The Indonesian Journal of Occupational Safety and Health
2023, 12 SI(1): 35-41
p ISSN: 2301 8046, e ISSN: 2540 7872
http://doi.org10.20473/ijosh.v12iSI1.2023.35-41

ORIGINAL ARTICLE

Ergonomic Risk Assessment and MSDs Symptoms Among Laboratory Workers Using SNI 9011-2021

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ABSTRACT

Introduction: Musculoskeletal Disorders (MSDs) symptoms are experienced by 1.71 billion of the human population and are characterized by persistent pain that decreases the ability to work in almost all types of occupations, including laboratory workers. The various stages of work in laboratory can cause complaints due to repetitive motions, manual handling, static and awkward posture, as well as long-duration of work. Therefore, this study aimed to determine risk level of work ergonomic and MSDs symptoms among laboratory workers. **Methods:** This study used a cross-sectional design involving 71 laboratory workers who were observed from 8 to 22 June 2022. The respondents were categorized into three Similar Exposure Group (SEG), namely administrative officers, analysts, and field workers. Risk level of MSDs symptoms and work ergonomic of each SEG was measured using the instrument of SNI 9011-2021, while individual factor was estimated through the questionnaire. **Results:** Out of the 71 respondents, the majority were males, aged <35 years, and had <5 years of work experience. The survey revealed that half of workers experienced MSDs symptoms with a high-risk level in analysts and field workers, particularly in the lower back. The highest MSDs symptoms in all SEG were neck, lower back, upper back, and right shoulder. **Conclusion:** Ergonomic risk level in laboratory was dangerous for analysts and field workers, and required further assessment by administrative officers. To reduce risk level of work ergonomic, particularly for analysts and field workers, engineering control and the use of manual handling equipment can be implemented.

Keywords: ergonomic risk, laboratory workers, musculoskeletal disorders symptoms, msds, SNI 9011-2021

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INTRODUCTION

Musculoskeletal Disorders (MSDs) symptoms are one of the problems that arise from the high risk of ergonomic in the workplace and are among the main contributors to global health issues (World Health Organization, 2022). MSDs are a significant health problem in every country that must be solved, as they are generally work-related injuries (Tavakkol *et al*., 2020). According to a report on MSDs risk observation in 2018 (Park, Kim and Han, 2018), MSDs are classified as work-related health disorders that occur most frequently in Europe. MSDs are experienced by 1.71 billion of the human population worldwide and are generally characterized by persistent pain, leading to limited mobility, agility, and level of skeletal muscle function, which affects working ability (World Health Organization, 2022). These conditions can be developed from mild to severe levels, rarely life-threatening, but interfere with human life quality (Health Safety and Executive, 2021). Therefore, there is a need to assess and control ergonomic factors in the workplace that has a potency of ergonomic risk (Kemnaker RI, 2018). The potency of ergonomic risk includes the way work is performed, the design of work equipment, the workplace, and overload manual handling.

According to AlNekhilan *et al*. (2020), clinical laboratory workers in Saudi Arabia complained MSDs symptoms in several parts of the body such as the lower back (61%), neck (46%), upper back (44%), wrist/hand (34%), ankle/foot (29%), knee (28%), hip/thigh (17%), and elbow (10%). Penkala, El-Debal, and Coxon (2018) reported that symptoms were experienced by laboratory workers in the lower back (30%), neck (24%), and upper back (21%). The high risk of MSDs in workers can also be caused by awkward posture, twisting, bending, and limited physical space (Yadi and Kurniawidjaja, 2019). Most of MSDs are caused by repetitive motions and manual handling (Rajendran *et al*., 2021), with 86.4% being suffered by workers who lift heavy loads in awkward posture compared to 45.5% who do manual handling (Lukman, Jeffree and Rampal, 2017), followed by pushing or pulling at 10.3% and lifting loads at 8.0% (Yang, Park and Jeong, 2020). Preparing samples in the chemistry laboratory also indicates a moderate to high risk of MSDs, where the prevalence rates of upper extremity MSDs are up to 60.2% (Park, Boyer, and Punnett, 2022). Repetitive activities, static, awkward postures, and poor design of work desks in laboratory is contributing factors to MSDs (Penkala, El-Debal, and Coxon, 2018).

