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Cabinetware Employee Work System (Case Study at CV Diamond, Bandung, Indonesia)

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Abstract.
Background. The problems found in CV Diamond Cabinetware stem from the fact that all production activities for furniture and door handles are carried out using human labor, assisted by several machines. The factory's machines include bending, pounding, stamping, drilling, grinding, and hand shears.
Aim. This study evaluates the current work system and designs ergonomic improvement solutions to reduce the risk of musculoskeletal disorders (MSDs). Data were collected through direct observation, semi-structured interviews, and workers completing the Nordic Body Map questionnaire.
Methods. The risk analysis was carried out using the Rapid Entire Body Assessment (REBA) method, and the results showed a high level of ergonomic risk at specific workstations.
Results. Based on the analysis results, improvements were made to ergonomic chairs and tables using SolidWorks software. Proposed improvements were evaluated through Human CAD simulations using CATIA V5 to assess the effectiveness of the design in reducing the risk of injury.
Conclusion. The study's results show that the proposed ergonomic design has improved work posture, reduced physical stress, and improved employee comfort.
Implementation. This study makes an essential contribution to the application of ergonomics in small-medium industries and is expected to be a reference for developing healthier and more productive work systems.

Keywords: Ergonomics, Musculoskeletal Disorders, Nordic Body Map, Rapid Entire Body Assessment, Rapid Upper Limb Assessment, Anthropometry, Ergonomic Design.

INTRODUCTION

CV. Diamond Cabinetware is a small and medium private manufacturing company that produces furniture accessories such as hinges, door handles, table elbows, and similar equipment. This company was established in the late 1970s and has frequently changed locations. Initially, this company was established on Jl. Kopo, Bandung, West Java and moved to Jl. Sukamenak Raya No. 153, Bandung, West Java in 2010 until now.

Originally, the company only produced door handles and widened the types of products, but now, 43 products have been produced. This expansion was undertaken to expand the goods they produce and continue to look at the existing market situation.

The employee comfort must be considered as a company engaged in manufacturing and mass production. The reason is that there is no automated machines to carry out production, so it depends on employees who still work manually. In addition, CV Diamond Cabinetware implements working hours from 07:00 for the start of the workday to 17:00 for the end. With the duration of the work, the company also sets rest hours from 12.00 to 12.30. The company also sets a rest period from 12:00 to 12:30. In order to meet production targets and fulfill customer orders, all workers on the production floor perform physically demanding tasks, as well as repetitive and fast movements while operating machines. Referring to scientific journals by Sirzai & Dundar (2022), it was found that the most common issues faced by industrial workers were lower back disorders (66.5%), followed by neck and shoulder disorders (58%), and upper extremity disorders (23%). These findings are based on the results of initial observations carried out using the fishbone diagram, which can be seen in Figure 1.

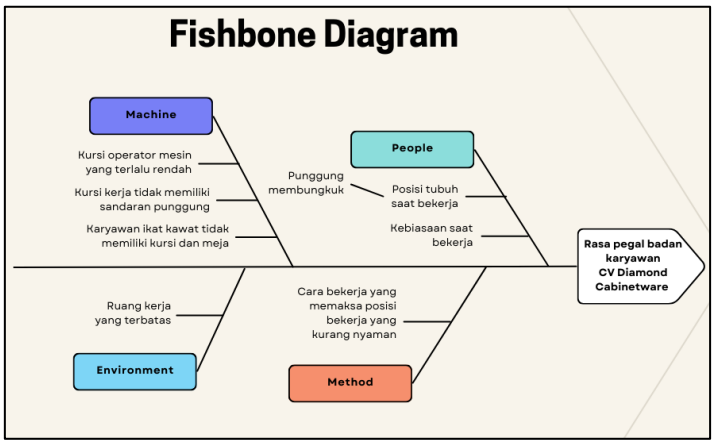


Figure 1. Fishbone Diagram

Figure 1 is a fishbone diagram for identifying initial problems in CV Diamond Cabinetware. It was found that many employees had non-ideal working posture, such as a hunched back and neck or an uncomfortable leg positions because the chairs were too low or there were no seats at all. In addition to making observations, this initial stage also includes interviews with workers on the production floor, of CV Diamond Cabinetware. It was found that out of 11 workers on the production floor, at least 90% of them complained of pain or discomfort from their work positions. Through the interview, the

production floor employees stated that the pain or soreness they experienced was in the back, neck, and legs. Of course, if the body of the production machine operator often experiences pain and soreness, it can have a negative impact that harms both the company and the workers themselves.

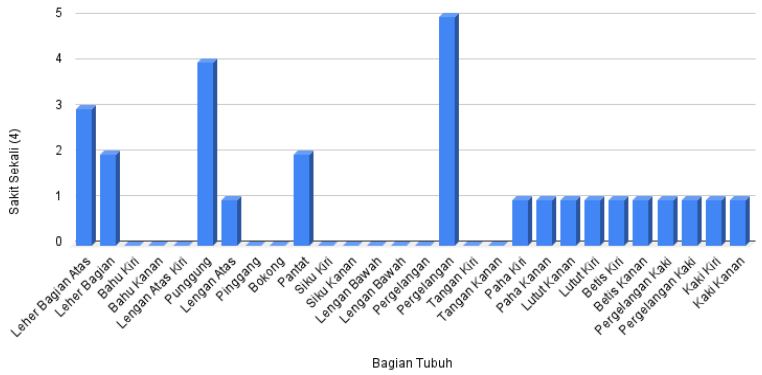


Figure 2 Frequency of Assessment of Pain in Workers' Body Parts

Figure 2 illustrates the frequency of ‘once sick’ assessments across various body parts of a CV Diamond Cabinetware worker. Of the 28 body parts evaluated, 16 have been assessed as ‘once sick’ indicating a need for improvements to reduce the risk of *Musculoskeletal Disorders* (MSDs). Based on the background provided, the research questions are as follows.

