Identification and Measurement of Physical Workload on Manual Repetitive Work in Small Medium Enterprises

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Abstract. Manual work in small medium enterprises involves a lot of repetitive activities that have potential to result in high musculoskeletal disorder. This study was conducted at PT ASM, a small industry that produces electrical spare parts with a make to order system using manual tapping machine operated by an operator.The purpose of this study was to determine and evaluate work postures on manual work at the tapping machine workstation. The methods used in the observation are Nordic Body Map and Rapid Upper Limb Assessment. The results of this study using the Nordic Body Map questionnaire showed a high-risk score with the location at risk of injury being in the upper and hand skeleton. Complaints from operators who operate tapping machines are pain, especially in the back and right arm, which prevents work Based on risk mapping, the identification of work postures using the RULA method was carried out, showing a score of 5 so that improvements were needed immediately.

Keywords: manual work · Nordic body map · RULA

1 Introduction

According to Badan Pusat Statistik (BPS) Indonesia, there are four categories of industrial companies: large industries with 100 or more employees, medium industries with 20–99 employees, small industries with 5–19 employees, and home industries with 1–4 employees. The most prevalent health problems in the industry, particularly on a small- to medium-scale, are musculoskeletal disorders (MSDs). In small and midsize enterprises, most production jobs are still carried out by humans [1]. Furthermore, SMEs are also more vulnerable to workplace dangers and hazards than large businesses due to their constrained resources and technical competence [2]. Work that involves humans requires ergonomic work facilities to minimize the risk of musculoskeletal injuries.

Musculoskeletal disorders (MSDs) are disorders of the condition of nerves, tendons, muscles, and supporting structures of the human body The condition of most of the work is done manually with certain positions, long periods, and wrong work postures that cause discomfort [3]. PT ASM is a small industry that produces electrical spare parts, processing might begin with raw materials or semi-finished goods. The usage

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of manual machinery dominates the production process at PT ASM. As a result, the machine's utilization depends on the operator's skill and ability.

In this study, the ongoing production process is the manufacture of threads on the terminal clamp M5. The production process for the terminal clamp M5 is a processing process for semi-finished goods using a barrel machine and a tapping machine. In the barrel machine, there is a process of rarefaction the surface of the material that works automatically. The process of making threads using a manual tapping machine requires operator assistance to operate the spindle tapper for the threading process. Operators who operate tapping machines have musculoskeletal complaints due to non-ergonomic work postures with long working hours. The workday at PT ASM is 9 h long, with 8 h of productive labor and 1 h of rest.

Working in difficult and inconvenient conditions can cause temporary discomfort in all parts of the body, and working for an extended period can lead to further discomfort in the musculoskeletal or peripheral nerve systems, and, subsequently, to various disabilities [4]. Sitting and static work postures for 8 h of work, cause discomfort to the back of the tapping machine operator. Furthermore, the work performed by the tapping machine operator is repeated on the right arm to pull the spindle tapper. In performing its work, the worker has a non-ergonomic posture with repetitive and static gestures. Due to static muscular stress, complaints are often uncomfortable on the back, waist, arm, and hip [1]. Abnormal work posture increases the risk of musculoskeletal problems, which cause discomfort or injury to the musculoskeletal [5]. Figure 1 and Fig. 2 shows the working posture of the tapping machine operator.

The purpose of this study was to identify the magnitude of the risks associated with tapping machine operators based on complaints of body pain and the operator's working posture. Then for evaluation, an analysis of the relationship between work posture and pain complaints was carried out from the results of the Nordic Body Map questionnaire and the Rapid Upper Limb Assessment observation sheet. Work posture problems can be analyzed using the Nordic Body Map method by providing a questionnaire mapping pain complaint, which are measured based on pain from the operator after completing the work. Furthermore, the results of the mapping of pain complaints were analyzed based on the operator's work posture using the Rapid Upper Limb Assessment method.

2 Methods

2.1 Data Collection Methods

This study has been carried out posture risk assessment tapping machine operators. The risk assessment of msds was performed on rula, which based on the questionnaire survey the production areas for the m5 terminal clamping product process are barrel machines and tapping machines. observations were at tapping machine workstation by looking at the work process to analyze the operator's work posture. The respondents in this study were two female operators at the tapping machine workstation. Work posture and risk measurement data were collected with the nordic body map questionnaire and the rula sheet. The mechanism of using the method in this study can be described in the research framework as shown in Fig. 3.

