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RISK ANALYSIS OF INJURY AND WORKING PRESSURE USING LAMP REPLACEMENT TOOLS

Hari Purnomo[1], Erniyani[2], Fikrihadi Kurnia[3], Ahmad Padhil[4]

[1,2] Department of Industrial Engineering, Faculty of Industrial Engineering, Islamic University of Indonesia
[3] Department of Industrial Engineering, Faculty of Engineering, Proclamation University 45
[4] Department of Industrial Engineering, Faculty of Industrial Engineering, Moslem University of Indonesian
Jl. Kaliurang Km. 14,5 Sleman, Yogyakarta 55584
E-mail: haripurnomo@uii.ac.id, 18916109@students.uii.ac.id

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ABSTRACT

Lamp replacement is a work activity that is carried out manually using a chair or using a lamp replacement tool. The tool used to replace the lamp is deemed ineffective, which can lead to musculoskeletal complaints. Therefore it is necessary to redesign the replacement lamp to suit the needs of the user. The product proposed for lamp replacement design will be compared with existing tools to measure the level of work speed and stress. The analysis used to measure the level of work speed and stress is the Quick Exposure Check (QEC). The results showed that the percentage of exposure level for the old lamp replacement tool was 41% -59% so that further investigation was needed by redesigning the lamp replacement tool. Thus the use of replacement tools for old lamps when used is ineffective. The exposure level for a new lamp replacement is in the range of 20% -35%, meaning that it is accepted and recommended for use. In this case, the proposed lamp replacement tool is quite effective to use.

Keywords: (Lamp replacement device, Quick Exposure Check, musculoskeletal disorder, Effective, Ergonomic.)

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Universitas Muslim Indonesia
Address :
Jl. UripSumoharjo Km. 5 (Kampus II UMI)
Makassar Sulawesi Selatan.
Email :
Jiem@umi.ac.id
Phone :
+6281341717729
+6281247526640

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1. Introduction

Lights are the most important part of everyday life as a supporter of lighting (Mochtiarsa, 2016; Fatahilah et al. 2019). Lighting affects human activities and energy-efficient lighting technology is currently developing (Gerhardsson et al. 2019). Energy-saving lamps help reduce PLN's electricity costs at home (Novelan & Nababan, 2019). Light Emitting Diode (LED) is a type of energy-saving lamp that can reduce energy by 80%. Besides that, LEDs are environmentally friendly lamps compared to Compact Fluorescent Lamps (CFL) which have energy-saving incandescent capabilities and can save energy by 75% (Lathifah & Widyastuti, 2018). LED is growing very rapidly in Indonesia and the use of LED growth is around 500 million units in 2013-2014 (Revantino et al. 2018).

The growth in the use of lamps results in damage or expiration of use, so it is necessary to replace new lamps. Lamp installation is usually done manually, such as using a chair and using a lamp replacement tool (Prakoso & Tontowi, 2010). The process of changing the lamp using a chair is very dangerous which can result in a fall. Meanwhile, changing the lamp using a complicated, not strong, and less ergonomic tool will result in musculoskeletal complaints and work pressure. Musculoskeletal complaints about workers result from a rigid work attitude, repetitive movements, overwork, and local mechanical stress (Karimi et al. 2020). One of the methods used to assess the risk of injury is QEC (Ibrahim et al. 2020). With this method, it can be used as a reference for designing a lamp replacement device based on the complaints experienced by users.

Research related to the design of a lamp replacement tool was carried out by Prakoso & Tontowi, (2010). The results showed that the respondents had a high level of satisfaction with the ease of use of tools and their weaknesses when tightening small lamps with slippery handles. Based on the above problems, a lamp replacement tool was reviewed using QEC. The choice of this method is due to its ease of use and comprehensiveness. Several studies related to the QEC method have been carried out. Research by Hassanvand et al. (2018) evaluated the risk factors for musculoskeletal disorders for oil refinery workers. Some workers show a high prevalence of musculoskeletal disorders in the lumbar region. Meanwhile, Ramasamy et al. (2017) on an evaluation of musculoskeletal disorders associated with motorcyclists. Research on the inconvenience of using a lamp replacement tool using QEC has never been conducted. Therefore, in this study, an analysis of the inconvenience of using a light bulb replacement tool will be carried out. The results of the study are used as the basis for designing a new replacement device.

