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Short Communication

Ergonomic risk identification and postural analysis in electrical transformers manufacturing company located in Southern India

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ABSTRACT

Introduction: Musculoskeletal disorders are the major factors resulting in discomfort at work in manufacturing industries to workers and these conditions contribute to the poor health of the workforce, subsequently to lower productivity. Therefore, the design of a workstation based on Ergonomic principles is becoming significant to reduce the effects of MSD. This study aimed to identify and assess the ergonomic risks associated with the work tasks in the company through posture analysis and develop recommendations for reducing those risks.

Methods: About 36 manufacturing workers from five sections were randomly selected for the cross-sectional study. The chosen team members were from Core building, Core winding, Assembly, Tanking and Tank fabrication sections with experience of more than two years. The presence of MSDs was assessed using a Nordic musculoskeletal questionnaire. For postural analysis, Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA) were utilized. Few selected postures were analysed using CATIAV5 software and improvements reducing the risks of postures were recommended.

Results: All of the 36 workers selected for the study were male with a mean age of 32 years, average experience of 10 years and 75% of workers had normal body mass index. The MSD questionnaire indicated discomfort of 86% mostly on the lower back portion of the body. The combined findings of RULA and REBA showed that about 44% of postures were in the high-risk group.

Conclusion: Well-defined ergonomic interventions such as redesigning the workstation are suggested to reduce awkward postures and manual handling risks, leading to improvement in job performance and productivity.

Keywords: Ergonomics, Musculoskeletal Disorders, Postural Analysis, RULA, REBA

Introduction

The current manufacturing industries are continuously making efforts to improve the productivity of their organization and at the same time focusing on safety aspects of their workforce to ensure their well-being.[1] Ergonomics is a science that can be used for designing and arranging work environments, equipment, and systems to fit the people who use them, and it plays a key role in achieving the expected goals.[2] Ergonomic risk identification is concerned with identifying workplace factors that may cause musculoskeletal disorders (MSDs) or other ergonomic injuries. These factors can include repetitive motions, forceful exertions, awkward postures, and vibrations. On the other hand, posture analysis involves analyzing workers' postures while they

perform their tasks to identify any deviations from the recommended postures. Poor posture can lead to MSDs, fatigue, discomfort, and decreased productivity.[4]

Conducting ergonomic risk identification and posture analysis are crucial to minimize workplace injuries and improve employee overall health and productivity.

Work systems that are designed keeping ergonomics in mind will always help to achieve a balance between worker qualities and job needs.[5] The adoption of ergonomics techniques in the workplace is crucial for the manufacturing sector since this can improve productivity and quality, increase revenue, reduce rejection costs and provide a better safety work environment.[6] The primary cause of workers' discomfort, decreased productivity, and monetary losses is work-related musculoskeletal ailments.[7] Musculoskeletal disorders may be caused because of continuously carrying out repetitive tasks, awkward postures, and anthropometric mismatches performing heavy physical work and using forceful exertion. This may lead to a high level of absenteeism among the workers.[8,9,10]

A transformer manufacturing industry, like any other manufacturing industry is involved in many manufacturing activities that expose workers to ergonomic risk factors.[11] The available literature indicates that there is strong acceptance of ergonomic tools as an effective means of improving productivity in the manufacturing sector.[12] However, the application level of ergonomic tools in industries, especially in small and medium-sized enterprises, needs to be improved, current research work has been undertaken to identify ergonomic deficiencies in the working methods of the workers in the transformer manufacturing industry, study postures, and identify risks using ergonomic assessment tools like RULA and REBA.[13,14,15] Catia v5 software is used to create a digital model of the workspace and automatically calculate the RULA score for a posture.[16,17]

Methods

The present study was carried out in a local electrical transformer manufacturing industry located in Kalaburagi City, Karnataka, India. A total of 36 male workers above 20 years of age, with a minimum of 2 years of work experience in manufacturing and who gave consent were included in the study. The chosen workers were from the following five sections, core building, core winding, assembly, tanking and tank fabrication and their work scope is to core building, winding, and tanking of transformer coils for long durations.