1. What are the results of evaluating the CV Diamond Cabinetware employee work system in its current condition?
2. What is the proposed plan for improving the work system to reduce the risk of musculoskeletal injuries in CV Diamond Cabinetware employees?

Limitations of Research Problems and Assumptions

This section will discuss the formulation of the problem and the assumptions of the applied research. The following are the limitations of the problems set for this study.

1. This research was conducted at the CV Diamond Cabinetware factory.
2. The research focused on machine operators on the production floor and pre-production employees responsible for tying small components for the coating process.
3. The implementation stage of the improvement proposal does not include the creation of a physical prototype; it utilizes 3D modeling software, SolidWorks, as a medium for digital prototype visualization.

In addition to setting problem limitations, research assumptions are also formulated to facilitate the research process. The following are the assumptions used in this study: during the study, the workers who were the subjects did not change.

Research Objectives

There are several research objectives to be achieved. The research aims to determine the targets and a solutions to the problems that have been formulated previously. The following are the research objectives to be achieved.

1. Evaluate the work system of CV Diamond Cabinetware employees.
2. Draft proposals for work system improvements to reduce the risk of musculoskeletal injuries among CV Diamond Cabinetware employees.

Research Benefits

This research is expected to provide practical benefits for CV Diamond Cabinetware in improving work efficiency and comfort on the production floor. By identifying and analyzing employees' work posture and ergonomic risks using the REBA and RULA methods and the Nordic Body Map, the company can reduce the potential for musculoskeletal injuries that often occur due to repetitive physical activity and poor work posture. The results of this research can also later serve as the basis for redesigning a more ergonomic work system, namely the creation of healthier and safer use of assistive devices for employees.

In addition to practical benefits for companies, this research also makes an academic contribution to the development of ergonomics, especially in the context of small and medium industries in Indonesia. This study can be a reference for other researchers who want to explore similar topics, primarily related to the application of REBA and RULA methods, as well as the Nordic Body Map in the manufacturing work environment. Thus, this research benefits the companies conducting the study and can enrich the scientific literature in the ergonomics and occupational health field.

LITERATURE REVIEW

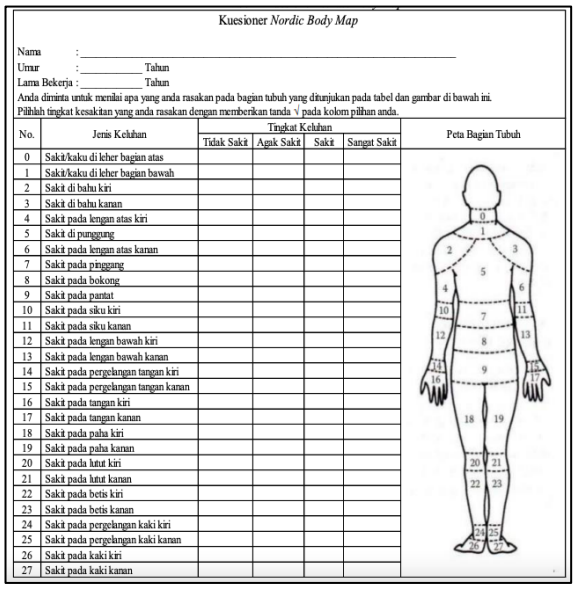
The literature review discusses the concepts and theories related to this research. The theoretical basis includes ergonomics, REBA, RULA, anthropometry, the Nordic Body Map, and musculoskeletal disorders. This theoretical foundation will help in understanding the research being conducted.

Ergonomics

According to Sutalaksana et al. (2006), ergonomics is a branch of science that systematically utilizes information related to human nature, abilities, and limitations in designing a work system. The goal is to work effectively, efficiently, safely, and comfortably. The term ergonomics comes from Latin, namely "Ergos," which means work, and "Nomos," which means natural law. Ergonomics is a study that investigates the human perspective in the work environment, involving an understanding of physiology, psychology, management, engineering, and design (Nurmianto, 2008). Ergonomics encompasses various aspects, including engineering, physical and psychological experience, and anatomy. Applying ergonomics in life aims to balance human abilities and limitations with work that must be done regularly. In addition, ergonomics is essential in designing work systems because it can increase effectiveness at work.

Nordic Body Map **(NBM)**

The Nordic Body Map is one of the instruments used to determine the depiction of *musculoskeletal disorders.* The Nordic Body Map is a questionnaire that assesses discomfort or pain in the worker's body. This questionnaire includes several types of MSD complaints displayed on the body map. After filling out the questionnaire, we will determine which part of the body has complaints and the severity, ranging from "Not Sick," "Somewhat Sick," "Sick," and "Very Sick." This method is considered highly subjective because the workers will independently fill out a questionnaire about complaints at work.



Kuesioner *Nordic Body Map*

Nama : _____
Umur : _____ Tahun
Lama Bekerja : _____ Tahun
Anda diminta untuk menilai apa yang anda rasakan pada bagian tubuh yang ditunjukan pada tabel dan gambar di bawah ini.
Pilihlah tingkat kesakitan yang anda rasakan dengan memberikan tanda √ pada kolom pilihan anda.

