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Analysis of Work Posture and Improvement of Worker Activities at a Four-Wheeled Vehicle Lighting Company

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A B S T R A C T

PMG, Ltd is a company that manufactures and subcontracts for car lighting companies.The problem on the automobile lamp factory floor is that workers do repetitive operations and lifting loads manually without using tools. The goal of this research is to determine the risk level of work posture and provide recommendations for improvements to four-wheeled vehicle lighting component companies. The methods used to assess operator working posture are the Nordic Body Map (NBM), Quick Exposure Check (QEC) and Ovako Working Posture Analysis System (OWAS) questionnaires. Based on the results of the NBM questionnaire, Musculoskeletal Disorder (MSD) symptoms were found on the neck, back, hands and feet. The score for the QEC method is 65.43%, which means further research and changes are needed, and the OWAS method is in category 2, which means that corrective action is needed in the near future. Improvements in working posture were carried out by redesigning the work table according to anthropometric ergonomics principles and reducing the flow of stages in the lamp production process from 11 steps to 8 work steps.

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1. INTRODUCTION

Shop-floor workers often have repetitive jobs, increasingly complex job demands, taking the same position for long periods, awkward posture, lifting excess weight, lack of knowledge, and limitations of workers cause workers not to pay attention to their body posture while working (Ogedengbe et al., 2022). Inadequate and unergonomic work equipment and facilities can result in the emergence of occupational diseases (Giovanni et al., 2023; Nino et al., 2023; Teixeira et al., 2022).

One of these activities is moving goods, as in this study case, where the operator moved materials manually without tools. Bending lifting activities caused by too heavy a load can cause spinal injuries or musculoskeletal Disorder and other muscle disorders (Finco et al., 2023). Apart from that, goods moving activities must also be paid attention to improve occupational health and safety (Ogedengbe et al., 2022). Several studies related to work posture analysis in automotive companies in Malaysia have shown that workers are required

to carry out repetitive manual operations such as automation, semi-automation, and repetitive manual activities in spare parts production (Gan et al., 2024). In addition, surveys regarding Musculoskeletal Disorder (MSD) among students who spend time using smartphones using the Rapid Upper Limb Assessment (RULA) method and ergonomic assessment. The results of the RULA score for using a smartphone in a lying position at night have a RULA score of 6, which means the posture is at risk of MSD and must be changed (Gorce & Jacquier-Bret, 2023).

The following research compared the Ovako Working Posture Analysis System (OWAS), RULA, and Rapid Entire Body Assessment (REBA) methods with 209 cases of upper-body musculoskeletal disorders (MSDs) diagnosed by medical doctors (Kee, 2021) and the study to measure the maximum holding times (MHTs) for symmetric and asymmetric body postures and to compare three representative observational methods (Kee et al., 2020). Next, work posture analysis is used using the Quick Exposure Check (QEC) method of 51 work tasks performed by 14 workers (Oliv et al., 2019). This research aims to determine the risk level of work posture and provide recommendations for improvements to four-wheeled vehicle lighting component companies.

2. LITERATURE REVIEW

The Nordic Body Map (NBM) determines workers complaints of MSD. MSD complaints will be identified using a questionnaire in the form of several types of MSD complaints on a human body map (Wang et al., 2021). Through this questionnaire, it can be find out which part of the muscle is experiencing complaints, with complaints ranging from no, somewhat painful, painful, and very painful. NBM results can estimate the type and level of complaints, fatigue, and pain in muscle parts felt by workers by looking at and analyzing body maps taken from filling out the NBM questionnaire, ranging from discomfort to very painful. Respondents were asked to assess the part of their body that felt sick during work activities according to a predetermined Likert scale. Then, the respondent fills in the NBM questionnaire form; the respondent ticks which parts of the body the respondent feels sick with according to the level of complaint (Kee, 2021).

QEC is a method of measuring posture load. QEC assesses four areas of the body, including the back, arms, wrists, and neck, which are exposed to the highest risk of work musculoskeletal disorders (WMSDs) in operators (Atuna & Safirin, 2023; Oliv et al., 2019). The action level in the QEC method is if the total exposure level is <40% then treatment is safe, 40 to 49% need further research, 50 to 69% need further research and changes, and ≥ 70% need research and changes as soon as possible. The formula for calculating exposure level is:

$$E\% = \frac{X}{X\,max} \times 100\% \quad (1)$$

The classification of working postures from the OWAS method is based on the movement of the back, arms, legs, and weight. Each body posture consists of four back postures, three arm postures, and seven leg postures. The weight of the load lifted is also assessed by dividing it into three scales. The work posture score is calculated using the OWAS table. Furthermore, the OWAS score is categorized as follows: Category 1: Improvements are not needed, Category 2: Improvements are needed in the long term, Category 3: Improvements are needed as soon as possible, and Category 4: Applying improvements now (Wahyudi et al., 2015).