Data collection was carried out by giving consideration to type of data. The primary information was obtained directly from workers and management through interviews and surveys, such as the manufacturing process of transformers, Temperature, and Humidity in the workplace, and Size of the production space. Workers' complaints of physical aches in certain areas were recorded through the Nordic musculoskeletal questionnaire.[18] Work postures were photographed or video recorded using a mobile phone camera directly for further analysis. Anthropometric measurements of workers were carried out using a flexible measuring tape and weighing scale.

Meanwhile, secondary information is obtained indirectly from the subject of research. Secondary information in this study includes general information about the transformer manufacturing industry such as organizational structure, hours of operation, manufacturing procedures, and other information pertinent to the research issues.

Two posture evaluation methods were used in the present study to assess ergonomic disorders among employees. The first technique is called RULA (Rapid Upper Limb Assessment), and it is often used in research to measure upper extremity postural.[19,20] The second technique, called REBA (Rapid Entire Body Assessment), assesses the participant's posture to decide if it is appropriate or inappropriate.[21,22]

The work postures of the body had also been examined manually using the RULA evaluation worksheet and through the use of the Catia-v5

application software to offer a more precise RULA score, body postures alignment and the load's weight had all been set up and entered into the software. The weight of the load is used to calculate the forces and moments that will be generated on the workers' body. Then, to lessen the problem of musculoskeletal disorders, body postures were suggested to be modified as a result of the analysis performed in the study.

Results

All the participants in the study were men, ranging in age from 20 to 46 years. According to the body mass index (BMI), 75% of employees have normal weight, while only eight percent were overweight. The study was carried out during the day shift. Table 1 shows the details of the demographic figures of workers.

Table 1: Demographic figure of workers (n=36)

Sl.No.	Particulars	Minimum	Maximum	Mean (SD)
1	Age (Years)	20	46	31.41(8.17)
2	Height (Meters)	1.52	1.77	1.67(0.05)
3	Weight (Kg)	46	85	61(9.93)
4	Experience (years)	2	20	9.26(5.71)
5	BMI (Kg/M^2)	16.49	26.77	21.8(3.16)

Table 2: Nordic musculoskeletal Questionnaire Findings

Body Parts	Number of workers (n=36)	Percentage %
Neck	9	25
Shoulder	21	58
Upper Back	20	55
Lower Back	31	86
Wrist	22	61
Elbow	6	16
Thighs	20	56
Knees	25	69
Ankles/Feet	18	50

In ordert to determine the occurrence of MSDs, the Nordic musculoskeletal questionnaire was used. The prevalence of work-related MSDs in different body parts of workers is presented in Table 2. The MSD questionnaire reveals that more than four-fifths (86%) of the workers were suffering from lower back discomfort.

As stated, the risks associated with the working postures were determined using the RULA and REBA evaluation methods. Thirty-six postures were taken from five sections. Photographs taken using a good-quality phone camera were examined. The risk score was determined using the RULA assessment and scoring sheet. Table 3 displays the results of the analysis.

Table 3: Distribution of RULA score among workers

RULA Level	RULA Score	Action	Number of Postures(N=36)	Percentage %
0	1-2	Acceptable posture	7	19.4
1	3-4	Further Investigation and change may be needed	10	27.7
2	5-6	Further Investigation, change soon	05	13.8
3	7	Investigation and Implement change	14	38.8

Table 4: Distribution of REBA score among workers (n=36)

REBA Level	REBA Score	Action	No. of Postures	Percentage %
0	1	Negligible risk	01	2.7
1	2 to 3	Low risk, change may be needed	08	22.2
2	4 to 7	Medium risk, further investigation change soon	10	27
3	8 to 10	High risk, investigate and implement change	17	47.2
4	11+	Very high risk, implement change	0	00
		Total	36	100%

Similarly, the REBA assessment and scoring sheet were used to determine the risk score and consequently, the appropriate action. Table 4 summarizes the analysis findings.

The analysis of the worker's body postures while performing three different tasks was conducted by using images of the worker's actual postures. Figure 1 shows the workers involved in three different activities.

The worker in Figure 1, image A, was lifting 16 kg of mild steel sheets. Awkward working body posture and repetitive heavy lifting are major workplace postures, with two lifts performed every minute.

The worker in Figure 1, image B, was spraying the transformer tank on the floor. The critical working posture requires frequent bending which is prone to injury. The worker in Figure 1, image C, was operating a coil-winding machine. The upper body parts are at risk of MSD due to the vibration of the winding machine as it is done for a longer duration, under the noise of the machine.