No.	Jenis Keluhan	Tingkat Keluhan				Peta Bagian Tubuh
		Tidak Sakit	Agak Sakit	Sakit	Sangat Sakit	
0	Sakit/kaku di leher bagian atas					
1	Sakit/kaku di leher bagian bawah					
2	Sakit di bahu kiri					
3	Sakit di bahu kanan					
4	Sakit pada lengan atas kiri					
5	Sakit di punggung					
6	Sakit pada lengan atas kanan					
7	Sakit pada pinggang					
8	Sakit pada bokong					
9	Sakit pada pantat					
10	Sakit pada siku kiri					
11	Sakit pada siku kanan					
12	Sakit pada lengan bawah kiri					
13	Sakit pada lengan bawah kanan					
14	Sakit pada pergelangan tangan kiri					
15	Sakit pada pergelangan tangan kanan					
16	Sakit pada tangan kiri					
17	Sakit pada tangan kanan					
18	Sakit pada paha kiri					
19	Sakit pada paha kanan					
20	Sakit pada lutut kiri					
21	Sakit pada lutut kanan					
22	Sakit pada betis kiri					
23	Sakit pada betis kanan					
24	Sakit pada pergelangan kaki kiri					
25	Sakit pada pergelangan kaki kanan					
26	Sakit pada kaki kiri					
27	Sakit pada kaki kanan					

Figure 3. Nordic Body Map Questionnaire
(source: Wijaya (2019))

As shown in Figure 3, the *Nordic Body Map* questionnaire identifies 27 body parts. The limbs cover the upper part of the body, namely the neck, to the lower part of the body, namely the legs. A value of 1 represents "Not Sick," a value of 2 represents "Somewhat Sick," a value of 3 represents "Pain," and a value of 4 represents "Very Sick." According to Wijaya (2019), there are four classifications of risk levels based on the total individual score from the *Nordic Body Map.*

Table 1. Nordic Body Map *Risk Level Classification*

Total Score	Corrective Action
28-49	Low (no corrective action is needed yet)
50-70	Medium (may require action at a later date)
71-90	High (immediate action required)
91-122	Very High (thorough action is required as soon as possible)

Table 1 shows the four final results from the Nordic Body Map questionnaire. If the total score is below 49, the worker's posture is ideal and does not cause injury in the long term. Meanwhile, if the total score is above 91, improvements must be made immediately because the posture experienced by workers can be classified as having a high risk of injury.

***Rapid Entire Body Assessment* (REBA)**

Rapid Entire Body Assessment (REBA) is a method in the field of ergonomics that assesses the working position of workers' necks, backs, arms, wrists, and legs. In its assessment, this method is also influenced by coupling factors (relationships between body parts), external loads supported by the body, and the activities of workers (Masudha & Sulistyowati, 2024). Assessment using the REBA method is used to identify complaints or health risks that workers may experience. The difference between the REBA method and other analysis methods is that the REBA method analyzes all parts of the worker's body by focusing on the overall posture, which is expected to reduce the occurrence of musculoskeletal disorders in the worker's body.

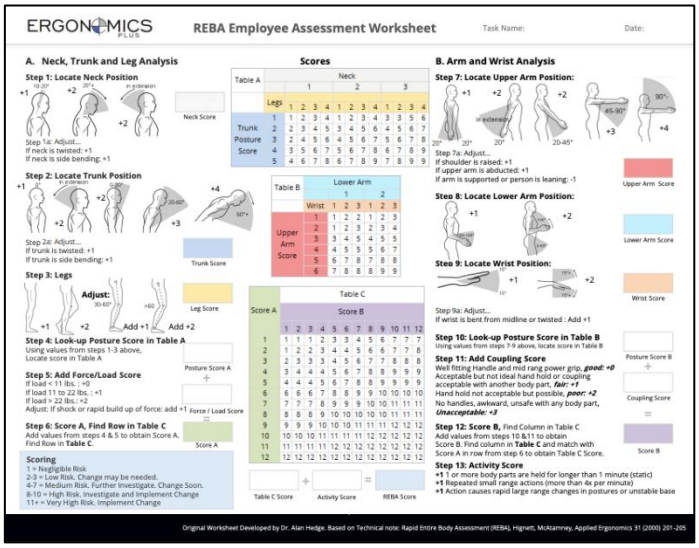


Figure 4. Rapid Entire Body Assessment
Source: Hignett, S., & McAtamney, L. (2000). 201–205.

In the REBA method, as seen in Figure 4, the body parts are divided into two groups, namely Group A and Group B. Group A is used to analyze the middle body parts of the worker, such as the torso, neck, and arms. Meanwhile, Group B is used to analyze the right and left body parts, including the right arm and left arm. A thorough analysis of groups A and B is essential for effective results. After conducting the REBA analysis process, the results will be obtained in the form of scores. This score indicates the level of risk workers face, and from this score, they can take corrective actions to reduce health risks related to workers' posture.

Rapid Upper Limb Assessment (RULA) is an ergonomic method that examines posture by focusing on the human body. This method of assessing working posture does not require special tools to measure neck, back, and upper body posture. Figure 8 illustrates the assessment using the RULA method.

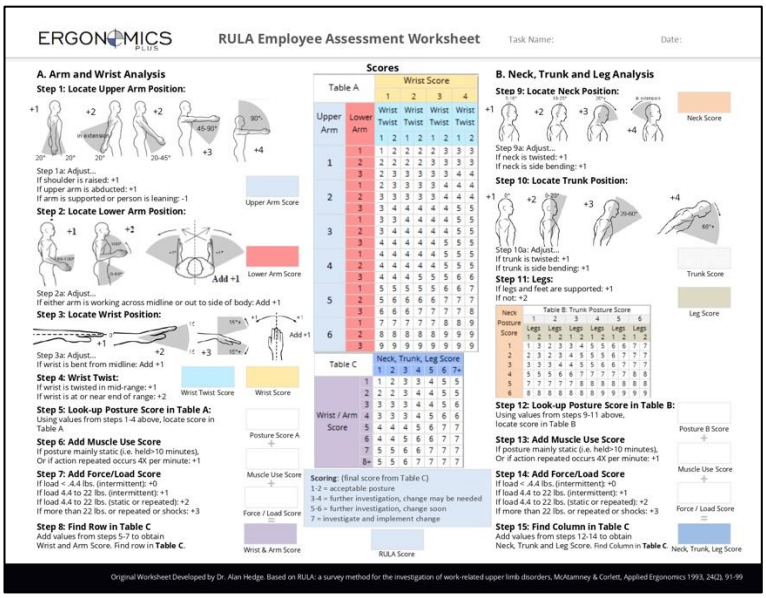


Figure 5. Rapid Upper Limb Assessment
Source: McAtamney, L., & Corlett, E. N. (1993). 91–99.