Anthropometry can be stated as a study related to measuring the dimensions of the human body. Humans will have shapes, sizes, weights, and so on, which are different from one another. Anthropometrics will be widely used as ergonomic considerations in the design process of products and work systems that will require human interaction (Imansuri, 2019; Imansuri et al., 2021; Saptaputra et al., 2021; Sumasto et al., 2022).

3. RESEARCH METHOD

3.1 Job Description

PMG, Ltd is a company engaged in manufacturing and subcontracting for car lamp companies. This company employs 1 operator to produce car lights with 7 working hours per

day. The production flow for four-wheeled vehicle lights can be seen in Table 1.

Table 1. The current production flow for four-wheeled vehicle lights

Row	Production Flow	
1	Take one plastic box as a wedge base socket container.	
2	Prepare a small box to put the wedge base socket, copper contacts and rubber gaskets.	
3	Take copper contacts.	
4	Take the wedge base socket.	
5	Take out the rubber gasket.	
6	Take one sheet of mica plastic to the work table.	
7	Prepare polyboxes as containers for finished products.	

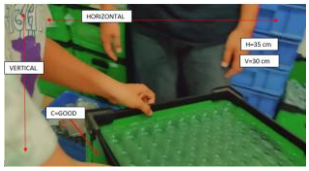
8	Carry out the insert process.	
9	Carry out the process of pressing the wedge base socket.	
10	Carry out the process of installing the rubber gasket on the wedge base socket.	
11	Move the polybox, which is already filled with 300 wedge bases.	

Figure 1 shows the current layout of the production floor at PMG, Ltd.

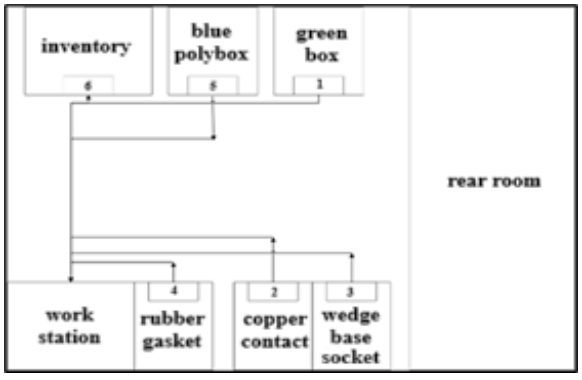


Figure 1. Production floor

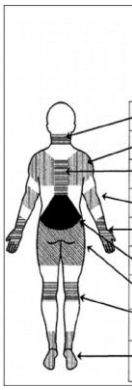
Below in Figure 2, the operator's position while assembling the lights for a four-wheeled vehicle is with a standing working posture, and the angle formed by the bent neck is 53.5^0, and the angle formed by the arm is 74^0.

Figure 2. Body posture of the operator while working

3.2 Method Assessment

The methods used to identify MSD in work postures are NBM, QEC, and OWAS. These methods are combined to solve the MSD problem. The NBM used to identify work posture is shown in Figure 3. The results of the

NBM questionnaire which is determined based on the level of complaints felt by workers. Based on the results of filling out the NBM questionnaire, it was found that with this working posture, the operator experienced aches in the neck, hands, and knees in the last 12 months with a score scale of 2 out of 10 and did not receive treatment for these complaints. The anthropometric data of the worker is a 20-year-old male with a height of 165 cm and a weight of 60 kg.