Fig. 1. Work Posture of Tapping Machine Operator 1.

Fig. 2. Work Posture of Tapping Machine Operator 2

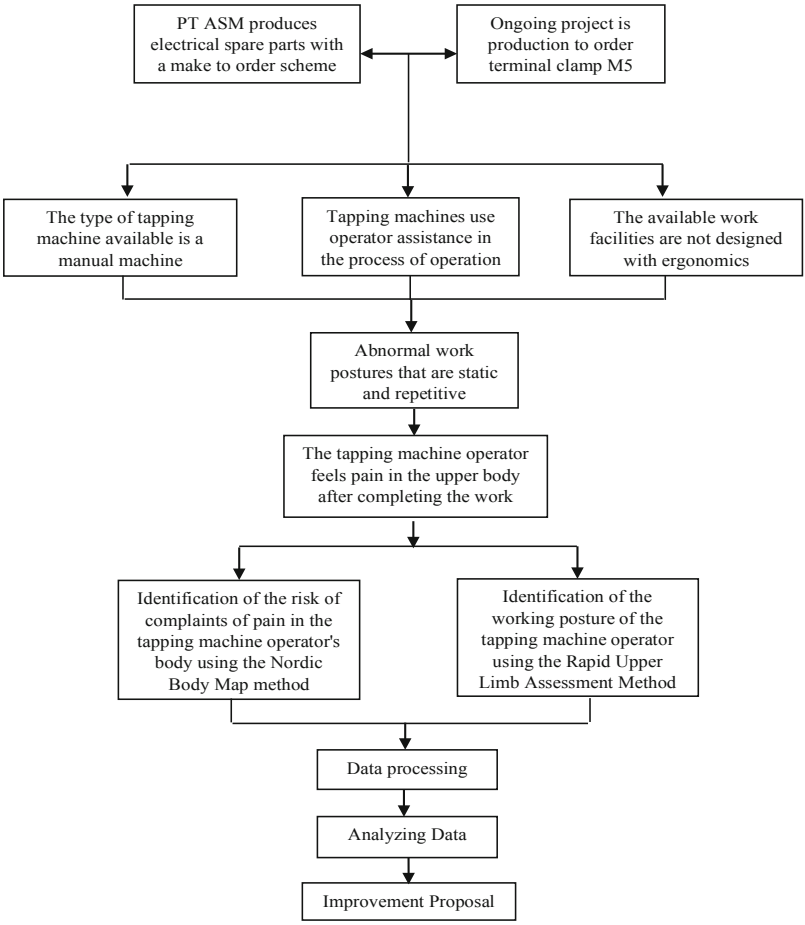

Fig. 3. Study Framework

2.2 Data Analysis

A cross-sectional field survey of female operators tapping machine was conducted using a self-report occupational physical activity questionnaire, along with direct work observations. The primarydata from respondent as object of study and direct observation are used to identify and measurement risk of MSDs. This study is only a case-study with a relatively limited of participants gathered information about self-reported musculoskeletal complaints.

3 Result and Discussion

Research respondents' data for tapping machine operators at PT ASM are in the age range of 20–25 years and have a working period of fewer than five years. This tapping machine operator's age range is within the productive age range, indicating that their body's health is still in great condition. According to the findings of interviews, workers are assigned a daily target of 25 kg for the threading process, which is frequently not met owing to pain in the body, particularly the back and right arm, requiring a short rest during the tapping process.

3.1 Identification with Nordic Body Map

The Nordic Body Map questionnaire was filled in directly by the two tapping machine operators by placing a tick (√) on the part of the body that experienced complaints after doing work. Then the pain weights in each body part are summed to determine the risk score for complaints. The Nordic Body Map score from the tapping machine operator for operator 1 with a score of 77 and operator 2 with a score of 71 indicates a high level of risk it necessary to evaluate the operator's work posture. Evaluation of work posture aims to minimize the risk of musculoskeletal disorders that can occur if work with inappropriate work postures is carried out in the long term.

