Ergonomic Risk Study With Nordic Body Map Method on Workers

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Abstract. Optimal performance and high productivity of human resources are significant aspects that a company wants to achieve continuously. PT. Bali Bangunan Konstruksi is a construction services industry engaged in the implementation of Villa buildings. One of the obstacles experienced is illness and accidents resulting from work-related illnesses, as well as suboptimal worker performance in their jobs. This is because the construction work process still relies on manual tools, which can pose a risk of muscle injury to workers under such conditions. Referring to this problem, an analysis was conducted on workers at the concrete work station using the Nordic Body Map method. The purpose of this study was to analyze the level of ergonomic risk in construction workers. Work with a standing or bending work posture is carried out for a long working time duration of eight hours per day or even exceeding the specified time, so that this condition can cause complaints of pain and even muscle injuries to workers. This study employs a random sampling technique, resulting in a sample of 25 workers. The object selection technique used in this study is purposive sampling. The research method employs a literature study, incorporating a Nordic Body Map questionnaire that identifies points of body parts frequently reported to experience pain by workers at PT. Bali Bangunan Konstruksi. Based on the results of the study of ergonomic risk due to musculoskeletal disorders (MSDs), it shows that the most complaints of pain are the left calf 60% and the right calf 70%.

Keywords: Ergonomics, Nordic Body Map, Workers

1 Introduction

According to Presidential Regulation of the Republic of Indonesia Number 7 of 2019 Concerning Diseases According to Presidential Regulation of the Republic of Indonesia Number 7 of 2019 Concerning Occupational Diseases, it explains that there are several classifications of Occupational Diseases including: diseases caused by exposure to factors (chemical, physical, biological), diseases based on the target organ system (respiratory, skin, muscle and skeletal, mental and behavioral), occupational cancer, and specific diseases. Ergonomics is a discipline that examines the relationship

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between humans and their work environments. Ergonomics also enables people who design tools to create a work system and tools that are tailored to user comfort (Balaputra & Sutomo, 2017).

A project is an activity that takes place within a certain period and with limited resources. The project management process begins with the planning stage, followed by engineering and design, procurement or tendering, construction, operational tests, and the utilization and maintenance stage (Nurhayati, 2020). Implementing construction projects has risks. Project risks can originate from various sources, including political, environmental, planning, marketing, economic, financial, natural, project-related, technical, human, criminal, and safety-related. These risks can affect the cost, quality, and time of project implementation. Occupational Health and Safety (K3) risks are identified through the Hazard Identification Risk Assessment Determine Control (HIRADC) Method (Achmad et al., 2020).

Unnatural work postures are often used in work processes, but awareness of this is often lacking. Of course, this is due to fatigue and muscle injury, which can impact workers' performance while they are at work. The physical conditions associated with this context, which workers are advised to avoid, are known as work-related Musculoskeletal Disorders (WMSDs) and can affect their performance while working. Of course, in this case, it is very detrimental to a company due to the suboptimal performance of a worker who experiences complaints of musculoskeletal disorders. Complaints in the musculoskeletal system are complaints in parts of the skeletal muscles that are felt by a person, ranging from very mild complaints to very painful (Tarwaka, 2011) .

Ergonomics is a scientific discipline that examines the relationship between humans and their work environment. Ergonomics also allows people who make tools to create appropriate work systems and work tools according to user comfort (Balaputra & Sutomo, 2017). One of the consequences of non-ergonomic workplaces and tools is the occurrence of Occupational Diseases (PAK) and Musculoskeletal Disorders (MSDs), which can result in loss of work time, reduced work productivity, decreased alertness, and an increased risk of work accidents (Gunawan, 2021).

According to the International Labor Organization, the incidence of occupational diseases due to ergonomic factors in 2016 was 12.27 million cases in 183 countries. The most common complaints are back and neck pain, often resulting from prolonged sitting, excessive exposure to whole-body vibration, and manual handling of materials. Micro, Small, and Medium Enterprises (MSMEs) are a significant example of informal employment and play a substantial role in Indonesia’s economic activity. The existence of MSMEs can open new job opportunities, reduce unemployment, and improve the community’s economy (Nurhayati, 2020) .

PT. Bali Bangunan Konstruksi is an industry specializing in construction services for villa buildings. In working on the villa building in Ungasan Jimbaran, there are 25 workers. In interviews conducted with workers, many have reported complaints of muscle pain and leg pain. Based on the research results and the above considerations, it is crucial to conduct an ergonomic risk assessment using the Nordic Body Map Method for workers at PT. Bali Bangunan Konstruksi.

