SUSTAINABLE ERGO RISK ASSESSMENT TO MINIMIZE OCCUPATIONAL DISEASES

I.A. Primasari[1*], D.A.N. Putri[2]

[1, 2]Faculty Of Industrial Technology, Industrial Engineering Study Program
Universitas Ahmad Dahlan, Yogyakarta, Indonesia

*Corresponding Author's Email: isana_pria@ie.uad.ac.id

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ABSTRACT: Most of the metal casting industry is still done manually, therefore requires manual work with heavy loads and a working environment that is not conducive results to workers suffering from work-related illnesses. Over time, this can lead to musculoskeletal disorders. Based on the interviews, it was found that 100% of the workers complained of pain in their hands and back, 50% of the workers complained of pain in their necks, and 16.7% of the workers complained of pain in their legs. Therefore, it is necessary to study work posture, find out the relationship between MSD complaints and the level of ergonomic risk, and propose risk controls. The OWAS was used to assess posture. The modified SNQ and the VAS were used to determine pain complaints. Tests were then conducted to determine the relationship between the level of ergonomic risk and the level of pain complaints. Based on the assessment using the OWAS method, it is known that turning activities have a very high risk, so improvements are now needed. The test results show that the level of ergonomic risk has a significant relationship with upper and lower back complaints. The recommended risk control proposals are muscle stretching and improving work equipment to ensure a safe working posture.

KEYWORDS: *Musculoskeletal Disorders (MSDs), Standardized Nordic Questionnaire (SNQ), Visual Analog Scale (VAS), Chi-square, Ovako Work Posture Analysis System (OWAS)*

1.0 INTRODUCTION

Until now, the main factor in industrial processes has been human power. Many work processes, usually called work instructions, still involve manual equipment and human power. Labor has many limitations, unlike machines that can be repaired or replaced. Poor health of workers, especially because of work, can reduce productivity. Therefore, SME investment in workers' health is very important. Health services for informal sector workers are currently not adapted to heavy work. Jobs that still involve manual labor and traditional work systems are still vulnerable to health problems such as musculoskeletal disorders (MSDs).

Musculoskeletal Disorders (MSDs) are complaints experienced by a person ranging from mild complaints to complaints with very painful sensations in the musculoskeletal system including joints, nerves, muscles and spine due to unnatural work. [1]. According to the Bureau of Labor Statistics (BLS), in 1982, back pain accounted for 25% of all complaints and more than 20% of workers' compensation expenditures were related to work impairment. MSDs are caused by poor ergonomics and prolonged use of certain awkward positions. The musculoskeletal system, which consists of the nervous system, tendons, muscles, and supporting structures such as intervertebral discs, includes pathological conditions called MSDs that disrupt the normal function of soft tissues (Putri, 2019). Musculoskeletal disorders (MSDs) are characterized by damage to the muscles, tendons, ligaments, nerves, joints, cartilage, bones, or blood vessels in the hands, feet, head, neck, or back. Musculoskeletal disorders can be caused or aggravated by work, the work environment, and work performance. Damage to muscle tissue can interfere with daily activities, such as working, and reduce work productivity. Efforts must be made to prevent and minimize the occurrence of MSDs in the workplace. The benefits of preventing MSDs include reduced costs, increased productivity

and quality of work, fewer work-related injuries, improved employee health, well-being and job satisfaction [2].

In the industrial sector, activities with less ergonomic working postures are still common. One of them is CV. TSA Yogyakarta Small and Medium Industry. A small and medium enterprise called CV. TSA has now grown to employ 45 people and produce products in the form of frying pans. The working hours of the employees at TSA Yogyakarta are 8 working hours from 07.00-15.00 WIB and rest time from 11.30-12.30 WIB.

The process of making a wok through 5 workstations includes melting, forming the wok, filing, smoothing, turning the wok, and polishing. The working posture during melting is a standing position with the neck slightly bent and carrying a weight in the form of a wedge weighing about 7 kg. This work is repeated so that the muscles in the hands become tense. In printing, the working posture is a standing position with the back bent and the hands reaching for the mold pan, creating a tense posture that is repeated. In the filing activity, a sitting posture is formed with the neck bent down and the back slightly bent, and there is an activity of reaching for the frying pan to file and file, which causes a tense hand posture.

