Ergonomic Workspace Design to Reduce the Risk of Musculoskeletal Disorders

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Abstract. Office activities were closely tied to document handling and computer interaction. Based on initial identificationwith the Nordic Body Map, MSDs (Musculoskeletal Disorders) complaints were identified in the shoulders, wrists, waist, buttocks, and back. This study aimed to offer recommendations for enhancing office workstations to minimize the risk of MSDs. The methods used are ROSA to identify employee work postures, product design to provide proposed work facilities, 5S for document organization, and a Radar Chart for evaluation. Initial identification shows the problems that exist in work facilities, workspace layout, and work environment factors. The initial identification of the workspace with Radar Chart also showed a poor score on 5 aspects of Seiri, Seiton, Seiso, Seiketsu, and Shitsuke with an average of 41.75.The proposed intervention is the improvement of ergonomic tables and chairs, structuring documents by applying 5S aspects, and improving the layout of the workspace. The proposed improvements were then evaluated again using the Office 5S Audit Checklist and Radar Chart so that after the ergonomics intervention, the Radar Chart value became 90.75(excellent) and the 5S aspects (Seiri, Seiton, Seiso, Seiketsu, and Shitsuke) increased. The results of this improvement canbe expected to overcome the risk of MSDS problems in the lower neck, buttocks, back, and waist and the resulting ergonomic, organized, and efficient workstations.

1 Introduction

Administrative operations in the office are closely related to documents such as financial documents, company income, and expenditure documents [1]. Office employees interact intensely with laptops and peripheral equipment such as mice and keyboards [2]. With intense interaction with VDT, employees also often complain of dizziness and dry eyes. This is due to eye fatigue due to the screen position that is too close and too high intensity [3], [4]. Employeesgenerally work for 8 hours, from 8 am to 5 pm indoors as shown in **Fig. 1** (a) & (b).

Fig. 1 (a), the condition of the employee's workspace is not very organized, shelves that are very close to the door hamper employee mobility, and chairs that are close together are also one of the complaints of employees at workbecause they often collide

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with each other. Not only the poor layout of the workspace, but the arrangement of documents is also a problem.

Employees with a duration of 8 hours tend to be static and dwell on laptops because the work requires high interaction with laptops and documents (invoices) so there is not much movement by employees while working. The duration of the workers is more than the ideal limit of a static work position of 4 hours [5]. The lack of movement, poor posture, and lack of facilities at workstations that are adequate in working can be due to poor facilities and also the habits of employees in working so that several postures are not following ergonomic rules. **Fig. 1** shows examples of 2 workers who have less ergonomic work postures. **Fig. 1** consists of several identifications regarding poor work postures such as: elbows that are too bent so that the possibility of pain/pain in the elbow is high,backs that tend to bend forward so that there is a possibility of pain in the back, the position of the shoulders, upper arms to the elbows that are open too wide so that the occurrence of pain/pain in the shoulders is high. Poor work posture can trigger several complaints, especially MSDs complaints that are often complained about by employees. Poor work posture also causes pain and illness in certain parts of the body as shown in the NBM questionnaire takendirectly when employees work.

In the finance department itself, based on the results of the NBM (Nordic Body Map) questionnaire distributed to4 employees, it is proven that parts of the body such as the lower neck, buttocks, back, and waist are painful and stiff.This can be caused by the amount of intensity of computer use which can cause the risk of musculoskeletal disorders (MSDs).