2 Methodology

This research was conducted with a Descriptive Analytical design, with the object of research being the implementation of the Villa construction project at PT. Bali Bangunan Konstruksi, Perum Kesambi Raya, Blok E, No. 4X Kerobokan Denpasar, which was analyzed based on the Nordic Body Map (NBM) method, and then described and used as a basis for compiling an Ergonomics Study for K3 and Productivity. This research was conducted in several stages, starting with a literature study and problem identification, where the latter aims to identify and analyze the ergonomic risks experienced by workers after the problem has been identified.

The problem can be formulated to determine the purposeof this study, then conducting observations and distributing questionnaires filled out by the two workers, the next stage is to give a score to the questionnaire that has been filled out to find out the total individual score of the workers which will later be used as a reference in determining the level of complaint risk later, and the last stage is to conduct analysis and conclusions.

Population is a generalization area consisting of objects/subjects that have certain qualities and characteristics that are determined by researchers to be studied, and then conclusions are drawn (Sugiyono, 2012). To provide more direction or focus on selecting samples that can truly represent the population, a sampling technique is used, such as accidental sampling.

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3 Result and Discussion

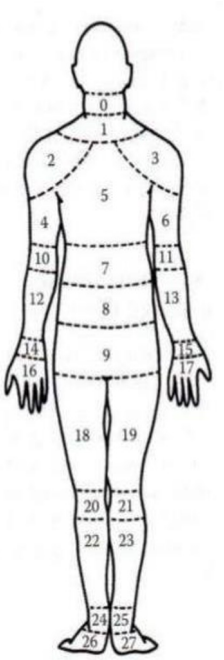
3.1 Result

This study was conducted among 25 workers, specifically those in the Villa building. The initial step taken was to conduct observations in the construction section. Table 1 is a questionnaire given to workers. Dam, tunnel, road, bridge, and other civil engineering projects require certain specifications, expertise, and technology, which are certainly different from housing or settlement projects. Risk management must be carried out throughout the project cycle, from the initial stage to the end of the (Abrar & Husen, 2011). This can help the placement of workers according to their expertise, the arrangement of the work area and work environment, and the arrangement of the order of work implementation, the placement of workers according to their expertise, the arrangement of the work area and work environment, and the arrangement of the order of work implementation (Wicaksono, 2014).

Unergonomic work attitudes or working conditions will ultimately cause complaints such as disorders of the musculoskeletal system (Manuaba, 2000). This study was conducted on workers in the project worker section. The initial step taken was to conduct observations on the project worker section. Furthermore, the Nordic Body Map questionnaire was administered before and after the work was completed. The following questionnaire was given to project workers.

Table 1. Nordic Body Map Questionnaire

Nordic Body Map Questionnaire
Name :
Age : Year
Work Time : Year
You are asked to rate how you feel about the body parts indicated on the table.

No.	Type of Complaint	Grade of Complaint NP	SP	P	VP	Body Parts Map
0	Pain/stiffness in the upper					
1	Pain/stiffness in the lower					
2	Pain in the left shoulder					
3	Pain in the right shoulder					
4	Pain in the left upper arm					
5	Pain in the back					
6	Pain in the right upper arm					
7	Pain in the waist					
8	Pain in the buttocks					
9	Pain in the buttocks					
10	Pain in the left elbow					
11	Pain in the right elbow					
12	Pain in the left forearm					
13	Pain in the right forearm					
14	Pain in the left wrist					
15	Pain in the right wrist					
16	Pain in the left hand					
17	Pain in the right hand					
18	Pain in the left thigh					
19	Pain in the right thigh					
20	Pain in the left knee					
21	Pain in the right knee					
22	Pain in the left calf					
23	Pain in the right calf					
24	Pain in the left ankle					
25	Pain in the right ankle					
26	Pain in the left leg					
27	Pain in the right leg					

The assessment of 4 Likert scales on the Nordic Body Map questionnaire consists of the TS indicator (Not Sick), which is worth 0, AS (Somewhat Sick), which is worth 1, S (Sick), which is worth 2, and SS (Very Sick), which is worth 3. The data obtained will be processed into percentages, showing the results of complaints regarding the parts of the body assessed by the respondents. With the results of this data, it will determine the ergonomic factors in each work process carried out

The study was conducted at PT. Bali Bangunan Konstruksi, one of the manufacturing industry's production facilities, specializes in the production of cardboard boxes and cardboard. The production process of making cardboard boxes is carried out from Monday to Friday, with working hours from 08:00 to 16:00 WIB. The production of cardboard boxes is adjusted to the orders requested, starting from shape, size, color, and so on.