In the refining workplace, a sitting posture is formed, the hands are under the shoulders, then there is the activity of putting down and picking up the pot, which is on the side, so you must reach to the side, which can cause the hands to become tense. The body posture that is formed when performing rotating activities is a standing position, the back is slightly bent, and the legs are slightly bent. At the rotating workstation, there is an activity of picking up the pan located below, so the worker must bend down to reach the pan. This can cause a strained posture on the worker's back and hands. After smoothing and turning, polishing is done in a sitting position with the back slightly bent. When the worker picks up the frying pan to polish, the worker's hand must reach the frying pan, which is slightly backward, causing the worker's hand to rotate slightly backward, which causes the shoulder muscles to become tense.

2.0 METHODOLOGY

The subjects of this research are six workers from the melting, ladle forming, filing, smoothing, ladle turning, and polishing workstation at CV. TSA in Yogyakarta Special Region. The focus of the research was on the body posture of workers on the back, hands and feet.

2.1 SNQ and VAS Questionnaire

The workers used as respondents were male. The respondents were healthy workers and had no history of illnesses such as broken bones and no history of bone surgery. While observing, interviews were conducted to collect data regarding the complaints felt by the workers. Modified *Standardized Nordic Questionnaire* (SNQ) and *Visual Analog Scale* (VAS) questionnaires were used to measure complaints in depth.

SNQ is used to identify complaints with category levels ranging from very sick, sick, somewhat sick and not sick. The main purpose of the questionnaire is as an instrument in screening musculoskeletal disorders in the context of Ergonomics, and for health service work. The Visual Analogue Scale (VAS) is a psychometric response scale and measure of subjective characteristics that can be used in questionnaires. The scale included in the VAS is called a Likert scale and has a straight line from zero to 10 or zero to 100. Then there is a verbal explanation at each end, such as zero (no pain) to 10 (severe pain). With a VAS score of 0-<4 = mild pain, 4-<7 = moderate pain and 7-<10 = severe pain [3].

The Visual Analogue Scale (VAS) is the most widely used method for assessing pain. This linear scale visually depicts the gradations of pain levels a person may experience. The pain range is represented as a 10 cm long line, with or without markings at each centimeter. The marks at both ends of this line can be numbers or descriptive statements. One end represents

no pain, while the other end represents the most severe pain. The Visual Analog Scale (VAS) can be made vertical or horizontal.

2.2 The Stages of Ergonomic Risk Assessment

Next, body weight is measured using scales and the worker's posture is assessed using the OWAS method. Based on the movement and load of the back, arms and legs, the OWAS method categorizes several types of work postures. In total there are several postures in this set, consisting of three arm postures, seven leg postures, and finally four back postures. On a three-point scale, the value of the work is also evaluated. The stages of ergonomic risk measurement in this research are shown in Figure 1.

2.3 Chi-Square Statistical Test

Chi-square is a type of non-parametric comparative test. This test is used to test the homogeneity of variance in several populations. In this study, a chi-square test was carried out which aims to determine the relationship between the level of Ergonomic risk and the level of MSDs complaints. The dependent variable in this research is the level of Musculoskeletal Disorders (MSDs) complaints in production workers.

In this study, statistical analysis was carried out using the chi square test which aims to determine the relationship between the level of Musculoskeletal Disorders (MSDs) complaints and the level of Ergonomic risk. As for the hypothesis used in this research, the hypothesis itself is a temporary assumption regarding the problem being studied. So variables that have a P-Value < 0.05 can be said to have a significant relationship, which means H1 is accepted. The following are the hypotheses in this research:

H0: There is no significant relationship between the level of Ergonomic risk and the level of Musculoskeletal Disorders (MSDs) complaints
H1: There is a significant relationship between the level of Ergonomic risk and the level of Musculoskeletal Disorders (MSDs) complaints