X Laboratory is a private laboratory accredited for testing, calibration, and consultation. Due to repetitive

Cite this as: Kusumawardhani, A., Djamalus, H. and Lestari, K. D. (2023) 'Ergonomic Risk Assessment and MSDs Symptoms Among Laboratory Workers Using SNI 9011-2021', *The Indonesian Journal of Occupational Safety and Health*, 12(SI1), pp. 35-41.

 doi:10.20473/ijosh.v12iSI1.2023.35-41
Received September 03, 2022; 1st revision February 16, 2023; 2nd revision April 03, 2023; Accepted April 14, 2023, Published: May 2023. Published by Universitas Airlangga.

motion and manual handling, every stage of work in laboratory has several activities that potentially developed MSDs. The result of the survey according to Appendix B: SNI 9011-2021 elucidates that 54.9% of workers suffered MSDs symptoms. Based on the percentage, this study was conducted to discover ergonomic risk levels and MSDs symptoms among workers in X Testing and Calibration Laboratory.

METHODS

This cross-sectional study involved 71 workers who were taken from the population in laboratory. Workers were divided into 3 Similar Exposure Group (SEG) based on job characteristics such as administrative officer, analyst, and field workers. The data were collected from 8 to 22 June 2022 through interviews conducted using a questionnaire and observing work activities in every SEG.

Analysis of MSDs symptoms and ergonomic risk level in work activities of every SEG referred to SNI 9011-2021 about Assessment and Evaluation of Ergonomic Risk in Workplace. This Indonesian standard, namely SNI 9011-2021 defined a method for identifying MSDs symptoms, determining the workplace that required evaluation, and methodology for assessing and evaluating ergonomic risk. MSDs symptoms were assessed using the Nordic Body Map questionnaires to decide which job or workers will be examined more closely. Ergonomic risk was assessed by observing each work cycle for 5–15 minutes. However, factors such as gender, age, and working period were assessed using a questionnaire.

The collected data and information collected were displayed in a table to demonstrate the prevalence and risk level. Table 1 was used to analyze and evaluate risk level of MSDs Symptoms as reported by workers. Meanwhile, analysis and evaluation of ergonomic risk level were carried out using a checklist of potential hazards of ergonomic factors in appendix D: SNI 9011-2021. The analysis focused on the duration of exposure, manual handling, as well as upper and lower body posture, such as awkward postures, pressure, vibration, work rhythm, pulling and pushing activities, and movement in the arms and legs. The total score was the result of ergonomic risk level and was evaluated using Table 2.

RESULT

Respondent Characteristics

The results showed that 60.6% of respondents were male, with an average age of 33 years old. The age range of respondents was between 25 and 62 years old, while 66.2% of them were <35 years old (66.2%). The working period ranged from 1 to 20 years with an average of 6 years. Respondent characteristics were shown in Table 3.

Table 1. Risk Matrix of MSDs Symptoms

Frequency	Severity			
	No Problem	Uncomfortable	Pain	Severe Pain
Never	1-Low	2–Low	3–Low	4-High
1 – 3 x/year	2–Low	4–Low	6–Moderate	8-High
1 – 3 x/ month	3–Low	6–Moderate	9–High	12-High
Everyday	4-Low	8-High	12-High	16-High

SEG Characteristics

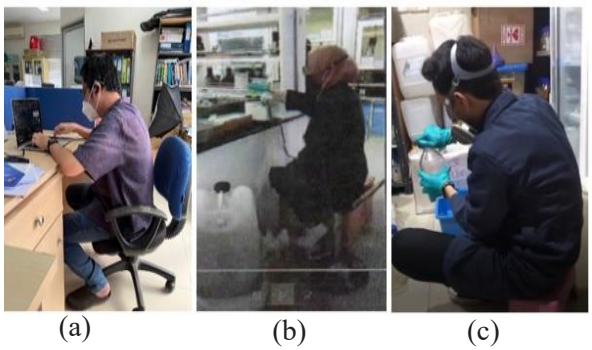
SEG of administrative officers included workers who worked in front of a computer with the task of composing and interpreting the testing report, inputting sample data, collecting administration, creating a marketing video, and conducting a program or management system. SEG of analysts was workers who analyzed samples according to parameters, and Laboran was a supporting staff of analysts who prepared and cleaned required equipment in analyzing, dismissing hazardous waste, and managing storage moreover sample removal in laboratory. Meanwhile, SEG of field workers included those who were in charge of taking the sample that will be analyzed in the customer area, as shown in Figures 1 and 2.