In the work at PT. Bali Bangunan Konstruksi has 5 work units, namely Sliter (Cut), Slotter (Perforating), Screen Printing, Stitching (Sewing), and Dycat (Cut), at PT. Bali Bangunan Konstruksi itself has 25 workers, each with various types of work assigned to them. The initial process involves conducting observations during each production process. Then conduct questions and answers regarding the Nordic Body Map questionnaire for 25 workers. The following image shows the work process activities of workers at PT. Bali Bangunan Konstruksi.

After collecting data in the form of a questionnaire with 25 samples of PT. Bali Bangunan Konstruksi workers, the following data results were obtained:

Table 2. Respondents' Age

Age (Years)	Frequency (n)	Percentage (%)
17 - 27	3	30
38 - 38	1	10
39 - 49	5	50
50 - 60	1	10
Total	10	100

Based on Table 2 shows that the highest results in the age category of 39-49 years are 5 people (50%), while the lowest results in the age categories of 28-38 and 50-60 years are 1 person each (10%).

Last Education. The last level of education for workers encompasses elementary school through higher education. The following are the levels of respondents.

Table 3. Last Education

Last Education	Frequency (n)	Percentage (%)
Elementary School	1	4
Junior High School	3	12
Senior High School/Vocational High School	20	80
Higher Education	1	4
Total	25	100

Based on Table 3, the highest level of education obtained was high school, with the most, as many as 20 people (80%), and elementary school had the fewest results, namely 1 person (4%).

Length of Work in a Day. The level of respondents based on the length of work in a day is as follows.

Table 4. Working Hours in A Day

Working Hours in a Day	Frequency (n)	Percentage (%)
5	5	20
8	20	80
Total	25	100

The results of Table 4 show that the maximum working time per day is 8 hours for 20 people (80%), and the minimum is 5 hours for 5 people (20%).

Height. The height of PT. Bali Bangunan Konstruksi workers range from 155 - 170 cm. The description of respondents based on height is as follows.

Table 5. Height

Height (cm)	Frequency (n)	Percentage (%)
155 - 160	6	30
161 - 165	9	45
166 - 170	5	25
Total	20	100

The results of Table 5 show that the height ranges from 161 to 165 cm, with 9 people (45%), and the least is 5 people each (25%).

Body Weight. The weight of PT. Bali Bangunan Konstruksi workers range from 49 - 73 kg. The description of respondents based on body weight is as follows.

Table 6. Weight

Weight (kg)	Frequency (n)	Percentage (%)
40 - 50	2	8
51 - 60	5	20
61 - 70	15	60
71 - 80	3	12
Total	25	100

Based on Table 6 shows the weight of workers at PT. Bali Bangunan Konstruksi most at 61 - 70 as many with 15 people (60%), while the number of respondents least is 40 - 50 kg as many with 2 people (8%).

Identification Results with the Nordic Body Map Method. The following is a collection of questionnaire data using the Nordic Body Map method, as follows.

Table 7. Results of Nordic Body Map Grouping Data Based on the Assessment Scale

No.	Type of discomfort	Nordic body map questionnaire data			
		Number of workers			
		TS (0)	AS (1)	S (3)	SS (4)
0	Pain/stiffness in the upper	6	1	3	0
1	Pain/stiffness in the lower	5	3	2	0
2	Pain in the left shoulder	5	1	4	0
3	Pain in the right shoulder	7	0	3	0
4	Pain in the left upper arm	5	1	3	1
5	Pain in the back	4	2	4	0
6	Pain in the right upper arm	6	1	2	1
7	Pain in the waist	6	1	3	0
8	Pain in the buttocks	6	1	3	0
9	Pain in the buttocks	7	0	3	0
10	Pain in the left elbow	8	1	1	0
11	Pain in the right elbow	8	1	1	0
12	Pain in the left forearm	8	0	2	0
13	Pain in the right forearm	6	0	4	0
14	Pain in the left wrist	8	0	2	0
15	Pain in the right wrist	7	0	3	0
16	Pain in the left hand	8	0	2	0
17	Pain in the right hand	7	0	3	0
18	Pain in the left thigh	6	1	3	0
19	Pain in the right thigh	5	1	4	0
20	Pain in the left knee	6	2	2	0
21	Pain in the right knee	7	0	3	0
22	Pain in the left calf	3	0	7	0
23	Pain in the right calf	2	0	8	0
24	Pain in the left ankle	7	0	3	0
25	Pain in the right ankle	7	0	3	0
26	Pain in the left leg	7	1	2	0
27	Pain in the right leg	7	0	2	0