In the RULA method shown in Figure 5, the body parts are divided into two groups: Group A and Group B. Group A is used to analyze the upper arm, forearm, and wrist, while Group B is used to analyze the neck, body, and legs. A thorough analysis of both groups is essential for effective results. After conducting the RULA analysis, the results are obtained as scores. These scores indicate the risks workers face; based on these scores, corrective actions can be taken to reduce health risks related to workers' posture.

METHODS

This company is a small and medium-sized private manufacturer engaged in producing furniture accessories such as hinges, door handles, table elbows, and similar equipment. It was established in the late 1970s and has relocated once. Initially, the company was established on Jl. Kopo, Bandung, West Java, and moved to Jl. Sukamenak Raya No. 153, Bandung, West Java, in 2010, where it remains today. Employee comfort must be considered, as the company is engaged in manufacturing and mass production.

This is particularly important because there are no automated machines to carry out production, so the process still relies on employees who work manually. Additionally, CV Diamond Cabinetware implements a working schedule from 07:00 for the start of the day and 17:00 for the end of the workday. The company also provides rest hours from 12:00 to 12:30. To meet production targets and fulfill customer orders, all workers on the production floor at CV Diamond Cabinetware perform physically demanding tasks, which include repetitive and rapid movements while operating machines.

This study employs both qualitative and quantitative approaches, utilizing observation, interviews, and ergonomic data analysis methods. The initial phase involves collecting primary data through direct field observations to assess the working conditions of employees on the production floor of CV Diamond Cabinetware. These observations focus on work posture, physical workload, and repetitive activities that may lead to musculoskeletal complaints. Additionally, semi-structured interviews are conducted with workers to gather information about physical complaints experienced and their perceptions of occupational comfort and safety. Secondary data from scientific literature, ergonomic standards, and relevant research journals complement this primary data.

The collected data is then analyzed using the Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA) methods to evaluate the level of ergonomic risk associated with employee work postures. These methods assess musculoskeletal risk in various body parts, such as the neck, back, arms, and legs. Furthermore, the Nordic Body Map is employed to identify physical complaints in more detail based on workers' subjective experiences. The results from the REBA, RULA, and Nordic Body Map analyses will provide an overview of the health risks workers face. Based on these findings, the study will offer recommendations for improving the work system to enhance comfort and efficiency and reduce the risk of injury to employees. The research stages are illustrated in the following flow chart.

RESULT AND DISCUSSION

In this chapter, the data collection and processing methods employed are explained. Data collection of painful body parts was conducted using the Nordic Body Map questionnaire. In contrast, the processing of employee position and posture data utilized the Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA) methods. Subsequently, the research proceeded with designing improvement

proposals in the form of digital prototypes of chairs and tables using SolidWorks software. After completing the digital prototype design, the proposed improvement design was evaluated by conducting a digital human CAD simulation using CATIA V5 software.

Table 2. Nordic Body Map Wire Tie Workers

***Nordic Body Map* CV. Diamond Cabinetware**					
Name:	Luki	**Working Time:**	3 years		
Age:	20 Years	**Working Time:**	10 Hours (30 minutes break)		
		Work Activities:	Tying the wire		
It	**Types of Complaints**	**Complaint Rate**			
		1	**2**	**3**	**4**
0	Pain/stiffness in the upper neck	V			
1	Pain/stiffness in the lower neck			V	
2	Pain in the left shoulder	V			
3	Pain in the right shoulder	V			
4	Pain in the left upper arm	V			
5	Pain in the back		V		
6	Pain in the right upper arm	V			
7	Pain in the lower back			V	
8	Pain in the buttocks			V	
9	Pain in the buttocks			V	
10	Pain in the left elbow	V			
11	Pain in the right elbow	V			
12	Pain in the left forearm	V			
13	Pain in the right forearm	V			
14	Pain in the left wrist			V	
15	Pain in the right wrist			V	
16	Pain in the left hand			V	
17	Pain in the right hand			V	
18	Pain in the left thigh	V			
19	Pain in the right thigh	V			
20	Pain in the left knee		V		
21	Pain in the right knee		V		
22	Pain in the left calf			V	
23	Pain in the right calf			V	
24	Pain in the left ankle		V		
25	Pain in the right ankle		V		
26	Pain in the left leg			V	
27	Pain in the right leg		V		
Description: 1 (Not sick), 2 (somewhat sick), 3 (sick), 4 (very sick)					

Assessment of Work Systems with Nordic Body Map

To find out the current work system in the factory, interviews will be conducted using a Nordic Body Map questionnaire, where workers will state the perceived scale based on the statements provided by the researcher. Filling out the Nordic Body Map questionnaire will identify complaints about the musculoskeletal system that a person experiences in various parts of the body. For the first worker, the complaint is related to the wire tie area, which can be seen in Figure 3. Based on Figure 4, the worker was not provided with facilities such as small chairs or desks while working. Next, an interview was conducted using the Nordic Body Map questionnaire.

Table 2 shows that workers experience several complaints related to the neck, waist, hands, and lower body. From the recapitulation results, a score for the classification of risk level was obtained. The value was determined by adding up the pain assessment for each worker, followed by an average calculation, which resulted in a final score of 55. According to Table 1, this value falls under the medium classification (may need improvement). Next, a histogram was created to visualize the percentage of 3 (Sick) and 4 (Sick) assessments on the worker's body parts. A bar graph was also created to show the percentage of complaint rates per body part.