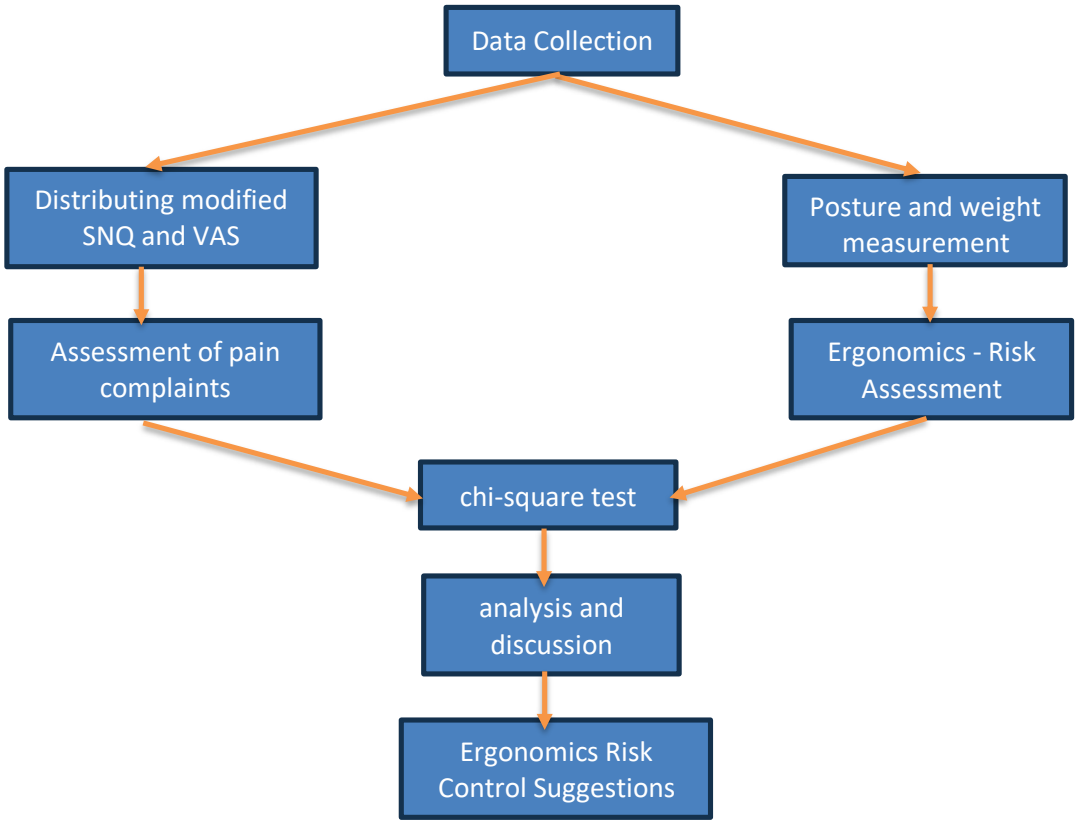

Figure 1: The Stages of Ergonomic Risk Measurement

3.0 RESULTS AND DISCUSSION

3.1 Results of the SNQ-VAS Modification Questionnaire

The questionnaire results were obtained from the recapitulation of filling in the SNQ-VAS questionnaire which had been modified by workers. Where the final results of the questionnaire before the chi-square test were carried out were the percentage of pain for each part of the body felt by the six workers. The following are the results of the modified SNQ-VAS questionnaire which can be seen in table 1.

Table 1: The Results of the SNQ-VAS Modification Questionnaire

No	Parts of body	Mean ± SD (0)	Percentage
1	Neck	5,7 ± 1,8	14%
2	Shoulder	5,1 ± 1,3	13%
3	Upper Back	6,0 ± 2,1	15%
4	Elbow	4,3 ± 1,6	11%
5	Lower Back	6,6 ± 1,9	17%
6	Wrist	4,0 ±1,8	10%
7	Hips	2,9 ± 2,2	7%
8	Knee	3,0 ± 2,3	8%
9	Ankle	2,1 ± 1,8	5%
Total		39,5	100%

3.2 Work Posture Assessment

Work posture assessment is carried out based on data obtained from recorded images of work posture and load loads. Then it is processed using the OWAS method based on the back, arms, legs and weight of the load to obtain a combination code. Second, determine the category score by entering the combination code in the OWAS table to produce a category for the level of risk experienced. Third, determine when and whether improvements need to be made based on the categories obtained. The following is an assessment of work posture using the OWAS method which can be seen in table 2.