2. Research Methods

2.1. Research Subject and Object

The research subjects were users of light bulb replacement equipment in the Parippung area of Bone Regency, South Sulawesi with the following inclusion criteria: (1) productive age 20-45 years; (2) are male; (3) in a healthy physical and spiritual

condition. While the object of research is a lamp replacement tool. This study aims to determine the work posture when changing lamps and the level of risk of injury experienced by users.

2.2. Method of Collecting Data

Data collection was carried out through interviews and observations. Interviews were conducted to determine gender, age, and height. While the direct observation of respondents by observing body posture and assessing the level of ergonomic risk using QEC consists of observer questionnaires and respondent questionnaires. The observer questionnaire is filled in based on the respondent's condition when replacing the light bulb which includes: (1) Back posture; (2) back movement; (3) Position and movement of the shoulders/arms; (4) position and movement of the wrist or hand; and (5) neck posture. Furthermore, filling out the respondent's questionnaire from several available questions. The assessment of lamp replacement equipment includes: (1) maximum weight; (2) long time to replace the lamp; (3) the level of strength used by the hand; (4) requires sight; (5) Difficulty replacing lamps; (6) stress levels in changing lamps. The QEC assessment is shown in Figure 1.

Figure 1. QEC Assessment

2.3 Data Analysis

The analysis was carried out from the results of the questionnaire that had been filled in by observers and respondents. The scoring concept is used to analyze the level of risk exposure to musculoskeletal complaints experienced by users. Scoring is done by combining and comparing the results of the questionnaire by observers and respondents to the level of risk exposure. Result
scoring is used to calculate the exposure level to determine the action taken. If the exposure level results are high, then evaluation and improvement will be carried out.

The formula for calculating the exposure level is as follows (Sari et al. 2017):

$$E(\%) = \frac{X}{Xmax} \times 100\%$$

Where

X : The total score of exposure to the risk of back, shoulder/arm, wrist, and neck injuries was obtained from the questionnaire calculation.

Xmax : The maximum total possible score for exposure to the back, shoulders/arms, wrists, and neck.

3. Analysis and Discussion

3.1 Product Identification

This study focuses on identifying musculoskeletal complaints in the process of changing the ceiling lamp. This process uses assistive media that have been widely sold in the market and proposed products. The old and new products are shown in Figures 2 and 3.

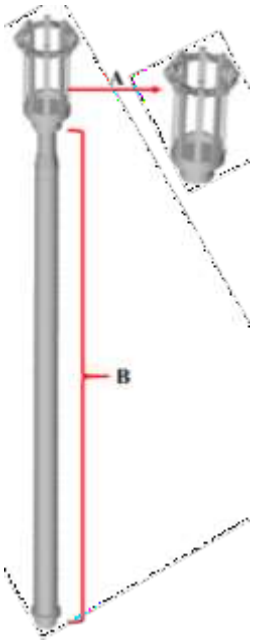
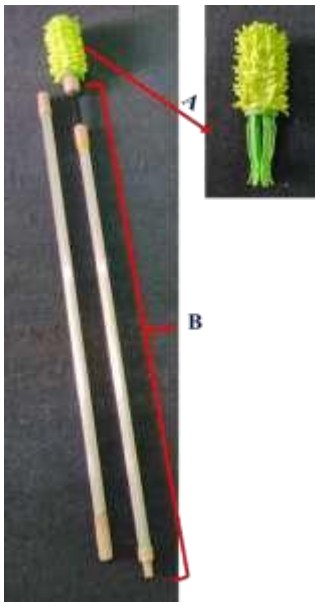


Figure 2. Replacement tool for old lamps



Figures 3. Replacement tools for the proposed lamp

Description: A = head / lamp holder; B = handle / rod

In general, the form of replacement for old and new lamps has different forms and functions. The comparison between old and new products is shown in Table 1:

Table 1. Comparison of new and old lamp replacement tools

No	Replacement for the old lamp	Replacement for the new lamp
Procedure		
1	Adjust the short length of the stick by the way the stick is pulled.	Adjust the short length of the stick by loading and unloading the stick and can be adjusted according to the ceiling height.
2	The stick is turned manually when changing the lamp.	The modular handle is rotated to replace the lamp by turning the handle located on the bottom of the wand
Differences in shape		
3	Has no ceiling cleaner	Has removable ceiling cleaner
4	Length can only be set from 1.5 meters to 2-meter	Length can be set from 1 meter to 3 meters.
5	Only used for reaching vertically	Can be used for reaching vertically and horizontally

Differences in shape

3.2. QEC (Quick Exposure Check) Analysis

The measurement of the risk of injury was carried out using the QEC method. The data collection activities were carried out with the following procedure: (1) Respondents

consisted of 10 men. Respondents work using a replacement tool for old lamps, followed by respondents working using a replacement tool for new lamps. One day replacement hose for old and new lamps; and (2) Respondents are assigned to replace light bulbs using old and new tools. Each respondent is given a maximum time of 10 minutes. In the QEC analysis, a three-part matrix of the body was carried out, namely the back, shoulders/arms, and wrists with load and duration. While one part of the body is the neck with duration and complaints visual. The results on four parts of the body are then used to find the percentage exposure level. Filling in the questionnaire with variable work speed and stress is used as a medium to determine the level of work pressure.

Recapitulation of the results of data collection of respondents to the QEC questionnaire as follows:

Table 2. Results of QEC recapitulation on old lamp replacement tools

Respondents	Back	Shoulder / Arm	Wrist	Neck	Total	E%	Measures
Respondent 1	20	28	30	16	94	58.02	Further investigation & change immediately
Respondent 2	24	30	32	10	96	59.26	Further investigation & change immediately
Respondent 3	10	22	30	14	76	46.91	Further investigation
Respondent 4	14	28	22	12	76	46.91	Further investigation
Respondent 5	10	26	28	8	72	44.44	Further investigation
Respondent 6	20	28	24	18	90	55.56	Further investigation & change immediately
Respondent 7	10	22	24	12	68	41.98	Further investigation
Respondent 8	24	36	36	14	110	67.90	Further investigation & change immediately
Respondent 9	16	28	30	16	90	55.56	Further investigation & change immediately
Respondent 10	18	20	18	18	74	45.68	Further investigation

Based on Table 2, it is known that the activity of replacing lamps using an old lamp replacement tool has an exposure level of 41% - 59%. In this case, it shows a high level of risk of injury to the back, shoulders/arms, wrists, and neck, so it is advisable to do improvement activities in the form of further investigations and change the design. The investigation aims to observe the most likely causes of complaints to occur. This investigation can be seen in the highest score of the complaints matrix of the respondent's body section. The next action is to

change the movement, posture, and design of the tools used. Based on these results, it can be seen that the activity of replacing the lamp using an old lamp replacement tool is not effective. Therefore, a new lamp replacement tool was repaired with the results of the QEC recapitulation shown in Table 3.

Table 3.QEC recapitulation results on a new lamp replacement tool

Respondents	Back	Shoulder / Arm	Wrist	Neck	Total	E%	Measures
Respondents 1	8	12	10	4	34	20.99	Accepted
Respondents 2	10	10	12	6	38	23.46	Accepted
Respondents 3	8	10	20	6	44	27.16	Accepted
Respondents 4	14	18	18	6	56	34.57	Accepted
Respondents 5	10	18	16	6	50	30.86	Accepted
Respondents 6	8	10	20	8	46	28.40	Accepted
Respondents 7	8	18	14	6	46	28.40	Accepted
Respondents 8	12	18	18	10	58	35.80	Accepted
Respondents 9	10	14	16	6	46	28.40	Accepted
Respondents 10	10	12	10	2	34	20.99	Accepted

In Table 3, it is known that the activity of replacing lamps using a new lamp replacement tool is at an exposure level between 20% -35%. This shows that changing the lamp using a new lamp replacement tool is accepted, with a low risk of injury to the back, shoulders/arms, wrists, and neck.