The upper skeletal muscles and the skeletal muscles of the arms are the body parts that experience complaints, according to the percentage recapitulation of the Nordic Body Map score. Including an average proportion of discomfort of 87.5%, the manual working attitude in controlling the machine in a sitting posture bent on creating pain in the upper skeletal muscles of employees, particularly in the shoulders, spine, and waist. The process of manually operating the spindle tapper by hand causes discomfort in the wrist skeletal muscles, especially in the elbow with an average percentage of 93.75%, a bent sitting position causing discomfort for the tapping machine operator. The lower skeletal muscle showed the lowest recapitulation percentage of 46% due to the operator's working posture not moving their legs much during the work process.

The tapping machine operator keeps the same working posture for eight hours for the duration of their shift. Sitting work posture and static hand motions while tapping have an effect on upper skeletal muscle and wrist skeletal muscle pain complaints. According to the results of interviews, the calves generate the most discomfort in the lower skeletal muscles because the calves that continue to bend owing to the design of the chair utilized do not give comfort for the tapping machine operator (Figs. 4, 5, 6, 7 and 8).

3.2 Measurement with Rapid Upper Limb Assessment

Repetitive work and awkward posture cause many people to experience the ill effects of outer muscle issues (MSDs). Based on the working posture of the tapping machine operator, are in a bent condition which causes the operator to often feel musculoskeletal complaints in the waist, spine, and shoulders after doing work. In addition, the repetitive motion of the right hand to operate the tapper spindle causes pain when the tapping process is complete. So, it is necessary to analyze the working posture of the tapping

