Conference Paper

Ergonomics Intervention Study of the RULA/REBA Method in Chemical Industries for MSDs' Risk Assessment

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Abstract

Workers in chemical industries, especially those who operate suspending agent workstations, face a risk of potentially developing musculoskeletal disorders (MSDs). This is because their work is often performed at high altitude or in dusty areas, and it frequently requires an awkward body posture because physical space may be limited. In order to reduce the risk of MSDs, researchers performed an ergonomic assessment using the RULA/REBA method directly at a workstation in a suspending agent area. Simulations were run using CATIA software to evaluate the designs of a conveyor, a jack-adjustable table, and the overall work method. This statistical study proved that work systems can be improved through the addition of specific tools, and that a worker's posture can be improved through the application of ergonomic principles. Software simulation provided a comprehensive solution for work-system development.

Keywords: ergonomic intervention, works posture, assessment, MSDs, RULA, REBA

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1. Introduction

Based on observations at suspending agent workstations in the chemical industry, workers face unique challenges, such as dust exposure, high altitudes, and limited space, which can cause these individuals to assume awkward body postures. Inappropriately designed workstations can cause workers to experience lower back pain [1]. The implementation of ergonomic interventions in a workplace can reduce MSDs and prevent adverse effects on worker health [2–4].

Work activities at suspending agent workstations include pouring chemical powders Cata F Tebutol peroxyneodekanoate and Cata H cumyl peroxyneodecanoate into stirring tubes as mixing materials for the product-making process. Work also consists of physical movements for carrying, pulling, pushing, and lifting weights more than 18 kg. Based on the data analysis of workers in the suspending agent workstation in 2016, almost 50 percent of the workers' body positions were not ergonomic, and almost 75 percent of their work was done manually. In addition, the workers were exposed to dust hazards, and generally they did not pay enough attention to their work posture (body position). Health-promotion efforts, environmental improvements, and employment initiatives to maximize industrial hygiene and workplace safety (ergonomics) will build organizational work culture conducive to worker health [13].

The study was conducted using ergonomic intervention tests with RULA (Rapid Upper Limb Assessment) [5] and REBA (Rapid Entire Body Assessment) [7]. RULA is widely used in various studies, and REBA was developed as a system to analyse work postures that are sensitive to musculoskeletal risks in a variety of tasks. REBA is also used as a tool to validate work postures when needed. Therefore, it is important to know the methods and approaches to be taken, and to determine the best method for effective assessment [6].

Currently, to reduce the prevalence of high MSDs in suspending agent workstations, strategic intervention is needed, on work systems, work postures, and support equipment, to create an effective, efficient, safe, and comfortable working environment.

2. Methods

2.1. Study design, participant, and data collection

This research is descriptive-analytic with simulation analysis using CATIA software. Prototype through simulation is a form of representation of a system. A simulation is a physical form and a model containing symbols that describe equipment, activity and task performance, and artificial intelligence tools. If they are implemented properly, they can act as tools to improve workers' ergonomic conditions [8].

The suspending agent workstation was selected based on the existence of a worker complaint report to a clinic about the potential of MSDs, due to the nature of the manual work. One group of non-shift employees participated in this study. The characteristics of the participants (height, body mass, age, and experience) can be seen in table 1. The data was collected from a medical check-up unit in 2016. All participants had at least

one year of experience. Information about their physical characteristics, demographics, and musculoskeletal disorders is derived from a questionnaire. Researchers gave the respondents oral explanations about the questionnaire, and the respondents were asked to read and to complete informed consent documents. Cameras were set up at strategic positions to record video and images of the participants' work postures. Observations can be seen in Figure 1.

Table 1: Participant characteristic (MCU PT. X 2016).

Characteristic	Mean	SD	Range
Height (cm)	166.5	2.4	163.5–169
Body mass (kg)	77.8	18.2	53–96
Age (years)	32.8	14.8	19–47
Experience (year)	12	11.8	1–25

2.2. Manual handling activity

The following are some of the manual activities performed in the observed suspending agent workstation (Figure 1):

1. Setting up a safety net to lift a pile of sacks containing chemical raw materials, which had been prepared on a palette
2. Lifting raw materials from bottom to top using a crane
3. Opening the safety net
4. Raising sacks
5. Opening the lid of the sack covers manually
6. Pouring the contents of the sacks into a mixer
7. Smoothing back the empty sacks

2.3. Measurement, procedure, and statistical analysis

Work postures measured using REBA have five levels of risk categories [7], while RULA uses a four-tier coded system [5]. CATIA software was used to create an ergonomic work posture simulation.

The research procedure was divided into three stages:

Figure 1: (a) Activity suspending agent; (b) Simulation posture.

1. Identification of tasks that may cause workers to be exposed to significant risk of musculoskeletal injury
2. Assessment of tasks systematically identified by operations first stage
3. Evaluating and implementing appropriate risk control solutions

Statistical analysis, including the calculation of median values and standard deviations, was used to find the worker's characteristics. A comparative paired t-test was performed, and $P < 0.05$ was used as a limit of significance. The hypothesis test for proportions was done to analyse the trend of result deviation.

3. Results

The systematic posture assessment (Figure 1) shows that the awkward work postures that had the highest risk of causing musculoskeletal disorders occurred on average in the upper arm and wrist, twist, muscle and extreme load. The high prevalence of MSDs among large random samples of the general working population are most evident in the lower back, neck, and shoulders [14].