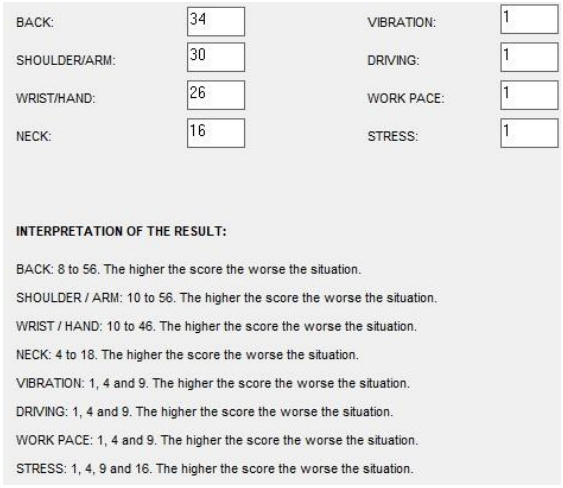


	Have you at any time during the last 12 months had trouble (such as ache, pain, discomfort, numbness) in:	During the last 12 months have you been prevented from carrying out normal activities (e.g. job, housework, hobbies) because of this trouble in:	During the last 12 months have you seen a physician for this condition:	During the last 7 days have you had trouble in:
NECK	☐ No ☑ Yes	☑ No ☐ Yes	☑ No ☐ Yes	☑ No ☐ Yes
SHOULDERS	☑ No ☐ Yes	☑ No ☐ Yes	☑ No ☐ Yes	☑ No ☐ Yes
UPPER BACK	☑ No ☐ Yes	☑ No ☐ Yes	☑ No ☐ Yes	☑ No ☐ Yes
ELBOWS	☑ No ☐ Yes	☑ No ☐ Yes	☑ No ☐ Yes	☑ No ☐ Yes
WRISTS/ HANDS	☐ No ☑ Yes	☑ No ☐ Yes	☑ No ☐ Yes	☑ No ☐ Yes
LOWER BACK	☑ No ☐ Yes	☑ No ☐ Yes	☑ No ☐ Yes	☑ No ☐ Yes
HIPS/ THIGHS	☑ No ☐ Yes	☑ No ☐ Yes	☑ No ☐ Yes	☑ No ☐ Yes
KNEES	☐ No ☑ Yes	☑ No ☐ Yes	☑ No ☐ Yes	☑ No ☐ Yes
ANKLES/ FEET	☑ No ☐ Yes	☑ No ☐ Yes	☑ No ☐ Yes	☑ No ☐ Yes

Part fo Body	If you have ever experienced problems (pain, discomfort) in this part of your body, please rate the pain you felt.	When you experience problems (pain, discomfort) in this part of your body, do you see a doctor?
neck	0 1 **2** 3 4 5 6 7 8 9 10	**Never** Yes
shoulder	0 1 **2** 3 4 5 6 7 8 9 10	**Never** Yes
upper back	**0** 1 2 3 4 5 6 7 8 9 10	**Never** Yes
elbow	**0** 1 2 3 4 5 6 7 8 9 10	**Never** Yes
lower back	**0** 1 2 3 4 5 6 7 8 9 10	**Never** Yes
wrist	0 1 **2** 3 4 5 6 7 8 9 10	**Never** Yes
buttocks	**0** 1 2 3 4 5 6 7 8 9 10	**Never** Yes
knee	0 1 **2** 3 4 5 6 7 8 9 10	**Never** Yes
ankle	**0** 1 2 3 4 5 6 7 8 9 10	**Never** Yes

Figure 3. Nordic body map questionnaire

Work posture analysis using the QEC method was carried out using Ergofellow software in Figure 4.



BACK:	34	VIBRATION:	1
SHOULDER/ARM:	30	DRIVING:	1
WRIST/HAND:	26	WORK PACE:	1
NECK:	16	STRESS:	1

INTERPRETATION OF THE RESULT:

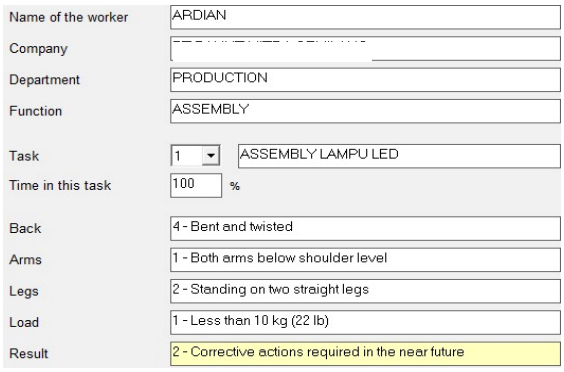
BACK: 8 to 56. The higher the score the worse the situation.
SHOULDER / ARM: 10 to 56. The higher the score the worse the situation.
WRIST / HAND: 10 to 46. The higher the score the worse the situation.
NECK: 4 to 18. The higher the score the worse the situation.
VIBRATION: 1, 4 and 9. The higher the score the worse the situation.
DRIVING: 1, 4 and 9. The higher the score the worse the situation.
WORK PACE: 1, 4 and 9. The higher the score the worse the situation.
STRESS: 1, 4, 9 and 16. The higher the score the worse the situation.