MSDs Symptoms

In assessment of MSDs symptoms of laboratory workers, several complaints suffered consecutively by administrative officers included lower back (46.7%), neck (49%), right shoulder (37.8%), left shoulder (37.8%), and right hand (35.6%). Symptoms that many occurred sequentially on Analyst were neck (72%), upper back (61%), lower back (61%), right shoulder (50%), and left shoulder (39%). Meanwhile, field workers reported a similar percentage of sequential MSDs symptoms, where 25% was lower back, neck, right hip, left hip, right calf, and left calf. Symptoms of all SEG were presented in Tables 4 and 5.

Table 2. Ergonomic Risk Level Interpretation

Score	Interpretation
≤2	Safe Work Place
3–6	Need Further Assessment
≥7	Dangerous



(a) (b) (c)

Figure 1. Work Posture of Administrative Officer (a), and Work Posture of Analyst (b-c)

Figure 2. Work Posture of Field Workers

Risk Level of MSDs Symptoms

MSDs symptoms experienced by workers were categorized based on risk level, namely low, moderate, and high risk. The result showed that moderate and high-risk levels were observed at most parts of the body surveyed, as indicated in Table 6.

Ergonomic Risk Assessment

Assessment of ergonomic risk potency in X Testing and Calibration Laboratory, as shown in Table 7 was divided into 3 SEG based on the type of jobs. These included administrative officers with administrative tasks, Analysts with furan analysts and Laboran, and field workers with vehicle emission, water, and illumination sampling. The outcome of assessment based on SNI 9011-2021 of Attachment D showed 2 categories of assessment that are high risk and required further observation. The high-risk category with the highest score total was discovered in Laboran (score total=23) of analysts and water sampling (score total=22) of field workers.

DISCUSSION

Gender

A total of 71 respondents participated in this study at X Laboratory, with 60.6% being male and 39.4% female. Study conducted among brickfield workers in India showed that gender significantly affected MSDs (Das, 2019). Among the respondents, 56.4% of women experienced injuries and inconveniences related to work in the past year. Persistent MSDs symptoms were more common in women compared to men and the prevalence of neck injuries was twice higher than in men (Øverås *et al*., 2021). Furthermore, the incidence rate of MSDs was higher in women (5.08/100 person per year) than in men (4.33/100 person per year), and increased with age (Peng *et al*., 2021).

Age

The age of workers in X Laboratory ranged from 25 to 62 years old with an average age of 33 years old. Approximately 66.2% of workers were <35 years old, while 33.8% were ≥35 years old. Workers aged <35 years old had the most MSDs symptoms with a proportion of 74.4%. According to Putri (2019), age correlated with MSDs symptoms, particularly those involving the shoulder and neck muscles. Haile, Taye, and Hussen (2012) stated that individuals between the ages of 33-<44 years were significantly affected by MSDs (p-value=0.001). MSDs symptoms were usually experienced initially at age 35, with improved conditions level as the age increased (Peng *et al*., 2021). This may be due to the reduction in muscle strength and endurance, with a decrease of 12% per decade in those over 30 years old (Cruz-Jentoft *et al*., 2020). However, as age and working period increased simultaneously, the level of MSDS symptoms was improved by 1.374 and 0.921 times, respectively (Haile, Taye, and Hussen, 2012).

Working Period

The working period of workers in X Laboratory ranged from 1 to 20 years, with an average of 6 years. Approximately 50.7% of workers had a working period of <5 years, while 49.3% had ≥5 years. According to Ramdan, Candra, and Fitri, (2020), there was a significant connection (p-value=0.015) between working period and MSDs, particularly in the type of work that used powerful strength. The number of the working period appeared to be closely linked to the number of MSDs complaints (Putri, 2019; Tjahayuningtyas, 2019).

The results showed that workers with ≥5 years of working period tended to commonly perceive numerous injuries in their bodies. Furthermore, they were found to be at higher risk of developing MSDs, especially when the working period was high and work focused on human labor. Administrative officers with ≥5 years of work period had approximately 58.7% of MSDs symptoms. According to Yong *et al*. (2020), working for more than 10 years was a risk factor for MSDs.

