sensitive, and tends to have high utility in screening and supervision. However, complementary examination of specificity and adequate repetition is very important for establishing a clinical diagnosis.

3. Method

The assessment using the Nordic Body Map questionnaire was a qualitative assessment. Questionnaires were given to operators to be selected on a scale A, B, C, D which represented the level of musculoskeletal operator disorders. Option A to not get sick, B to be somewhat sick, C to get sick and D to get very sick.

The Nordic Body Map questionnaire was given to five operators in the air cleaner installation line. The purpose of filling in the Nordic Body Map questionnaire is to find out the parts of the muscle that have pain with the level of pain ranging from discomfort (rather pain) to very sick. In filling out the Nordic Body Map questionnaire, it was carried out directly by giving a check mark (✓) to the part of the body experiencing the pain.

After completion of filling out the questionnaire by the operator, the results of the questionnaire will be given weights according to the level of pain. Weight 0 for choice A, weight 1 for choice B, weight 2 for choice C and last weight 4 for choice D. The weight will be multiplied by the number of operators who choose one scale of choice A, B, C or D so that scores for pain on each body part. The body part that gets the highest score is a priority for repairs.

4. Result and Discussion

The results of filling out the questionnaires that have been taken are then processed by data. The processed data will come out in the form of a percentage of pain felt by the operator. The focus of the main pain was observed in the top 5 pain. The percentage of pain experienced by five operators can be seen in Figure 3.

Based on Figure 3 regarding the percentage of pain for each member of the body, it can be seen that the five operators experienced different pain in each part of their body. The results can be obtained 5 biggest pain occur in the first right and left elbow body organs 93%. Second, 87% of the body's right knee and left knee, third, right and left forearm, 80% right and left wrist, fourth on the second upper arm and 73% on the palm. The fifth is on the right shoulder, back and calf 60%.

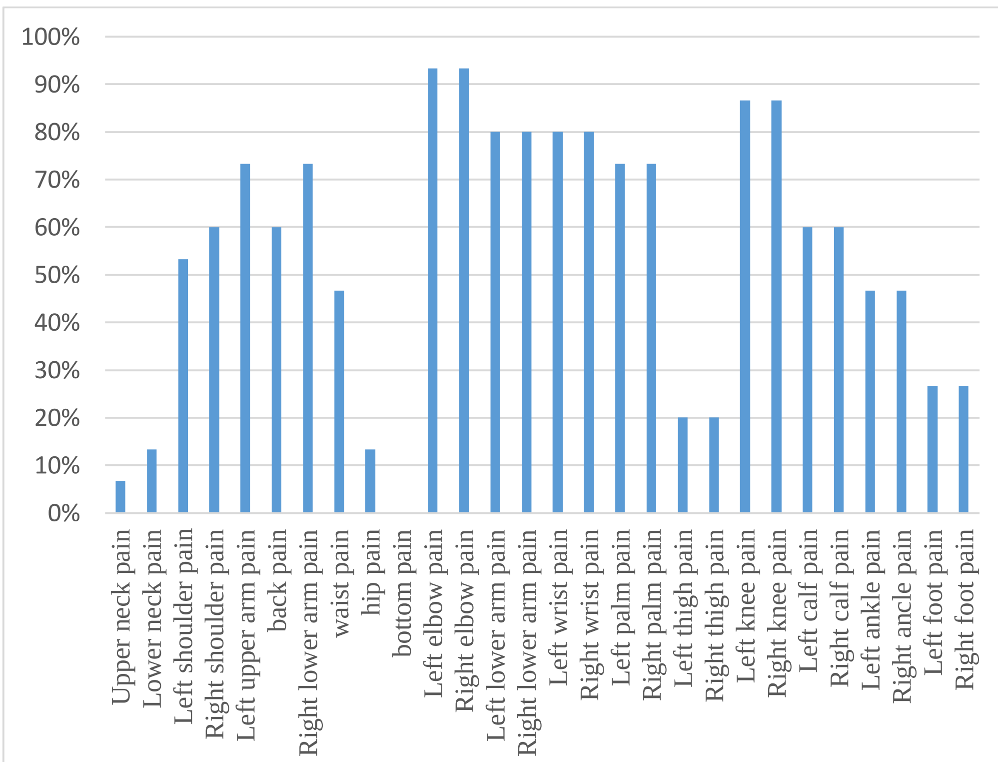

Figure 3 Percentage chart of operators pain

Actually, besides the five major pain mentioned above, there are still other pain, but at this time focused on 5 major pain first. After determining the parts of the body that have the highest pain, then the next is looking for possible causes of these pain. From observing the images that have been taken, the possible causes of pain can be seen in Table 1.

Table 1 Summary of operator pain cause

No	Body Parts	Pain Cause
1	Both of elbows	Lift and hold component loads, static when installing components
2	Both of knees	Position kneeling static when installing components
3	Both of lower arm Both of wrist	Installing components, static forearms, wrists trying to hold the components
4	Both of upper arm Both of palm	The upper arm is static, both palms have extension position when installing the component
5	Right shoulder, back, both of calves	the position of the shoulder is depressed when lifting using the right hand. Back bent forward when lifting parts. Static calf calms down body and part loads

From the results of the Nordic Body Map questionnaire, for the operator's working attitude, carrying a load in a standing position and then kneeling continuously and repeatedly is a work attitude that can cause pain and can cause musculoskeletal muscle injury.

5. Conclusion

Looking at the results of data processing that has been done using the Nordic Body Map, it can be seen that there are ergonomic risks in the work of installing air cleaner components. Ergonomic risks experienced in the form of pain and pain that is felt especially on the elbows, knees, forearms, wrists, upper arms, shoulders and back.

Further handling of the possibility of ergonomic risks must be carried out to avoid workers from obstacles that can arise, so as not to interfere with performance and productivity. Working statically and done repeatedly can cause a higher risk of WMSDs. Actions that can be applied to reduce the risk of ergonomics experienced, namely to make a tool that can be used to hold the load of components so that the operator simply installs the components, thus the workload of operator can be reduced. Tools such as hydraulic trolleys can make it easier for operators to help lift things

Further research related to risk and broader handling of these risks can be carried out using REBA and heart rate, so as to provide more accurate and continuous treatment and improvement alternatives to the performance and productivity of workers on this assembly line.

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