Table 2: The Assessment of Work Posture using the OWAS Method

NO	ACTIVITY	POSTURE ASSESSMENT				OWAS SCORE	Action
		Back	Arms	Legs	Heavy Load		
1	A1	1	1	2	1	1	Safe, no need for repairs
2	A2	4	1	3	1	2	Perlu perbaikan beberapa waktu ke depan
3	A3	4	1	7	1	2	Perlu perbaikan beberapa waktu ke depan
4	A4	3	1	2	1	1	Safe, no need for repairs
5	A5	1	1	2	1	1	Safe, no need for repairs
6	B1	1	1	2	1	1	Safe, no need for repairs
7	B2	2	1	2	1	2	Needs improvement in the future
8	B3	2	1	2	1	2	Needs improvement in the future

NO	ACTIVITY	POSTURE ASSESSMENT				OWAS SCORE	Action
		Back	Arms	Legs	Heavy Load		
9	B4	4	1	2	1	2	Needs improvement in the future
10	B5	2	1	2	1	2	Needs improvement in the future
11	B6	4	1	2	1	2	Needs improvement in the future
12	B7	2	1	4	1	3	Needs improvement soon
13	B8	2	1	2	1	2	Needs improvement in the future
14	B9	1	1	4	1	2	Needs improvement in the future
15	B10	2	1	3	1	2	Needs improvement in the future
16	B11	4	1	3	1	2	Needs improvement in the future
17	B12	2	1	2	1	2	Needs improvement in the future
18	B13	2	1	4	1	3	Needs improvement soon
19	B14	2	1	3	1	2	Needs improvement in the future
20	B15	1	3	2	1	1	Safe, no need for repairs
21	B16	1	1	3	1	1	Safe, no need for repairs
22	C1	3	1	1	1	1	Safe, no need for repairs
23	C2	2	1	1	1	2	Needs improvement in the future
24	C3	1	1	1	1	1	Safe, no need for repairs
25	C4	1	1	1	1	1	Safe, no need for repairs
26	C5	2	1	1	1	2	Needs improvement in the future
27	C6	2	1	1	1	2	Needs improvement in the future
28	D1	1	1	1	1	1	Safe, no need for repairs
29	D2	1	1	1	1	1	Safe, no need for repairs
30	D3	3	1	1	1	1	Safe, no need for repairs
31	E1	2	1	4	1	3	Needs improvement soon
32	E2	1	1	2	1	1	Safe, no need for repairs
33	E3	1	1	2	1	1	Safe, no need for repairs
34	E4	4	1	4	1	4	Needs improvement now
35	E5	1	1	2	1	1	Safe, no need for repairs
36	E6	1	1	2	1	1	Safe, no need for repairs
37	E7	1	1	7	1	1	Safe, no need for repairs
38	F1	2	1	1	1	2	Needs improvement in the future
39	F2	1	1	1	1	1	Safe, no need for repairs
40	F3	2	1	1	1	2	Needs improvement in the future
41	F4	1	1	1	1	1	Safe, no need for repairs
42	F5	2	1	1	1	2	Needs improvement in the future
43	F6	2	1	1	1	2	Needs improvement in the future

Based on the results of the risk level assessment recapitulation that has been carried out using the OWAS method, it can be concluded that the percentage of each action category is in table 3.

Table 3: The Risk Level Assessment Recapitulation

Action Category	Action	Action Percentage	
1	Safe, no need for repairs	19	45,2%
2	Needs improvement in the future	20	47,6%
3	Needs improvement soon	3	7,1%
4	Needs repair now	1	2,4%

3.3 Chi-Square Test

The chi-square test was carried out to determine the relationship between the level of MSDs complaints and the level of ergonomic risk in workers. Where the body part that is related is back posture with complaints in the neck, upper back and lower back. Then posture the arms with complaints on the shoulders, elbows and wrists. Foot posture with complaints of hips, knees and ankles. Finally, the total score resulting from OWAS processing is associated with all complaints from the neck to the ankles. The results of the chi-square test for the level of MSDs complaints with the level of Ergonomic risk can be seen in table 4.