MSDs Symptoms and Ergonomic Risk Assessment

Administrative Officer

The highest MSDs symptoms were experienced by all SEG including the lower back, neck, upper back, and right shoulder. Administrative officers such as administrative resources, who work in front of a computer/laptop every day, had complaints of the lower back at 46.7%, with 20.8% high and 12.5% moderate risk level, neck at 49% with 8.3% severe risk level and 25% moderate risk level. Furthermore, the upper back had a proportion of 37.8%, with 8.3% each for severe

Table 3. Respondent Characteristic

Respondent Characteristic	Total (n=71)		Administrative Officer (n=45)		Analyst (n=18)		Field Workers (n=8)	
	∑	%	∑	%	∑	%	∑	%
Gender								
Male	43	60.6	23	51.1	12	66.7	8	100
Female	28	39.4	22	48.9	6	33.3	0	0
Age								
<35 Years	47	66.2	27	60	15	83.3	3	37.5
≥35 Years	24	33.8	18	40	3	16.7	5	62.5
Working Period								
<5 Years	36	50.7	19	42.2	14	77.8	3	37.5
≥5 Years	35	49.3	26	57.8	4	22.2	5	62.5

and moderate risk levels due to a static sitting position for a long duration without any adequate crutch. According to Ramdan, Candra and Fitri (2020), prolonged sitting hours had a significant relationship with MSDs prevalence (p-value=0.032).

Administrative officers who used the right parts of the body also complained of the right shoulder at 37.8% with 8.3% severe and 12.5% moderate risk levels. Furthermore, the right hand had a proportion of 35.6%, with 4.2% each for high and moderate risk levels since awkward wrist posture bending forward/aside, and intensive keyboard use. Study conducted by Phuspa (2017) in Y Laboratory showed that using a computer had ergonomic risk factors such as awkward and static posture on the neck, back, feet, arm, and wrist. There was also non-neutral on the lower arm that can cause MSDs on the neck, shoulder, lower back, elbow, wrist, as well as hand and feet fingers. Situmorang, Widjasena, Wahyuni (2020) explained that there was a significant association between neck pain and posture of computer use (p-value=0.003).

Table 4. MSDs Symptoms

Parts of Body	Total (n=71)		Administrative Officer (n=45)		Analyst (n=18)		Field Workers (n=8)	
	∑	%	∑	%	∑	%	∑	%
Neck	37	52.1	22	48.9	13	72.2	2	25
Right Shoulder	26	36.6	17	37.8	9	50	0	0
Left Shoulder	21	29.6	13	28.9	7	38.9	1	12.5
Upper Back	29	40.8	17	37.8	11	61.1	1	12.5
Lower Back	34	47.9	21	46.7	11	61.1	2	25
Right Elbow	12	16.9	8	17.8	3	16.7	1	12.5
Left Elbow	8	11.3	4	8.9	3	16.7	1	12.5
Right Arm	17	23.9	13	28.9	3	16.7	1	12.5
Left Arm	16	22.5	13	28.9	3	16.7	0	0
Right Hand	21	29.6	16	35.6	4	22.2	1	12.5
Left Hand	11	15.5	7	15.6	3	16.7	1	12.5
Right Hip	16	22.5	10	22.2	4	22.2	2	25
Left Hip	15	21.1	9	20	4	22.2	2	25
Right Thigh	7	9.9	6	13.3	0	0	1	12.5
Left Thigh	4	5.6	3	6.7	0	0	1	12.5
Right Knee	15	21.1	9	20	5	27.8	1	12.5
Left Knee	10	14.1	6	13.3	3	16.7	1	12.5
Right Calf	13	18.3	7	15.6	4	22.2	2	25
Left Calf	10	14.1	4	8.9	4	22.2	2	25
Right Foot	16	22.5	10	22.2	5	27.8	1	12.5
Left Foot	10	14.1	7	15.6	2	11.1	1	12.5

Assessment of the high-risk ergonomic potency of Administrative Officers obtained a total score of 6, indicating a need for further observation. Assessment of ergonomic risk was in line with the result of MSDs condition risk level that showed a moderate risk level.

Analyst

MSDs symptoms of analysts showed that the lower back had a high-risk level of 30.8%, the neck had a moderate risk level of 46.2%, and the right shoulder with 30.8% moderate risk level. The analysis of ergonomic risk on analysts' gains resulted in a final score of 10 and 23 for Furan Analysts and Laboran, indicating that the job was categorized as high risk.

Working in laboratory involved static posture in long duration and repetitive motions. Static body posture produced an improvement of load on muscles and tendons leading to fatigue or exhaustion (Ganjave and Shikrapurkar, 2021). This corresponded with numerous conditions sequentially experienced by analysts, namely neck 72%, upper back 61%, lower back 61%, right shoulder 50%, and left shoulder 39%. Study by (Alwahaibi *et al*., 2021) on Laboratory-related Musculoskeletal Disorders (LMSDs), the prevalence of MSDs symptoms was the most common in the neck at 50.6%, followed by shoulder and lower back, with proportions of 49.4% and 43.4%.