Based on Table 7, the questionnaire grouping data using the Nordic Body Map (NBM) method yielded the final results, which identified the group with the highest complaints. The following are the total results of the Nordic Body Map (NBM) questionnaire of respondents. The final results of the total body parts identified as having the most pain were in the back, with a pain score of 10, and the left and right calf pain, which were each valued at 14 and 16. It can be seen that the work process at PT. Bali Bangunan Konstruksi itself can be directly observed working in a standing position, with the work process being carried out repeatedly, causing pain in certain body parts. Based on the final total results obtained, it will then be re-formed into a percentage, as follows:

Table 8. Nordic Body Map Grouping Data Based on the Assessment Scale in Percentage

No.	Type of discomfort	Nordic body map questionnaire data			
		Number of workers			
		TS (0)	AS (1)	S (3)	SS (4)
0	Pain/stiffness in the upper	60	10	30	0
1	Pain/stiffness in the lower	50	30	20	0
2	Pain in the left shoulder	50	10	40	0
3	Pain in the right shoulder	70	0	30	0
4	Pain in the left upper arm	50	10	30	10
5	Pain in the back	40	20	40	0
6	Pain in the right upper arm	60	10	20	10
7	Pain in the waist	60	10	30	0
8	Pain in the buttocks	60	10	30	0
9	Pain in the buttocks	70	0	30	0
10	Pain in the left elbow	80	10	10	0
11	Pain in the right elbow	80	10	10	0
12	Pain in the left forearm	80	0	20	0
13	Pain in the right forearm	60	0	40	0
14	Pain in the left wrist	80	0	20	0
15	Pain in the right wrist	70	0	30	0
16	Pain in the left hand	80	0	2	0
17	Pain in the right hand	70	0	30	0
18	Pain in the left thigh	60	10	30	0
19	Pain in the right thigh	50	10	40	0
20	Pain in the left knee	60	20	20	0
21	Pain in the right knee	70	0	30	0
22	Pain in the left calf	30	0	70	0
23	Pain in the right calf	20	0	80	0
24	Pain in the left ankle	70	0	30	0
25	Pain in the right ankle	70	0	30	0
26	Pain in the left leg	70	10	20	0
27	Pain in the right leg	70	0	20	0

Based on Table 8, the data results in the percentage of pain complaints experienced by PT. Bali Bangunan Konstruksi workers show that the score for the no pain value gets the highest percentage with a value of 100% in the left elbow, the value of slightly pain with a value of 20%, the most results in the back, the most pain value with a value of 60% and 70% in the left calf and right calf respectively, the value of very pain is the most with 10% showing in the left upper arm and right upper arm.

3.2 Discussion

Working in a standing position for an extended period can cause sore legs, swollen legs, varicose veins, muscle fatigue, back pain, and stiffness in the neck and shoulders. This is caused by the body being affected by the non-ergonomic arrangement of the work area, resulting in the worker's body position during activities feeling limited. This limitation can lead to various body problems, such as the worker's body being bent over excessively, which can cause back pain. Standing too long makes the muscles stiff, which can reduce the blood supply to the muscles. This results in reduced blood flow that should be delivered to the muscles, causing very rapid fatigue and pain in certain parts of the body. This is certainly very concerning. Therefore, it is important to identify hazards, assess risks, and determine the type of risk control in the part where the work accident occurred (Achmad et al., 2020).

Table 4 explains the causes of pain felt by the two workers, such as shoulder pain when pressing during the screen printing process, then the upper arm feels pain due to repetitive movements during the screen printing process, and finally the wrist feels pain due to being the support of the load when the worker is doing the screen printing process. Ergonomic interventions are necessary to ensure that work can be conducted safely, healthily, and productively. To carry out ergonomic interventions, sometimes appropriate technology tools are needed so that work becomes more effective, safe, efficient, and productive(Yusuf & Irwanti, 2022). Therefore, based on the results of this study, it is highly recommended to conduct further research in the form of ergonomic interventions on construction workers in Bali.

4 Conclusion

Based on the results of the ergonomic risk study that has been shared and filled out by 25 respondents due to musculoskeletal disorders in PT. Bali Bangunan Konstruksi workers using the Nordic Body Map questionnaire found that the body parts experiencing the most pain complaints were the left calf (60%) and the right calf (70%). The advice that can be given is that prevention and minimization of MSD complaints need to be carried out. Prevention that can be done to reduce musculoskeletal disorders complaints is by doing stretching before and after doing work that aims to reduce pain in the muscles, bones, and joints that often do repetitive work, and limit lifting heavy loads, administering anesthetic drugs or non-steroidal anti-inflammatory drugs through injections into the painful area when experiencing excessive pain according to the doctor's recommendations.

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