Figure 1: Postures of workers involved in different work activities (Image A, B, and C respectively)

Catiav5software includes human modeling and ergonomics analysis capabilities. The software has four modules: Human Builder, Human Activity Analysis, Human Posture Analysis, and Human Measurement Editor. These modules allow users to create and customize human models, analyze their postures and movements, and identify potential ergonomic risks. RULA is one of the tool which is supported by this module.[23] The work postures prior and after rectification are shown in Figure 2.

The postures shown in Figure 2 (a) correspond to a worker lifting a 16 kg to 30 kg load depending on the size of the transformer plates. Due to the worker's requirement to bend their backs and the excessive use of back muscles, an awkward body posture might be observed. A ligament sprain or muscle strain may be caused by improper lifting

or overstressing of weak back muscles.[24] A high RULA score was obtained for the left side of the body from this working position. The weight that must be physically lifted shouldn't be more than 50 pounds (22.67 kilogram).[24] Otherwise physical heavy lifting might cause ergonomic problems, such as back sprains. Even though there is improvement in the work method, the improved work posture still has a substantial RULA score of 7 for both sides of the body as shown in figure 2(a). The most exposed body areas when lifting are the neck, arms, wrists, and muscles.

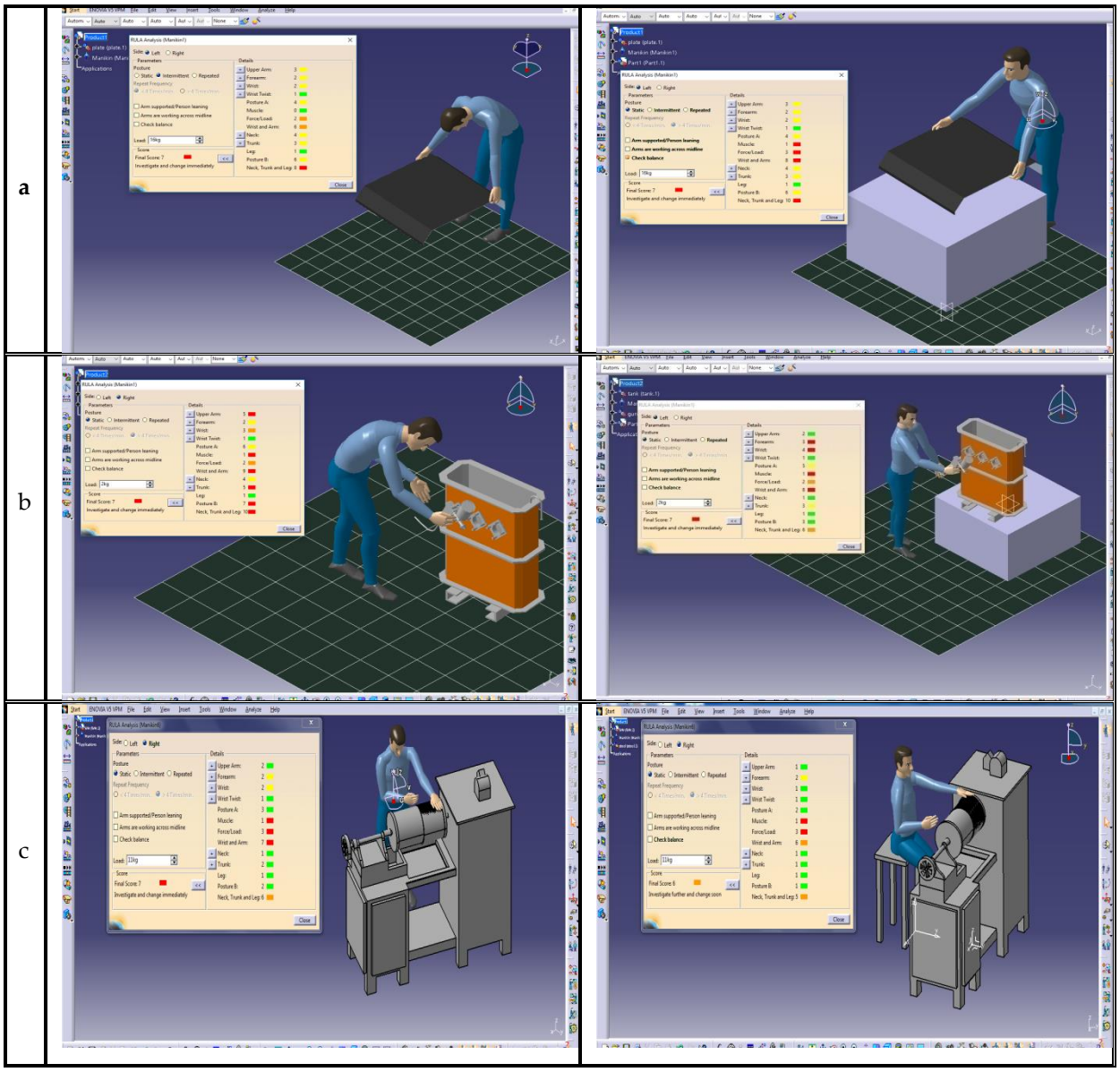

Figure 2: Work Postures A, B, and C before and after the Rectification

The postures shown in Figure 2(b) correspond to workers spraying a transformer tank on the floor. This work posture involves awkward working body postures. The upper body parts that are neck, and trunk are continuously bent forward and sideward for spraying operation. This can put too much strain on the body's lower back. Pressure is also seen in the wrist and arm due to carrying of spray gun for a longer duration of time. The RULA score remains high on both sides of the body despite the changes in working posture during the painting process as seen in Figure 2(b). This is due to the repeated working pattern necessary to complete the painting process. The task of painting requires workers to exert force on their forearm, and wrist muscles repeatedly, which is one of the reasons that contribute to injuries that must be avoided.

The postures shown in Figure 2(c) correspond to the worker operating a coil winding machine. It involves the continuous use of the shoulder, arms, and wrist of the worker. Due to the winding machine, the arms and shoulders are constantly vibrating, and the machine also makes a lot of noise. The changes made in the working methods resulted in a decrease of the RULA score slightly as shown in Figure 2(c) but ear plugs and gloves are still needed to protect the worker.