The working period of analysts was 8 hours per day and their tasks required many critical postures that can lead to MSDs. Workers who sit on small stools for less than 4 hours a day, with their back bent forward at an angle between 20°-45°, without adequate back support, and those who bent their neck forward at >20° were susceptible to MSDs. Sitting position for 3–6 hours also contributed to MSDs, with p-value=0.04 (Haile, Taye, and Hussen, 2012). A study of clinical laboratory personnel in Mumbai stated that neck conditions were contributing risk factor in increasing RULA assessment Ganjave and Shikrapurkar (2021), particularly among women (p-value=0.009). Furthermore, shoulder and lower back conditions were found to be associated with job tasks that involved pipetting, with p-values of 0.045 and 0.054, respectively (Alwahaibi *et al*., 2021).

Field Workers

Field Workers were also included in the high risk category, as shown by the analysis result of ergonomic

Table 5. Respondent Characteristic Who Has MSDs Symptoms

SEG	Gender		Age		Working Period	
	M	F	<35	≥35	<5	≥5
	%	%	%	%	%	%
Administrative Officer	45.8	53.2	66.7	33.3	41.6	58.4
Analyst	30.8	69.2	84.6	15.4	76.9	23.1
Field Workers	100	0	100	0	50	50
Total	43.6	56.4	74.4	25.6	53.8	46.2

Table 6. Risk Level of MSDs

Parts of Body	Risk Level	Total (n=39)		Administrative Officer (n=24)		Analyst (n=13)		Field Workers (n=2)	
		N	%	n	%	n	%	n	%
Neck	Low	23	59	16	66.7	5	38.5	2	100
	Moderate	12	30.8	6	25	6	46.2	0	0
	High	4	10.3	2	8.3	2	15.4	0	0
Right Shoulder	Low	30	76.9	19	79.2	9	69.2	2	100
	Moderate	7	17.9	3	12.5	4	30.8	0	0
	High	2	5.1	2	8.3	0	0	0	0
Left Shoulder	Low	31	79.5	20	83.3	9	69.2	2	100
	Moderate	6	15.4	2	8.3	4	30.8	0	0
	High	2	5.1	2	8.3	0	0	0	0
Upper Back	Low	32	82.1	20	83.3	10	76.9	2	100
	Moderate	4	10.3	2	8.3	2	15.4	0	0
	High	3	7.7	2	8.3	1	7.7	0	0
Lower Back	Low	22	56.4	16	66.7	6	46.2	0	0
	Moderate	7	17.9	3	12.5	3	23.1	1	50
	High	10	25.6	5	20.8	4	30.8	1	50
Right Elbow	Low	38	97.4	23	95.8	13	100	2	100
	Moderate	0	0	0	0	0	0	0	0
	High	1	2.6	1	4.2	0	0	0	0
Left Elbow	Low	38	97.4	23	95.8	13	100	2	100
	Moderate	0	0	0	0	0	0	0	0
	High	1	2.6	1	4.2	0	0	0	0
Right Arm	Low	35	89.7	21	87.5	12	92.3	2	100
	Moderate	1	2.6	1	4.2	0	0	0	0
	High	3	7.7	2	8.3	1	7.7	0	0
Left Arm	Low	36	92.3	22	91.7	12	92.3	2	100
	Moderate	1	2.6	1	4.2	0	0	0	0
		2	5.1	1	4.2	1	7.7	0	0
Right Hand	Low	36	92.3	22	91.7	12	92.3	2	100
	Moderate	2	5.1	1	4.2	1	7.7	0	0
	High	1	2.6	1	4.2	0	0	0	0
Left Hand	Low	37	94.9	22	91.7	13	100	2	100
	Moderate	1	2.6	1	4.2	0	0	0	0
	High	1	2.6	1	4.2	0	0	0	0
Right Hip	Low	35	89.7	21	87.5	12	92.3	2	100
	Moderate	2	5.1	2	8.3	0	0	0	0
	High	2	5.1	1	4.2	1	7.7	0	0
Left Hip	Low	36	92.3	22	91.7	12	92.3	2	100
	Moderate	1	2.6	1	4.2	0	0	0	0
	High	2	5.1	1	4.2	1	7.7	0	0
Right Thigh	Low	38	97.4	23	95.8	13	100	2	100
	Moderate	0	0	0	0	0	0	0	0
	High	1	2.6	1	4.2	0	0	0	0
Left Thigh	Low	39	100	24	100	13	100	2	100
	Moderate	0	0	0	0	0	0	0	0
	High	0	0	0	0	0	0	0	0
Right Knee	Low	32	86.5	19	86.4	11	84.6	2	100
	Moderate	3	8.1	2	9.1	1	7.7	0	0
	High	2	5.4	1	4.5	1	7.7	0	0