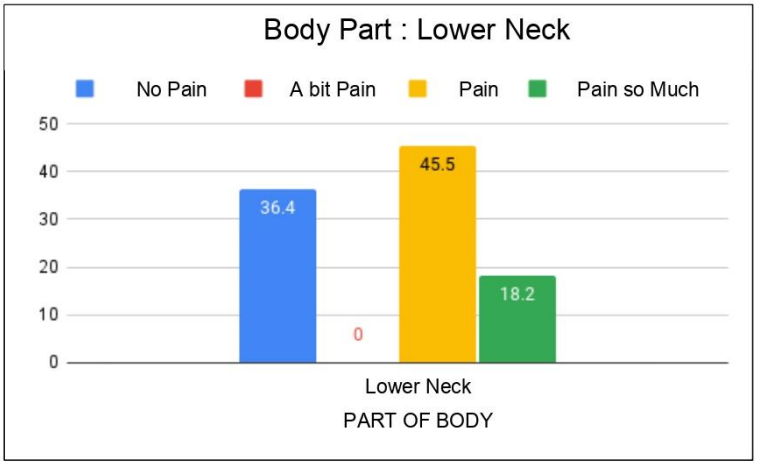


Figure 6. Percentage of Complaint Rate (Lower Neck)

Of the 11 workers who filled out the Nordic Body Map in Figure 10, 45.5% reported experiencing lower neck pain, while 36.4% reported no upper neck pain. Based on all the bar charts conducted, a percentage summary was made for assessments 3 and 4. Figure 10 is a bar graph displaying ratings 3 and 4 on the workers' bodies.

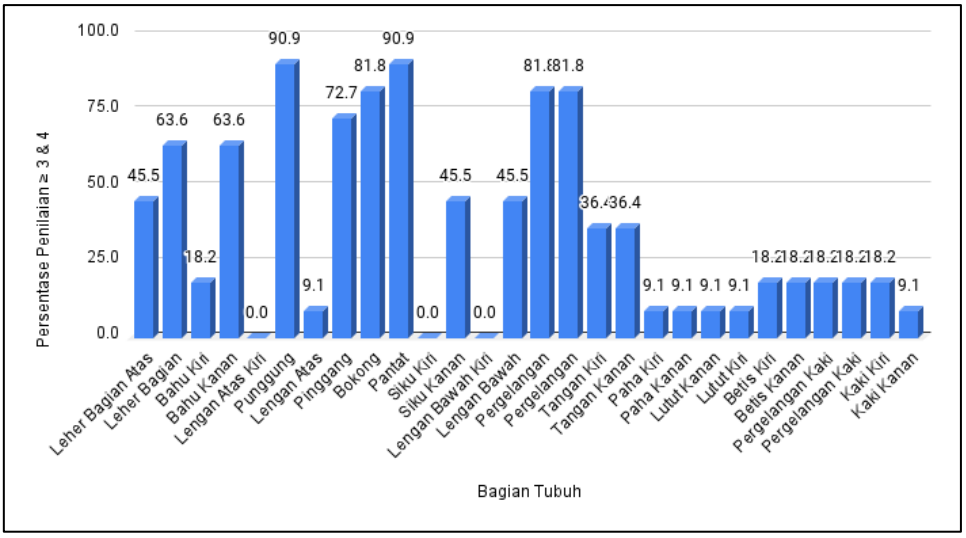


Figure 7. Rating Bar Charts 3 and 4

As shown in Figure 6, the most significant percentages are the back and buttocks at 90.9%, and the buttocks, left wrist, and right wrist at 81.8%. These values are quite high; if ignored, they could impact workers. Therefore, the researcher can improve and evaluate the work posture of CV Diamond Cabinetware workers.

Evaluation of Current Work Posture

Based on the results obtained using the Nordic Body Map questionnaire, the classification is moderate, so further improvements and evaluations are needed to reduce the risk of musculoskeletal disorders (MSDs) in workers. In this section, an evaluation of the work posture of CV Diamond Cabinetware workers is carried out using the Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA) methods to compare the best results.

The REBA method has a good approach to assessing overall posture, including the neck, torso, upper arms, forearms, wrists, and legs. Unlike RULA, which only focuses on the upper extremities, REBA assesses posture more thoroughly. For example, one of the important aspects of REBA is the assessment of the worker's foot posture, which includes the stability, support position, and load that the feet receive during work activities. An unbalanced leg position or a pedestal that is only focused on one side can increase the risk of musculoskeletal disorders, especially in the knee and ankle areas. Workers who sit in unstable positions or use machines with unaligned leg positions can

be at risk of musculoskeletal disorders. On the other hand, RULA focuses more on assessing upper body posture, especially the arms and hands, which play an important role in activities that involve repetitive movements and/or the use of heavy equipment. Using RULA, researchers can also evaluate the posture of the upper arms, forearms, and wrists specifically, providing an overview of potential risks to those parts of the body.

Table 3. REBA Evaluation for Current Working Posture

REBA Table									
NO	**Job Type**	**Table A**						**Table B**	
		Neck	***Trunk***	***Leg***	***Posture Score***	***Load Score***	***Score A***	***Upper Arm***	***Lower Arm***
1	Wire Tie	2	3	2	5	0	5	3	2
2	Bending Machine	2	3	2	5	0	5	4	2
NO	**Job Type**	**Table B**				**Table C**	**Total**		***Scoring***
		Wrist	***Posture Score***	***Coupling Score***	***Score B***	***Score C***	***Activity Score***	**REBA *Score***	
1	Wire Tie	3	5	1	6	7	1	8	*High Risk*
2	Bending Machine	2	6	0	6	8	1	9	*High Risk*

For this study, the evaluation of these two methods focuses on two main types of work: Wire Tie and Machine, each with different characteristics of movement and work posture. The data processing results from the REBA and RULA evaluations before the proposed improvements are presented in Tables 4 and 5. This data provides a clearer picture of the risk level of both methods and serves as a basis for developing ergonomic interventions to minimize the risk of MSDs to workers.