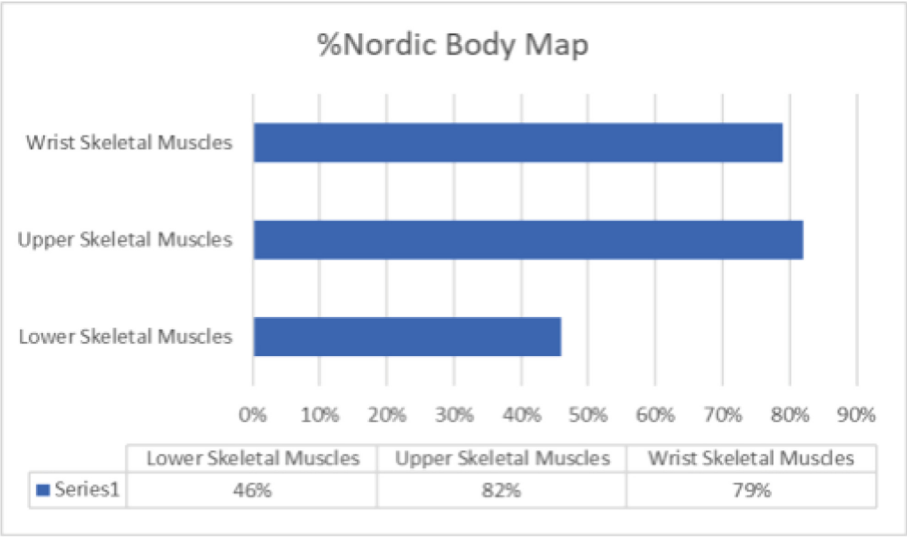

Fig. 4. Nordic Body Map Score Percentage

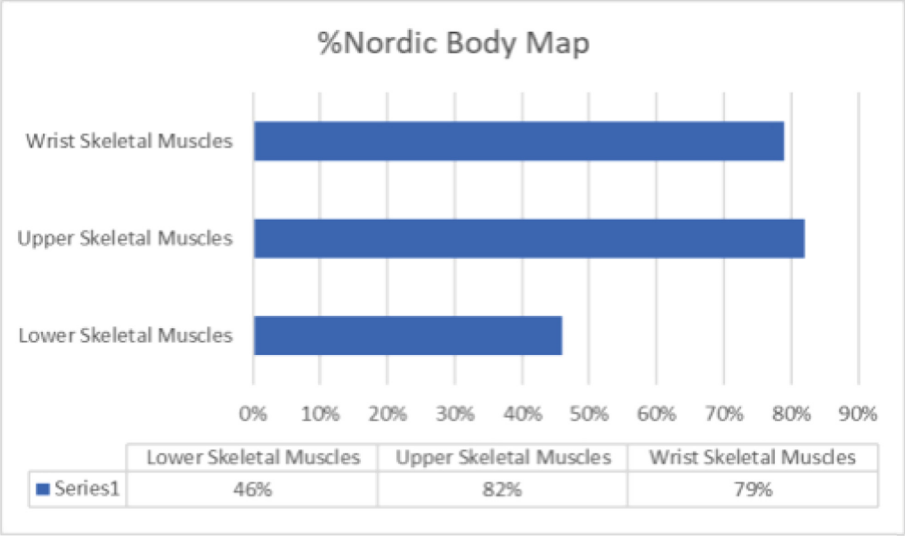

Fig. 5. Percentage of Upper Skeletal Musle Complaints

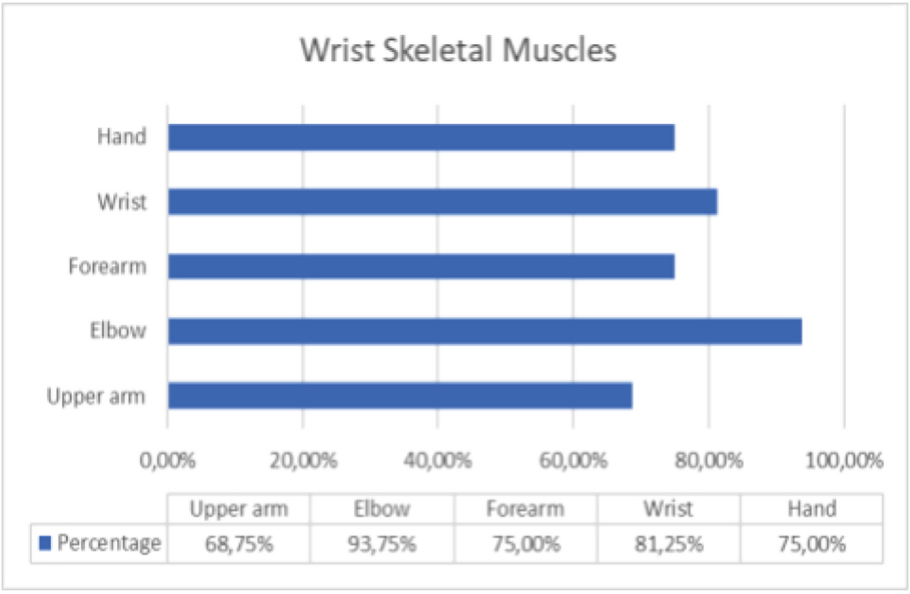

Fig. 6. Percentage of Wrist Skeletal Muscle Complaints

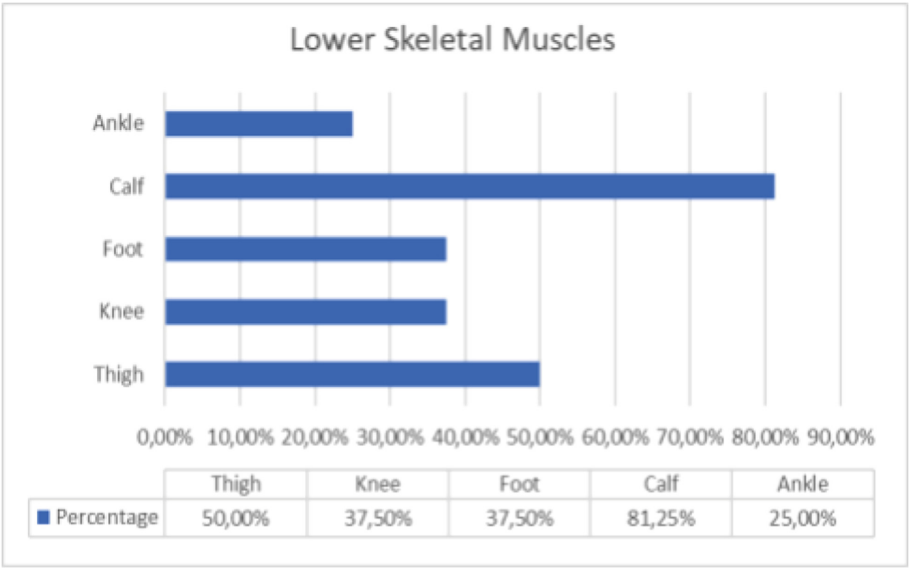

Fig. 7. Percentage of Lower Skeletal Muscle Complaints

machine operator to determine the level of musculoskeletal risk and evaluate work facilities to improve the operator's work posture. The method of analyzing work posture is carried out by documenting one of the operators with better competence; the judgment

Fig. 8. Work Posture Analysis with Rapid Upper Limbs

of competence based on the worker's supervisor's evaluation. The documentation data are used to determine the working posture angle of the tapping machine operator.