Advanced Table 6. Risk Level of MSDs

Parts of Body	Risk Level	Total (n=39)		Administrative Officer (n=24)		Analyst (n=13)		Field Workers (n=2)	
		N	%	n	%	n	%	n	%
Left Knee	Low	38	97.4	23	95.8	13	100	2	100
	Moderate	0	0.0	0	0	0	0	0	0
	High	1	2.6	1	4.2	0	0	0	0
Right Calf	Low	37	94.9	23	95.8	12	92.3	2	100
	Moderate	1	2.6	0	0.0	1	7.7	0	0
	High	1	2.6	1	4.2	0	0	0	0
Left Calf	Low	37	94.9	23	95.8	12	92.3	2	100
	Moderate	1	2.6	0	0	1	7.7	0	0
	High	1	2.6	1	4.2	0	0	0	0
Right Foot	Low	34	87.2	22	91.7	10	76.9	2	100
	Moderate	4	10.3	2	8.3	2	15.4	0	0
	High	1	2.6	0	0	1	7.7	0	0
Left Foot	Low	36	92.3	22	91.7	12	92.3	2	100
	Moderate	3	7.7	2	8.3	1	7.7	0	0
	High	0	0	0	0.0	0	0	0	0

Table 7. Ergonomic Risk Assessment

Work Characteristic	Work Posture	Risk Assessment Result			Score	Score Interpretation
		Upper Body	Lower Body	Manual Handling		
Adm. – Computer work	Sitting	4	2	0	6	Needs Further Assessment
Furan Analysis	Sitting	6	2	2	10	Dangerous
Laboran	Sitting	7	6	10	23	Dangerous
Emission Sampling	Squat	4	4	5	13	Dangerous
Water Sampling	Squat	5	6	11	22	Dangerous
Lux Sampling	Standing	3	1	6	10	Dangerous

risk on emission, water, and illumination sampling with values of 12, 22, and 10, respectively. Ergonomic risk analysis on field workers based on MSDs symptoms suffered showed a proportion of 25% each for neck and lower back with the high-risk level. The activities of Field Workers consisted of manual handling, squat position, kneeling, prolonged standing up, and bending forward with an angle between 20°-45° while taking the sample. Previous investigations reported that most of MSDs were developed due to repetitive movements and manual handling (Nagaraj, Jeyapaul, and Mathiyazhagan, 2019; Rajendran *et al*., 2021). Furthermore, kneeling, bending, and squatting positions while working also contributed to MSDs and posed a risk of joint discomfort (Pinzke and Lavesson, 2018; Yadi and Kurniawidjaja, 2019). The 4–6 hours of working period in standing up position was connected consequentially in MSDs emergence (p-value=0.004) (Haile, Taye and Hussen, 2012). Bending forward with lowered arms and kneeling resulted in dangerous lumbar compression (Pinzke and Lavesson, 2018; Mishra and Satapathy, 2019).

CONCLUSION

The result of MSDs survey showed that half of workers had MSDs symptoms with the low, moderate, and high ergonomic risk level. The highest MSDs occurred at all SEG, including the lower back, neck, upper back, and right shoulder. Analysts and field workers were susceptible to MSDs, especially in the lower back. Similarly, assessment result of ergonomic risk revealed that jobs such as analysts and field workers were categorized as high risk. Meanwhile, ergonomic risk level of administrative officers was included as the category that needed further observation.

Ergonomic risk level, particularly for analysts and field workers can be decreased through engineering control using supporting equipment such as a trolley to reduce manual handling activities. For Analysts, engineering control can be produced by redesigning the workplace and providing more ergonomic chairs and desks. Meanwhile, for field workers, it can be improved by designing supporting equipment for sample testing to eliminate any awkward posture such as the squat and bend-forward positions with an angle between 20°- 45°.

ACKNOWLEDGMENTS

The authors are grateful to the writers of the journals used in this study and all individuals who participated in the experiment.

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