Discussion

This study is an attempt to identify the ergonomic risks associated with workers in manufacturing areas and develop recommendations. Transformer manufacturing companies are highly labor intensive and most of the tasks are performed manually, which leads to high risks of MSDs. The prevalence of MSD symptoms and their risk factor was very high among selected workers (Table 2). The most common symptoms seen in the lower part of the body were lower back, knees, thighs, and wrist. From the analysis of results and scores(Table 3& 4) obtained by RULA & REBA postural assessment techniques, it can be observed that workers adopt awkward postures involving frequent twisting, bending, and stretching due to a lack of awareness and knowledge about ergonomic practices in work methods in the transformer manufacturing company. This is the result of poorly designed workstations and improper working postures.[2,8]

These findings support that MSDs are a serious problem in the manufacturing industry.[3,4,10] Findings are consistent with musculoskeletal pain among similarly related occupation study.[11]

The images generated in Catiav5 software can be used to identify potential issues with the workplace layout, evaluate the anthropometric fit of the workplace and the tools and equipment used, and identify work postures that might pose risks to workers. Subsequently, these identified postures can then be improved by redesigning the workplace or the tools and equipment used. To establish a work environment that is safer, more efficient, and more comfortable for all the employees.

Employer's initiative to provide a safe workplace for their employees by ensuring that the workplace is free of ergonomic hazards can save themselves from legal liabilities, fines, and damage to the company's reputation.[25] The employers should provide pre-employment training, health education on ergonomics and MSDs to the employees on knowledge and skills that are needed to perform their tasks safely and efficiently from the recruitment and it should be an ongoing process that covers the causes, symptoms, and prevention of MSDs.[26,27]

Conclusions

The results of the analysis carried out in the present study reveal that the working postures exhibited by the workers while executing their tasks are found to be unsafe. The primary cause for this was found to be some specific features of current methods, which involve repetitive jobs for longer durations and repeated handling of heavy exertion loads. Further, the findings of RULA/REBA methods which are used for posture analysis and assessment of each worker's exposure to occupational risk factors have changed the working postures to prevent WRMSD in the future. The recommendations will eventually improve workers' health and work efficiency and in turn, improve job performance and productivity.

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