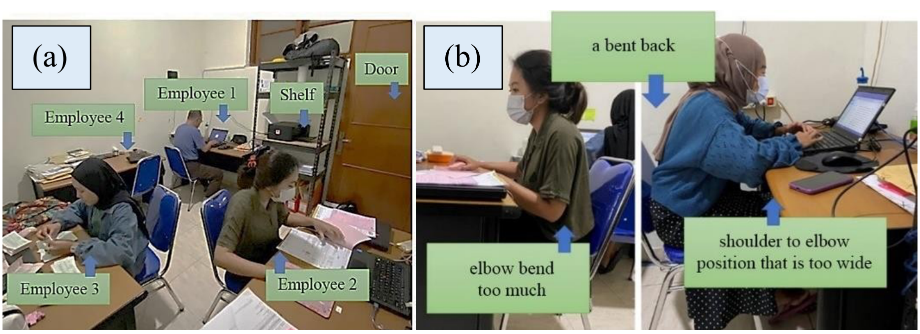

Fig. 1. (a) Room condition of finance department; **(b)** employee work posture

The NBM questionnaire itself is a measurement and assessment technique to identify the level of complaints and injuries to the skeletal muscles for disorders of the musculoskeletal system [6]. The NBM method is a questionnaire containing several types of MSDs complaints on a 28-part human body map starting from the upper neck to the lowerlegs and is used to determine which parts of the body have complaints. Risk classification is divided into 4 categoriesnamely No Pain (A), Somewhat Pain (B), Pain (C), and Very Pain (D). [7]. After filling out the NBM questionnaire, the average and total scores obtained in each section are calculated so that it can be seen which parts of the employees have MSDs complaints. The highest percentage felt by employees is pain/stiffness in the lower neck (100%), buttocks(75%), back (100%) and waist (100%). The results of the section half of the employees have experienced it. This canoccur due to work postures and workstations used by employees. The musculoskeletal symptoms according to the most affected areas are on average the same, with the lower back being the most affected, followed by the neck and shoulders. These results are consistent with the areas documented to have the highest symptoms in computer employees [8], [9]. This is due to static postures of the neck, shoulder, and upper limb muscles that overload and eventually cause injury [10], [11]. Further analysis was conducted using the ROSA (Rapid Office Strain Assessment)method which correlates more highly with musculoskeletal symptoms and is easy to use for assessing computer workstations. The results showed that ROSA can be used as a tool to identify and assess ergonomic risks in modern office environments [12]. The method can assist in assessing computer-related risk factors when other objective measurements are not available. In addition, the final ROSA score is positively associated with musculoskeletal symptoms [13].

This method has good reliability for evaluating MSDs. The assessment process in this method consists of three main parts and the scores obtained for the following parts are placed on each table including chair and sitting posture,screen and mobile phone, mouse and keyboard, human body posture while using these tools, and duration of use of each tool. If these tools are used for a long amount of time, it will increase MSDs complaints in employees. The finalROSA score is determined by summing up the scores obtained in each section.

To minimize MSDs complaints, especially the shoulders, neck buttocks, and waist based on the results of the NBMquestionnaire and ROSA analysis, this study aims to design workstations in the form of tables and chairs for office employees in the finance department so that the percentage of complaints against employees will decrease and also increase employee productivity and effectiveness.

2 Method

The flow of this research method is broadly carried out with six stages which can be seen in the flow chart listedin **Fig. 2**.

The stages in the research method begin with calculating employee complaints with NBM, then proceed with identifying work postures with ROSA, after obtaining ROSA results, product proposals are made. Furthermore, by identifying the initial arrangement before improvement with Radar Chart, then continued with the 5S improvement proposal, and finally by evaluating with Radar Chart.

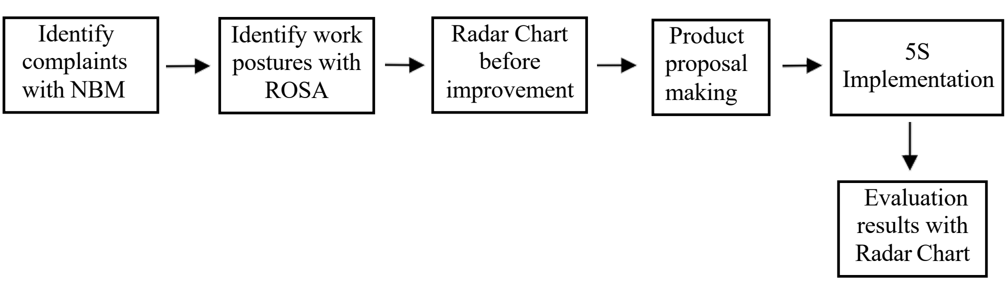

Fig. 2. Research method flow chart

3 Results and discussion

3.1 Work Posture Identification with ROSA

The ROSA calculation consists of several parts, namely first calculating the score of the seat height, seat depth, armrest, backrest, monitor, telephone, mouse, and keyboard. ROSA calculations depend on the actual circumstances that occur to employees. The ROSA calculation also reviews how long employees use work support facilities to identify the risk of MSDs. The data taken is posture data (**Table 1**).

Table 1. Identification table before improvement

Position	Picture			
Seat height & Seat depth				
Backrest and Monitor Height				
Keyboard and Mouse Usage				

After calculating the parts that have been determined, the score of each part (A, B, and C) will be calculated first to produce the peripherals & monitor score. The score of peripherals & monitors will be calculated together with the chair score to produce the final ROSA score.

In the four employees who have calculated the ROSA value, it is found that the four employees have a high risk when working because each employee has a high enough ROSA score, namely employee 1 and has a ROSA score of7, and employees 2 and 3 have a score of 9. This can cause MSDs problems such as back and waist pain.

3.2 Initial Office Identification with Office 5S Audit Checklist

Initial 5S identification was done by opening the Office 5S Audit Checklist questionnaire before improvement.

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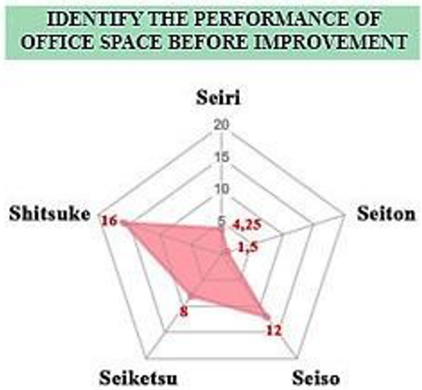

Fig. 3. Radar Chart of 5S performance in office space before improvement

Respondent data collection was carried out directly on the spot. Before the employees fill out the respondent questionnaire, this stage first conducts a brief briefing to educate the workers about the importance of implementing 5S in the work environment. 5S performance before improvement can be seen in **Fig. 3**.