Table 3 shows the results of REBA data processing before the proposed improvements, classified into two types of work: wire tie work and machine work. Wire tie work is characterized by placing a load on several important parts of the body, such as the torso, arms, and neck. Based on Table A, the neck position scored 2, indicating a slight bending of the neck that could cause muscle tension if it continues to recur. The torso position received a score of 3, which indicates that workers often perform unnatural bends

or postures, potentially increasing the risk of lower back injuries. The position of the legs, with a score of 2, indicates a stable static condition but still requires attention because it can trigger muscle fatigue. Furthermore, in Table B, the upper arm position received a score of 3, indicating that activities involved lifting or using the arm in an unergonomic position. The position of the forearm, with a score of 2, is relatively more stable but still exerts pressure. The wrist scored 3, indicating flexion or deviation of the wrist, which can increase the risk of injury. With a Posture Score of 5 plus a Coupling Score of 1, Score B becomes 6. These results show that the worker's grip or control needs improvement to be more stable and safer. In Table C, the final score, or Score C, reaches 7, combined with an Activity Score of 1, giving a Total REBA Score of 8. With this value, wire tie work is categorized as High Risk. This category indicates that the working posture of workers in wire tie activities has a high risk of musculoskeletal injury.

"In Bending Machine work, the worker's posture tends to be more stable than in wire binding work, but ergonomic risks must still be considered. Table A shows that the neck position scored 2, indicating a slight emphasis on the neck. The torso position received a score of 3, indicating a posture that leans slightly forward but is still more stable than wire tying work. The position of the legs, with a score of 2, indicates good stability, contributing to a Posture Score of 5. In Table B, the upper arm position obtained a score of 4, which indicates an activity that requires lifting the arm in an uncomfortable position. The forearm position obtained a score of 2, indicating better stability, while the wrist received a score of 2, which indicates a slight deviation but remained relatively stable. With a Posture Score of 6 and a Coupling Score of 0, the B Score for this job is 6. In Table C, the final score, or Score C, is 8, with an additional Activity Score of 1, so the Total REBA Score is 9. This score is categorized as High Risk, which indicates that the working posture of the Bending Machine job has a high risk of musculoskeletal injury.

Table 7. RULA Evaluation for Current Working Posture

RULA Table										
It	**Job Type**	**Table A**								
		Upper Arm	***Lower Arm***	***Wrist***	***Wrist Twist***	***Posture Score***	***Muscle Use Score***	***Load Score***	***Wrist & Arm Score***	
1	Bending Machine	3	3	1	1	4	1	0	5	
2	Wire Tie	2	3	1	1	3	1	0	4	
It	**Job Type**	**Table B**							**RULA *Score***	***Scoring***
		Neck	***Trunk***	***Legs***	***Posture Score***	***Muscle Use Score***	***Load Score***	***Neck, Trunk, Leg Score***		
1	Bending Machine	3	3	1	4	1	0	5	6	*Change Soon*
2	Wire Tie	3	4	2	6	1	0	7	6	*Change Soon*

Table 7 shows the results of processing RULA data before the proposed improvement. It is classified into two types of work: wire tie work and machine work. For the bending machine work, the assessment from Table A shows that the upper arm posture has a score of 3, which indicates that the angle of movement of the arm is large enough or the position does not support the comfort of work. The forearm gets a score of 3, which indicates that there is a position or angle that forces the worker to adopt a less-than-ideal posture, especially when the arm has to be moved a lot horizontally or vertically. The wrist was scored with a 1, which indicates a relatively neutral position. However, the movement of the wrist rotation received a score of 1, indicating light rotational activity but still needing attention—this posture overall results in a score of 4 for the arms and wrists. In addition, a muscle use score of 1 indicates significant muscle tension due to continuous activity without sufficient rest breaks. Meanwhile, a load score of 0 indicates that workers are not carrying additional loads in these activities. When all these factors are added up, the wrist and upper arm score is 5. Furthermore, from Table B, the neck section receives a score of 3, indicating that the neck is often bent during work. The torso receives a score of 3, indicating a tilt or forward bend that needs to be corrected. The feet get a score of 1, meaning the position is relatively stable. This score results in a posture value of 4. Considering a muscle use score of 1 and a weight score of 0, the total score for the neck, torso, and legs becomes 5. The combination of all these

assessments results in a final RULA score of 6, which indicates that corrective action needs to be taken soon.

In the Wire Tie job, the assessment results in Table A show an upper arm score of 2, indicating that the upper arm posture is slightly more neutral than in the Bending Machine work, but there is still a tendency for the working angle to be less than ideal. The forearm receives a score of 3, indicating that the angle between the forearm and wrist is forced or less ergonomic. The wrist receives a score of 1, indicating that the position tends to be neutral, but the wrist twist receives a score of 1, indicating a slight wrist rotation during the activity. Overall, this posture has a total score of 3 for the upper arms and wrists. Coupled with a muscle use score of 1, which indicates the presence of constant muscle activity, and a weight score of 0, the total score for the upper arm and wrist is 4. In Table B, the neck receives a score of 3, indicating that the neck position is often leaning forward or not in a neutral position. The torso receives a score of 4, indicating that the body's position tends to bend or tilt significantly, so it requires special attention. The legs receive a score of 2, indicating that the position of the legs is less stable or does not fully support the body well. The total posture score is 6, indicating considerable tension in this part of the body during work. By adding a muscle use score of 1 and a weight score of 0, the total score for the neck, torso, and legs is 7. Combining all assessment results gives a RULA score of 6, indicating the same great risk as the Bending Machine job. In the Wire Tie job, the assessment results in Table A show an upper arm score of 2, indicating that the upper arm posture is slightly more neutral than in the Bending Machine work, but there is still a tendency for the working angle to be less than ideal. The forearm receives a score of 3, indicating that the angle between the forearm and wrist is forced or less ergonomic. The wrist receives a score of 1, indicating that the position tends to be neutral, but the wrist twist receives a score of 1, indicating a slight wrist rotation during the activity. Overall, this posture has a total score of 3 for the upper arms and wrists. Coupled with a muscle use score of 1, which indicates the presence of constant muscle activity, and a weight score of 0, the total score for the upper arm and wrist is 4. In Table B, the neck receives a score of 3, indicating that the neck position is often leaning forward or not in a neutral position. The torso receives a score of 4, indicating that the body's position tends to bend or tilt significantly, so it requires special attention. The legs receive a score of 2, indicating that the position of the legs is less stable or does not fully support the