Based on the RULA analysis, the risk of injury to the operator's body can be seen in Table 1:

The Grand Score Rapid Upper Limb Assessment for the working posture of the tapping machine operator in the process of making the terminal clamp M5 thread obtained the activity risk level at action level 3, which indicates that investigations and changes are needed immediately.

Table 1. Rapid Upper Limb Assessment Score Details

Arm and Wrist		
Body Parts	**Score**	**Explanation**
Upper arm	2	The angle forms flexion between 20°-45° with an angle of 44°
Forearm	2	The angle forms a flexion > 100° with a large angle of 155°
Wrist	1	Angle 0°
Wrist Round	1	Twisted in mid-range
Table A Score	3	
Load	+ 0	Force < 2 kg
Muscle Use	+ 1	Static and repetitive movements
Arm and wrist final score	**4**	
Neck, Trunk, and Leg		
Body Parts	**Score**	**Explanation**
Neck	3	Forming an angle of 35°
Back	2	Forming an angle of 12°
Foot	2	Sitting position but the weight is not evenly distributed
Table B Score	4	
Load	+ 0	Force < 2 kg
Muscle Use	+ 1	Static and repetitive movements
Neck, trunk, and leg final score	**5**	

3.3 Correlation Analysis of Work Posture with Nordic Body Map Questionnaire

The results of the Nordic Body Map questionnaire have a relationship or conformity with the results of the calculation of work posture scores with the Rapid Upper Limb Assessment. According to the findings of the Rapid Upper Limb Assessment instead of the Nordic Body Map Questionnaire comparison, work facilities must be improved and changed to lower the risk of injury, particularly in the neck, back, and wrists. Because the tapping machine operator's working position is seated, the proposed work facility design takes the shape of an ergonomic chair. The comparison of the results of the Nordic Body Map questionnaire with the results of calculating the work posture score using the Rapid Upper Limb Assessment method is as follows (Table 2).

Table 2. Comparison of Rapid Upper Limb Assessment Results with Nordic Body Map Questionnaire.

No	Body parts	Score Rapid Upper Limb Assessment	%Nordic Body Map	Work Posture	Conclusion
1.	Neck	3	81, 25%	Sedentary	The value of the Rapid Upper Limb Assessment obtained and the results of the questionnaire indicate a moderate risk and require immediate changes
2.	Spine	2	87, 5%	Sedentary	The value of the Rapid Upper Limb Assessment obtained and the results of the questionnaire indicate a moderate risk and require immediate changes
3.	Wrist	4	81, 25%	Sedentary	The value of the Rapid Upper Limb Assessment obtained and the results of the questionnaire indicate a high risk and require immediate make repairs
4.	Foot	2	25%	Sedentary	The value of the Rapid Upper Limb Assessment obtained and the results of the questionnaire show a low risk and an acceptable posture

4 Conclusion

According to the results of the Nordic Body Map method identification on tapping machine operators, operator 1 has a score of 77 and operator 2 has a score of 71, both of which are in the high-risk category, requiring immediate investigation and intervention.

The tapping machine operator's complaints mostly felt in the upper skeletal muscles (82%), followed by the skeletal muscles of the hands (79%). The upper body work posture examined using the Rapid Upper Limb Assessment approach after learning about the tapping machine operator's complaints of pain. In accordance with the results of the Rapid Upper Limb Assessment observation data processing, a final score of 5 was achieved with the action category level 3, indicating that investigation and modification must be carried out immediately. The correlation between the Nordic Body Map questionnaire outcomes and work posture suggests the requirement for prompt research and improvement in work facilities. To lower the risk of musculoskeletal problems, particularly those of the neck, back, and wrists. Findings call attention to the need for research examining potential associations between physical exposures and MSDs.

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