3.3 Ergonomic Interventions

Ergonomic interventions that can be done to minimize the risk of MSDs are to make improvements to work facilities and improve office layout.

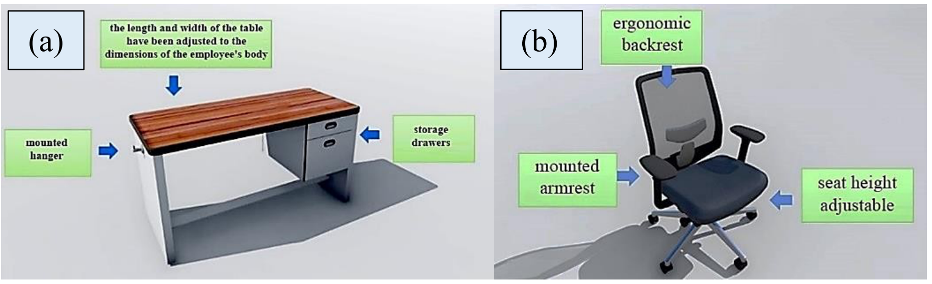

Fig. 4. (a) Table after improvement; **(b)** Seat after improvement

In the product, improvement, there are several improvements from 4 aspects, namely aspects of features, ergonomics, design, and durability. The height and width dimensions of the table have been adjusted by the body dimensions of each employee so that the size is suitable for employees so that employees are more comfortable at work. In the design aspect, the repaired table has a more unique design than the previous table design. repaired has strong durability.

The features of the chair are equipped with a hydraulic system so that the seat height can be adjusted. In the ergonomic aspect, the repaired chair has an armrest. The armrest functions to support the employee's elbow, the chair also has a backrest that is by ergonomic rules that follow the shape of the curve of the back.

Fig. 5. Office layout after improvement

Office space arrangement is carried out using the 5S method. This 5S method is useful for building a good and quality work environment, discipline and standards of employees will also increase [14], [15], [16]. The arrangement of office space follows 5 aspects, namely Seiri, Seiton, Seiso, Seiketsu, and Shitsuke [17]. The arrangement of the office space after improvement can be seen in **Fig. 5**.

3.3.1 Seiri/ Sorting

Useless items are documents that have been misprinted and should be discarded. **Fig. 6** shows the result of sorting documents from documents that need to be discarded.

Fig. 6. Useless documents

3.3.2 Seiton/ Arrangement

Seiton is the stage of selecting documents through sorting and organizing activities.

3.3.3 Seiso/ Cleaning

The cleaning process is carried out daily by the cleaning staff and at the end of each month by the employees**.** **Table 2** shows a comparison of the implementation of the workspace after and before the implementation of the seisoaspect.

Table 2. Comparison table of the implementation of seiso aspects

Before improvement	After improvement
	

3.3.4 Seiketsu/ Standard Setting

The determination of the 5S aspects is made in the display so that employees continue to remember and apply the5S aspects (seiri, seiton, seiso, seiketsu, and shitsuke) in the office.

3.3.5 Shitsuke/ Habituation

This stage is the most difficult because each employee must maintain, be responsible, and instill awareness of implementing the 5S procedure. Evaluation can be done at the end of each month to maintain and sustain 5S.

3.4 Evaluation After Improvement

The results of this evaluation are useful to see whether the application of 5S and the application of the results of the intervention have shown positive results or not so that it can see the difference between before improvement and after improvement. If the results of the evaluation have not shown good results, then a redesign is carried out. To seethe performance of 5S in the finance department office after improvement can be seen in **Fig. 7**.

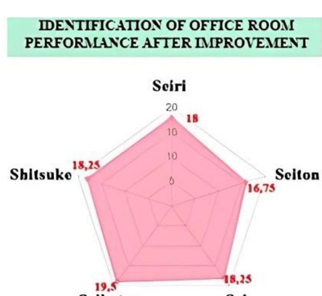

Fig. 7. Radar Chart of 5S performance in office space after improvement

On the Radar Chart, to see which aspects are better, look at the points and ends of the chart. If the end of the graphis away from the center point, it can be concluded that the value of that aspect is high and good. In the assessment after this improvement, the aspect with the highest score is the Seiketsu aspect. This aspect has a value of 19.5 and has the farthest point of the graph, while the lowest aspect of the five aspects is the Seiton aspect, which has a value of 16.75.

4 Conclusion

The results of ROSA and NBM identification indicate the risk of MSDs. The highest complaints occur in the lower neck (100%), buttocks (75%), back (100%) and waist (100%). The ergonomic intervention proposed to minimize the risk of MSDs is a table and chair product that considers features, design, ergonomics, and durability. Another proposed intervention is a new layout and document arrangement with 5S. The results of the 5S performance assessment in the office using the Office 5S Audit Checklist have an initial average before improvement a value of 41.75 which has a fair rating, after improvement to 90.75. With this, it can besaid that the workstation redesign method is effective in improving quality.

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