body well. The total posture score is 6, indicating considerable tension in this part of the body during work. By adding a muscle use score of 1 and a weight score of 0, the total score for the neck, torso, and legs is 7. Combining all assessment results gives a RULA score of 6, indicating the same great risk as the Bending Machine job.

DISCUSSION

This study aims to evaluate the work system **at** CV Diamond Cabinetware and design ergonomic solutions to reduce the risk of musculoskeletal injuries (MSDs) experienced by workers. Based on the results of the analysis conducted using the Rapid Entire Body Assessment (REBA), Rapid Upper Limb Assessment (RULA), and Nordic Body Map methods, it was found that most workers experienced complaints in various parts of the body, **particularly** in the back, neck, and lower extremities. This high level of complaints **indicates** the presence of **unergonomic work postures** and repetitive activities that have the potential to cause long-term injury. To overcome the problem, this study proposes to improve the work system in the form of **ergonomic chair and table designs** that are adjusted to worker anthropometric data. After the implementation of the design, the **analysis results** showed a significant decrease in REBA and RULA scores, indicating that these changes were effective in reducing the risk of musculoskeletal injury in the workplace. This discussion will review in detail the results of the evaluation of the work system before and after the repair, as well as the impact of ergonomic design on the comfort and health of workers. In addition, the relationship between the findings of this study and the existing literature **on** the application of ergonomics in the manufacturing industry, especially in the small and medium industrial sectors, will also be discussed. It is hoped that these findings can significantly contribute to efforts to improve working conditions and increase overall productivity.

Analysis of the current work system

The wire tie workers at CV Diamond Cabinetware are working in inadequate ergonomic conditions, where they sit cross-legged on the floor without using chairs and tables, so their working posture does not support the health of the body. This position, if done continuously, will increase the risk of Musculoskeletal Disorders (MSDs) due to repeated stress and unergonomic body position. Similar risks are also experienced by machine workers, especially in bending machines that have the highest RULA scores. The chairs used by machine workers are not

ergonomic and are too low in height, so workers have to straighten their legs or fold them in a squatting position to make it more comfortable. In addition, machines cemented in place are higher than seated workers, forcing workers to raise their heads and extend their arms to operate the machine levers, causing pain in the neck, back, and other parts of the body. Working hours that run from Monday to Saturday, from 7:00 a.m. to 5:00 p.m., with breaks of just 30 minutes each day, and the repetitive nature of work to pursue production targets further exacerbate this risk. This study uses a Nordic Body Map questionnaire to identify the parts of the body of workers who experience pain most often, providing a preliminary picture of the posture or activity that causes it. Furthermore, the REBA and RULA methods are used to evaluate ergonomic risk factors and provide improvement recommendations. As a solution, it is recommended that ergonomic chairs and tables be provided for wire tie workers to allow them to work in a more supportive posture. In addition, machine workers, especially in bending machines, also need ergonomic chairs that can be adjusted in height, so that their body position is more parallel to the machine, reducing the load on the neck, shoulders, and back. With this improvement, the risk of musculoskeletal disease can be minimized, thereby supporting workers' health in the long term while increasing work productivity.

Cost Calculation

In this section, a cost analysis is conducted for the production aids designed at CV. Diamond Cabinetware. The cost calculation utilizes a Bill of Materials (BOM) to ensure that material requirements are calculated in detail. This method helps identify components, unit prices, and quantities to produce accurate cost estimates.

CV. Diamond Cabinerware
Bill Of Material, Machine Worker Seat

Part Number	*Dimension*	*Level*	*Description*	*Unit of Measure*	*Decision*	*Unit Price*	*Quantity*	*Total Price*	**Link**
KRS100	-	0	Chair	*Each*	*Make*	-		-	
DDK100	480 x 522 x 30	1	Wooden Plate Stand	*Each*	*Buy*	IDR 110,000	1	IDR 110,000	https://www.tokopedia.com/cileestore/kayu-dudukan-kursi-ukuran-30cm
SDR100	480 x 412 x 30	1	Backrest Wooden Plate	*Each*	*Buy*	IDR 110,000	1	IDR 110,000	https://www.tokopedia.com/cileestore/kayu-dudukan-kursi-ukuran-30cm
KKR100	727 x 583 x 30	1	Wooden Leg Chair	*Each*	*Buy*	IDR 12,000	4	IDR 48,000	https://www.tokopedia.com/woodonlineshop/kaki-kursi-wood?utm_source=google&utm_medium=organic&utm_campaign=pdp-seo
MUR20	Ø20	1	Nut	*Each*	*Buy*	IDR 500	6	IDR 8,000	https://shopee.co.id/product/217985280/21585756321?gads_t_sig=VTJGc2RHVmtYMTlxTFVSVVRrdENkWVp3RFo3Mkw5czd4Z0hzdEF1WVFibDh6Y1pKeGNRbk5Od1pkVnRlbXd4QnlhWVI2UFZXUDJ6dWhOMzFLQkMrV0pYSWl6YjBmUXZkcXNwUklpWmVEdG9VUkZnUEZEK1hPb0NPUjVwMDRMRFA
BUT40	Ø20 x 40	1	Bolt	*Each*	*Buy*	IDR 1,000	16	IDR 16,000	https://shopee.co.id/product/217985280/21585756321?gads_t_sig=VTJGc2RHVmtYMTlxTFVSVVRrdENkWVp3RFo3Mkw5czd4Z0hzdEF1WVFibDh6Y1pKeGNRbk5Od1pkVnRlbXd4QnlhWVI2UFZXUDJ6dWhOMzFLQkMrV0pYSWl6YjBmUXZkcXNwUklpWmVEdG9VUkZnUEZEK1hPb0NPUjVwMDRMRFA