Table 4: The Results of the Chi-Square Test

No	OWAS	MSDs	*Chi-Square* (P-*Value*)
1	Back	Neck	1.596 (0.206)
		Upper Back	4.376 (0.036)*
		Lower Back	6.964 (0.018)*
2	Arm	Shoulder	20.988 (0.047)*
		Elbow	20.988 (0.047)*
		Wrist	0.077 (1.000)
3	Foot	Hips	6.008 (0.037)*
		Knee	13.011 (0.001)*
		Ankle	0.281 (1.000)
4	OWAS Score	Neck	0.705 (0.401)
		Shoulder	0.029 (1.000)
		Upper Back	4.800 (0.028)*
		Elbow	0.029 (1.000)
		Lower Back	9.223 (0.006)*
		Wrist	0.154 (1.000)
		Hips	1.467 (0.270)
		Knee	5.049 (0.055)
		Ankle	0.060 (1.000)

3.4 Analysis of Risk Control Proposals

Based on the results of the OWAS assessment, there are postures with risk category level 4 that require improvement in turning work activities. The control suggestion that can be recommended is for workers to stretch before starting work and if they start to feel tired, a duration of 5 to 10 minutes will make the muscles more flexible and the joints have a wider

range of motion. Stretching doesn't have to cause pain because the focus of stretching is on the muscles. If the muscles feel a little tense, then just stretching is enough. Stretching exercises can prevent complaints of pain or Musculoskeletal Disorders (MSDs). By providing stretching exercises to workers, it can have a significant impact in reducing MSDs complaints [4].

In research conducted by Anggriawan, [5], there was a reduction in the risk of musculoskeletal complaints before and after stretching in group B (treatment), namely from a moderate risk of complaints of 100% to a low risk of complaints of 100%. Based on the Ergonomics guidelines issued by the Indonesian Ergonomics Association, stretching exercises can be done in a simple way, and without moving places, so it is very easy to do and applied every day as in figure 2.

Figure 2: Muscle Stretching Guide
Source: (Yassierli et al., 2020)

Apart from that, it is recommended that practical training be carried out in the workplace in the form of training on the correct use of work equipment and safe manual work techniques, training on how to organize the workplace ergonomically to create a safe working posture. When carrying out turning activities, it is known that workers carry out work with their backs bent and their legs slightly bent, which causes discomfort for the workers. Therefore, it is necessary to organize the workplace ergonomically by improving work facilities such as increasing or reducing the height of the machine table used. According to Tarwaka et al., [6] based on Manuaba [7]; Sanders & McCormick [8]; Grandjean [9] recommends that the height of the work table in a standing position be based on elbow height, that is, for manual work which often requires space for equipment, materials and various types of containers, the height of the work table is 10-15 cm below the worker's standing elbow height.

Based on the measurements that have been taken, the height of the worker's standing elbow is 105 cm, so the height of the lathe worktable should be 95 cm. It is known that the current height of the turntable is still below the recommended size, namely 77 cm. This causes workers to have to work with bent legs and bent backs because the reach is not suitable for the worker. The following is an example of a standing working position according to Grandjean (1993) in the book Ergonomics for Occupational Safety, Health and Productivity by Tarwaka, et al [6] which can be seen in figure 3.

Figure 3: Standing Working Position with a Work Platform
Source: (Tarwaka et al., 2004)

4.0 CONCLUSION

1. The results of the work posture assessment using the OWAS method obtained a category 1 score of 45.2%, namely that there were 19 activities in category 1 or safe and no need for improvement. Then a category 2 score was obtained of 47.6%, namely that there were 20 activities in category 2 or requiring improvement in the future. For activities classified as category 3, the figure is 7.1%, namely there are 3 activities that require improvement in the near future. Activities classified as category 4 amounted to 2.4%, namely rotating activities with the code combination 4-1-4-1. Therefore, turning activity needs to be increased now.
2. The results of testing the relationship between the level of ergonomic risk and the level of MSDs complaints using the chi square test show that several parts of posture have a significant relationship with MSDs complaints, namely back posture with upper and lower back complaints, arm posture with MSDs complaints. shoulder and elbow complaints, leg and hip posture complaints. and knees, then the total OWAS score has a significant relationship with upper and lower back complaints.
3. The recommended risk control proposal is for workers to stretch their muscles so that the muscles do not get tense and remain flexible and the joints have wider range of motion. Then practical training is carried out in the workplace in the form of training on the correct use of work equipment and safe manual work techniques, training on how to organize work and the workplace ergonomically with improvements to work facilities, namely increasing the height of turns. table up to 95 cm to create a safe working posture.

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