Figure 4. QEC result

Calculation of action level values using formula (1):

$$E(\%)=\frac{106}{162}\times 100\%=65.43\%$$

So, we got a total exposure score of 106 and an action value of 65.43%, which means further research and changes are needed. Work posture analysis using the OWAS method was carried out using ergofellow software in Figure 5.



Name of the worker	ARDIAN
Company	
Department	PRODUCTION
Function	ASSEMBLY
Task	1 ASSEMBLY LAMPU LED
Time in this task	100 %
Back	4 - Bent and twisted
Arms	1 - Both arms below shoulder level
Legs	2 - Standing on two straight legs
Load	1 - Less than 10 kg (22 lb)
Result	2 - Corrective actions required in the near future

Figure 5. OWAS Result

According to the findings of the work posture analysis using the OWAS method, a score was obtained in category 2, which means that corrective action is needed in the near future. Based on a combination of several methods, it can be concluded that the Based on the results of the work posture. Analysis using the OWAS method, a score was obtained in category 2, which means that corrective action is needed in the near future. Based on a combination of several methods, it can be concluded that the

following parts of the human body experience complaints of pain due to body posture when working, including: (a) Bent or twisted neck posture, (b) Bent or twisted back posture, (c) shoulder/arm movement are frequent and the position at about chest height, (d) Standing on two straight legs.

4. RESULT AND DISCUSSION

4.1 Problem Obtained

Based on the results of filling out the NBM questionnaire, the operator experienced pain in the neck, hands and knees in the last 12 months. Pain in the neck with a score of 2, pain in the shoulder with a score of 2, pain in the wrist with a score of 2, soreness in the knee with a score of 2 and deep pain has not been examined by a doctor for this pain.

According to the findings of calculations using Ergofellow software for work posture analysis using the QEC method, a total exposure score of 106 was obtained and an action value of 65.43%, which means that the action that must be taken is the need for further research and making changes to the work process. In addition, based on the results of the analysis of work posture using Ergofellow software for the OWAS method, the results obtained were for category 2, which means that this posture is dangerous for the musculoskeletal system (work posture causes significant tension effects). Hence, it needs improvement in the near future.

4.2 Solution Based on Analysis Work Posture Method

After analyzing work posture using the QEC and OWAS methods, the results showed that all methods suggested changing the existing work posture. Apart from that, based on the results of the NBM questionnaire, there was pain felt by the operator, namely in the neck, shoulders, wrists, and knees, which felt sore. Improvements to work posture are made by providing recommendations for redesigning the operator's work desk (Anacleto Filho et al., 2023).

Redesign changes to the table with the aim of making the product assembly process more ergonomic. Redesign the work desk by eliminating the bent neck posture when carrying out the work process, and when placing the poly box, it is not bent because the poly box is placed on the work desk. Apart from that, the new work desk design can be adjusted in height according to the operator's comfort, and when the table part for placing the poly box is not in use, the table part can be folded so that it does not take up space at the workstation. The redesign of the table uses anthropometric data from Indonesians, male with an age range of 20 to 22 years. The selection of the 50th percentile is based on consideration of the average human body size so that it meets the comfort aspect. Anthropometric data used in the design can be seen in Table 2.

Table 2. Anthropometric data

Row	Purpose of data use	Anthropometric Data	Percentile 50^{th} (cm)	Allowance (cm)
1	Table height	Hip height	98.91	1
2	Table width	Reach your arms forward	77.89	2

(Source: antropometriindonesia.org)

The use of anthropometric data in design aims to ensure that the redesigned table has size specifications according to the dimensions of the human body . So that when working, the operator's neck does not bend too much because the height of the table is by anthropometric data, and the table's width is by the maximum reach of the operator's hand. By using the new table design, the production flow for four-wheeled vehicle lights will be shorter than before (from 11 steps to 8 steps, see Table 1) with details of the new production flow as follows: (1) Take one plastic box as a wedge base socket container. (2) Prepare a small box filled with a wedge base socket, copper contacts, and rubber gaskets taken from the poly box on the work desk. (3) Take one sheet of mica plastic to the work desk. (4) Prepare poly boxes as containers for finished products. (5) Carry out the insert process. (6) Carry out the process of pressing the wedge base socket. (7)

Carry out installing the rubber gasket on the wedge base socket. (8) Move the poly box, which is already filled with 300 wedge bases. In Figure 6 is a work table redesign drawn using Autodesk Inventor software. The budget plan for making a new table prototype can be seen in Table 3 with an amount of IDR 1,529,550.