CV. Diamond Cabinerware *Bill Of Material, Machine Worker Seat*									
Part Number	***Dimension***	***Level***	***Description***	***Unit of Measure***	***Decision***	***Unit Price***	***Quantity***	***Total Price***	
KPK100	-	1	Rubber Leg Protector Chair	*Each*	*Buy*	IDR 5,000	4	IDR 20,000	https://www.tokopedia.com/archive-ulldress-1711153619/karet-kursi-chitos-tutup-kaki-pipa-bulat-stainless-bangku-kursi-meja-ter-baru-size-1-2-12mm-7eb2f?aff_unique_id=&channel=others&chain_key=
LKY100	-	2	Wood Glue	*Scale*	*Buy*	IDR 25,000	1	IDR 25,000	*offline*
DWL100	Ø20 x 50	1	Wooden Dowel	*Each*	*Buy*	IDR 1,500	8	IDR 12,000	*offline*
CDK100	-	2	Wood Base Paint	*Scale*	*Buy*	IDR 35,000	1	IDR 35,000	*Offline*
TOTAL								**IDR 384,000**	

CV. Diamond Cabinerware *Bill Of Material , Wire Tie Table Chair*									
Part Number	***Dimension***	***Level***	***Description***	***Unit of Measure***	***Decision***	***Unit Price***	***Quantity***	***Total Price***	**Link**
KMI100	-	0	Wire Tie Table Chair	*Each*	*Make*		1		
DDK100	872 x 682 x 670	1	Chair Table Frame	*Each*	*Make*	IDR 273,000	1	IDR 273,000	https://www.tokopedia.com/wgarage/rangka-besi-kursi-atau-meja
SDR100	812 x 453	1	Table Leaf	*Each*	*Make*	IDR 34,000	1	IDR 34,000	https://www.tokopedia.com/pkadijaya/papan-ambalan-kayu-mahoni-2cm-x25cm-x40cm-de268?extParam=ivf%3Dtrue%26keyword%3Dpapan+kayu+kursi&src=topads
KKR100	40 x 40	1	Leaf Chair	*Each*	*Make*	IDR 110,000	1	IDR 110,000	https://www.tokopedia.com/cileestore/kayu-dudukan-kursi-ukuran-30cm
MURM8	Ø20	1	Nut	*Each*	*Buy*	IDR 500	12	IDR 6,000	https://shopee.co.id/product/217985280/21585756321?gads_t_sig=VTJGc2RHVmtYMTlxTFVSVVRrdENkWVp3RFo3Mkw5czd4Z0hzdEF1WVFibDh6Y1pKeGNRbk5Od1pkVnRlbXd4QnlhWVI2UFZXUDJ6dWhOMzFLQkMrV0pYSWl6YjBmUXZkcXNwUklpWmVEdG9VUkZnUEZEK1hPb0NPUjVwMDRMRFA
BUTM8	Ø20 x 40	1	Bolt	*Each*	*Buy*	IDR 1,000	12	IDR 12,000	https://shopee.co.id/product/217985280/21585756321?gads_t_sig=VTJGc2RHVmtYMTlxTFVSVVRrdENkWVp3RFo3Mkw5czd4Z0hzdEF1WVFibDh6Y1pKeGNRbk5Od1pkVnRlbXd4QnlhWVI2UFZXUDJ6dWhOMzFLQkMrV0pYSWl6YjBmUXZkcXNwUklpWmVEdG9VUkZnUEZEK1hPb0NPUjVwMDRMRFA
BRK100	L 40x40mm	1	Bracket	*Each*	*Buy*	IDR 5,000	4	IDR 20,000	*offline*
CDB100	-	2	Iron Base Paint	*Scale*	*Buy*	IDR 50,000	1	IDR 50,000	*offline*
CDK100	-	2	Wood Base Paint	*Scale*	*Buy*	IDR 35,000	1	IDR 35,000	*offline*
TOTAL								**IDR 560,000**	

The cost of manufacturing a machine worker chair is calculated based on components such as the stand, backrest, chair legs, and more. The total material cost for one unit of the chair is IDR 384,000. The wire tie table includes table frames, table leaves, nuts, bolts, and base paint, with a total material cost of IDR 560,000. The company assembles all materials after purchase. The cost calculation is based on evaluating the material requirements for each designed aid. This data was used to assess the efficiency of the design in reducing ergonomic risks, such as musculoskeletal injuries to workers. Evaluations are carried out to ensure that assistive devices can meet workers' ergonomic needs in a cost-effective manner.

CONCLUSION

Based on the initial evaluation of the work system carried out on CV Diamond Cabinetware using the Nordic Body Map and RULA methods, the risk of MSDs in the RULA assessment of machine operators and wire tie employees is still in the "change soon" category, so improvements are needed. The results of the draft proposal to improve the work system were presented to the employees who tie wires, in the form of chairs and tables, while for machine employees, especially those operating bending machines, the proposal was in the form of chair designs. After a re-evaluation using the RULA method, it was found that the draft improvement proposal for both machine operators and wire tie employees initially had a RULA score of 6 ("change soon"). After designing the improvement proposal, the score was reduced to 2 (acceptable posture) for machine operators and 3 ("change may be needed") for wire tie employees. This is effective in reducing the risk of MSD injuries to workers. With significant improvements in working posture, this chair design can improve worker comfort and productivity.

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