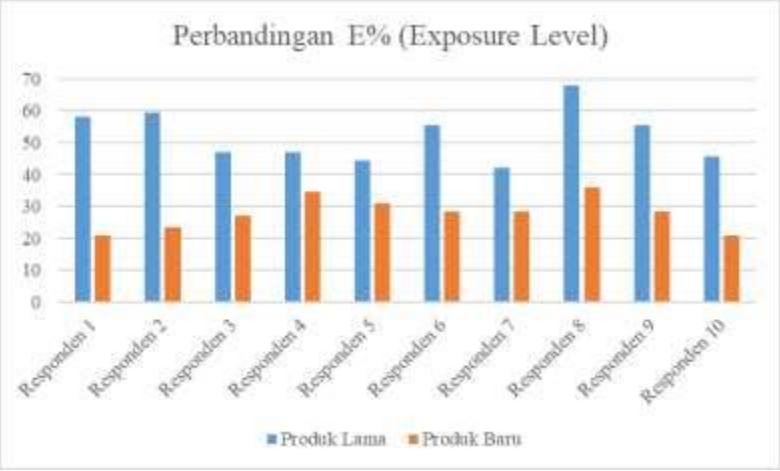


Figure 4. Comparison of the product's E% (Exposure Level)

The level of complaints on the QEC scale, namely, the larger the scale, the slower work speed), and the work stress on a scale of 1-4-9-16 (the larger the scale, the higher the stress level). The working pressure level using the old and new lamp cutlery is shown in Figures 5 and 6.

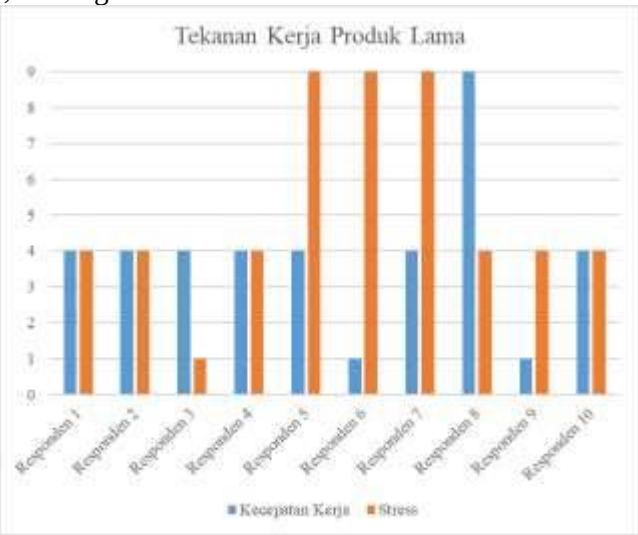


Figure 5. The level of working pressure using an old lamp usage tool

Figure 5, shows that the use of old lamp employees has a fairly high level of working pressure. The results showed that there were problems with the use of old lamp cutlery. Identify the level of work pressure as follows:

a. In response to the level of work speed, a scale with a representation of 3 scores is used, namely, 1 (fast working time), 4 (normal working time), and 9 (slow working time). Respondent 8 did the slow work time, while respondents 6 and 9 did the work fast enough. Respondents 1, 2, 3, 4, 5, 7, and 10 do their normal work.

b. At the level of work stress, 4 scores were used, namely, 1 (no stress), 4 (temporary stress), 9 (long perceived stress), and 16 (very high stress). Stress shows the level of difficulty when using light labor which has an impact on the user's psychological. The stress level shows that the high work stress by respondents 5, 6, and 7. The respondents with low / no stress levels are 3, while the rest (1, 2, 4, 8, 9,10) experience the level of perceived stress. only temporary.

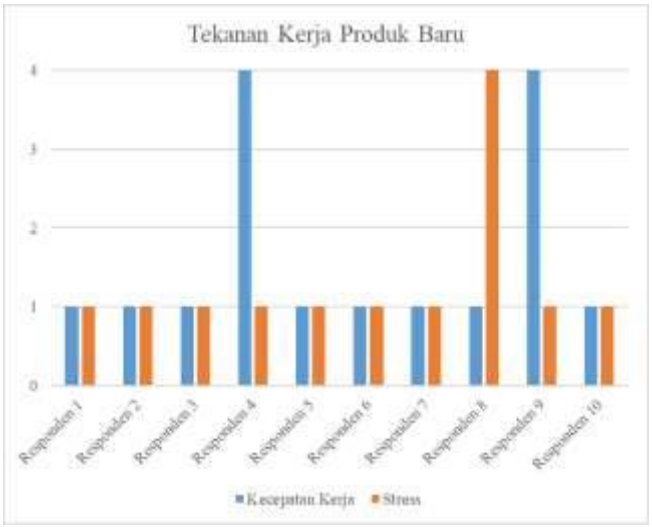


Figure 6. Level of working pressure when removing a new lamp

Figure 6 shows that the use of a new lamp replacement tool has a low working pressure level. The results show that there are no problems with the use of a new lamp replacement tool. The identification of the level of working pressure is described as follows:

a. In the identification of the level of work speed, a scale with 3 score representations is used, namely, 1 (fast working time), 4 (normal working time), and 9 (slow working time). The normal level of working time is done by respondents 4 and 9. Respondents 1, 2, 3, 5, 6, 7, 8, 10, and 10 do work that is fairly fast in completion
b. In identifying the level of work stress, 4 scores are used, namely, 1 (no stress), 4 (temporary stress), 9 (prolonged stress), and 16 (very high-stress level). Stress shows the level of difficulty when using a replacement lamp which has an impact on the user's psychological. The level of work stress shows that, while working stress is experienced by respondent 8, others do not experience stress when using a new lamp replacement tool.

The results above explain that the working pressure level of using an old lamp replacement tool is higher than the new one. In this case, it is more difficult for users to use old lamp replacement tools so that it is directly proportional to the level of complaints experienced.

3.1 Validation of Results

The validation of the results aims to identify the success rate of the proposed lamp replacement tool. This is done by comparing the level of complaints experienced between the old lamp replacement tool and the new lamp replacement tool. Furthermore, a different test is carried out to determine the difference between the old lamp replacement tool and the new one. Different tests using the Wilcoxon Signed Rank Test. There are seven functions used as attributes in testing. The different test results are shown in Table 4.

Table 4 Results of the Wilcoxon signed-rank test

Attribute	p-Value
The grip is not easy to damage the lamp	0,010
Light and strong stick	0,000
The stick is comfortable in the hand	0,001
Easy to use tool	0,012
The stick can reach every corner	0,018
Multifunctional tool	0,034
durable product	0,027

The test results show that all the attributes of the hypothesis H1 are accepted with a p-value smaller than 0.05, which means that there is a significant difference between the old and new lamp replacement tools. The results of different tests are then related to the results of the level of complaints experienced by users when using a lamp replacement tool. In the previous complaint level test, it was found that the complaint rate for the old lamp replacement tool was higher than that for the new lamp replacement tool. With this it can be concluded that the new lamp replacement tool is more effective and productive than the old lamp replacement tool. These results are supported by several studies which state that manual work can generally have an impact on health complaints (Sado et al., 2019; Svendsen et al., 2020). Besides, activities that involve body movements with an impactful lifting posture can overload certain parts of the body which cause local complaints (Yang et al., 2020; Al-Qaisi et al., 2020). Therefore, an improvement in the design of the old bulb replacement tool was made to reduce the level of complaints. New light bulb replacement device, the design is based on identifying the cause of the complaint. Sado et al., (2019) also emphasized that overcoming health complaints requires identifying the causes of these complaints. The identification results are used as the basis for designing effective and ergonomic tools in helping work activities (Doi, 2020). For this reason, a product that is based on consumer needs is needed in design (Arbizu et al, 2019; Wang & Zhou, 2020). The purpose of doing this is to increase the comfort and job satisfaction of consumers (Wang & Zhou, 2020).

4. Conclusions and Suggestions

4.1 Conclusion

This study aims to analyze the musculoskeletal complaints of using a lamp replacement device. The analytical method uses QEC to measure the musculoskeletal health complaints experienced by users. The calculation results show that the replacement tool for the old lamp is less effective than the replacement for the new lamp. The activity of replacing lamps using a replacement tool for old lamps has an exposure level of between 41% - 59%, that is, it is advisable to repair activities in the form of further investigation and change it immediately. The activity of replacing lamps using a new lamp replacement tool is at an exposure level of between 20% -35%. This indicates the act of replacing the lamp using a new lamp replacement tool is accepted. The working pressure level indicates that users of the old lamp replacement tool work slower with high stress than the new lamp replacement.

4.2 Suggestions

The lamp replacement design can be used as ongoing research in developing products.

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