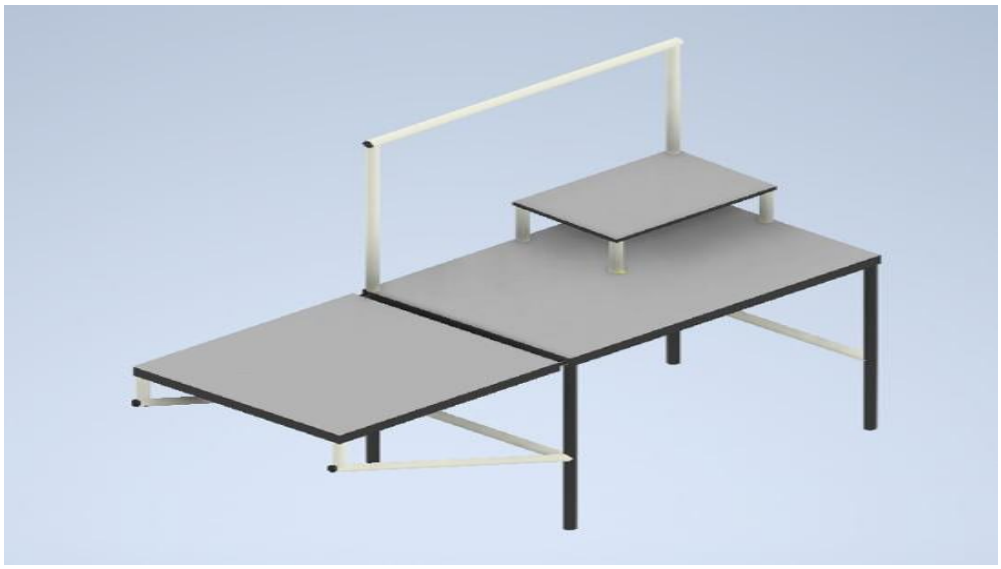


Figure 6. Table design in 3D

Table 3. Budget Plan

Row	Raw Material	Jnit Price (IDR)	Quantity	Estimate Price (IDR)
1	Pipa Adjustable	125,000	4	500,000
2	Fitting L	3,230	2	6,460
3	Fitting 3	4,810	9	43,290
4	Fitting 4	12,900	2	25,800
5	Plat Plastik PVC	670,000	1	670,000
6	Type of Paralon Pipe: – Paralon diameter 4x120 cm – Paralon diameter 4x80 cm – Paralon diameter 4x15 cm – Paralon diameter 4x18 cm – Paralon diameter 4x20 cm – Paralon diameter 4x95 cm – Paralon diameter 4x40 cm – Paralon diameter 4x85 cm	71,000	13.46 4.8 3.2 0.3 0.36 0.4 1.9 0.8 1.7	284,000
	Total			IDR 1,529,550

4. CONCLUSION

After analyzing and processing the data, this research aims to determine the risk level of work posture and provide recommendations for improvements to four-wheeled vehicle lighting component companies. So it was found that based on the analysis of work posture, there were symptoms of MSD on the operator's neck, back, hands, and feet (NBM questionnaire results). The cause, based on the results of work posture analysis using the OWAS and QEC methods, is fatigue due to the unergonomic size

of the work table and the activity of bending and walking when picking up copper contacts, wedge base socket, and rubber gasket materials to be placed on the work table. Because of this, the improvements were to redesign the work table by adjusting it to the operator's anthropometric size and placing a poly box of raw materials on the table so that the operator did not have to bend and walk to pick up raw materials. With this improvement, the production flow for lamps for four-wheeled vehicles can be reduced from 11 steps to 8 steps. Further research can be carried out by developing a workbench design using an operator experience approach using kansei engineering. Kansei engineering is a method for designing a holistic set of experience requirements into product service system design. Further research can be carried out by calculating the product cycle time and production capacity achieved before and after improvement.

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