Based on systematic assessment results using (RULA/REBA) in suspending agent workstations (Table 2), a RULA score of 7 indicates that investigation and changes are required immediately, and a REBA score of 13 indicates a very high risk and need to implement change. The method to follow up the results of existing measurements

and reduce the risk of MSDs was to conduct an evaluation and to control work posture risks, revise the work-system process, and integrate ergonomic concepts with the work equipment. The result of strategic intervention in the suspending agent workstation is shown in the final column of table 2, with simulation CATIA score RULA 3 ('low risk, change may be needed'). Methods of ergonomic intervention include the creation of an integrated worker system, such as the addition of a conveyor, a jack-adjustable table, and an ergonomic method for pouring the chemical materials into the mixer.

Table 2: Systematic posture assessment.

Body Part	Existing RULA (Score 7)	Existing REBA (Score 13)	Simulation CATIA (RULA Score 3)
Upper arm (degrees)	45–90	45–90	45
Lower arm (degrees)	60–100	60–100	60
Wrist up (degrees)	15	15	5
Wrist down (degrees)	15	15	15
Neck (degrees)	20	20	15
Trunk (degrees)	60	60	20
Legs (support)	2	2	2
Load (kg)	(>) 10	(>) 10	(>) 10

Improvement of work systems through simulations adding conveyor designs, adjustable jacks, and better operational methods has resulted in improved worker posture. As shown in Table 2, the average decrease in simulated score is seen on the upper arm (45 degrees), the lower arm (40 degrees), the wrist (10 degrees), the neck (5 degrees), and the trunk (40 degrees). A decrease in the average score simulation is indicated on the physical workload on suspending agent workers also decreasing, so it reduces the workload.

The simulation of the workstation design was adjusted to the role and function of the system components involved, that is, human, equipment, physical environment, and working methods. The role of human workers is based on their abilities and limitations, especially with regard to aspects of physical posture. The equipment (conveyor and adjustable table) functions to support the human operator in performing tasks in the suspending agent workstation. And the addition of foot pedals helps workers pour the chemical raw materials into the mixer. The pedal mechanism also reduces stress factors in the lower body.

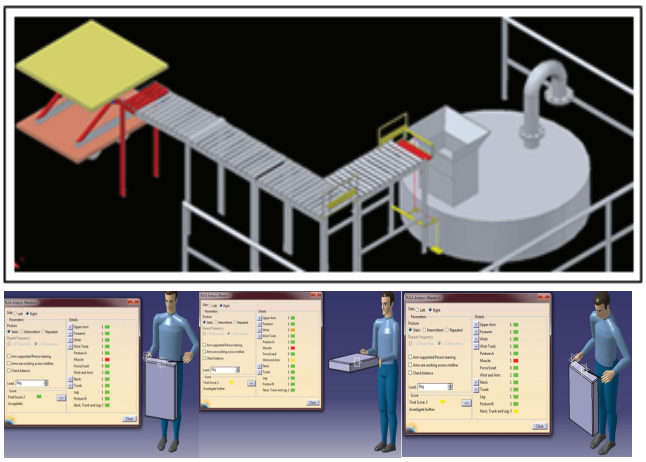
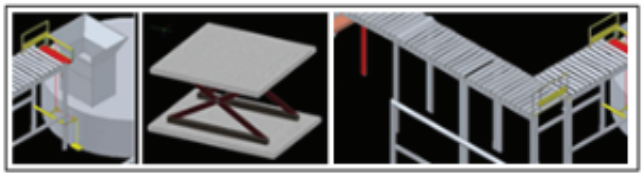
Integrated intervention ergonomic design	
- Ergonomic mechanism - Jack-adjustable table - Conveyor	

Figure 2: Integration intervention ergonomic design.

The value of the statistical analysis is a sig. (p = 0.045), the sig. value $p < 0.05$. There was a significant difference in improving awkward postures before and after simulating the intervention.

4. Discussion

Analysis of awkward work postures in suspending agents (Figure 1) shows that employees use the parts of the body that serve to reduce the movement of skeletal muscles in order to be more fitted when lifting weights. According to one of the company's clinic doctors, the clinic division had recommended that workers wear a body harness, but some employees complained about the distraction around the back. This indicates that workers in the suspending agent workstation are potentially affected by MSDs, so the effects of work-related musculoskeletal disorders (WMSD) should be considered [6].

The results of the RULA/REBA score on work in the suspending agent workstation fall into the high-risk category, which means immediate changes are required. One of the criteria to know the risk factors of work posture, namely: acceptable/no consequences; essential/redesign required; more detailed analysis [6]. The solution for

improving suspending agent workstations is to use simulations for designed work systems and to add aids such as conveyors, adjustable jacks, and ergonomic intervention methods. Ergonomics should be involved in the design of workplace intervention [15].

Statistical hypothesis test results by RULA/REBA show that changing the design of ergonomic work systems automatically leads to improvements in workers' posture. Ergonomic interventions can also improve workers' welfare, increase productivity, and enhance the quality of the work produced [11]. By using ergonomic interventions in the workplace, it is possible to reduce the risk of MSDs or prevent adverse health effects [2–4]. Changes in working conditions must be promptly implemented to protect workers, and installing appropriate equipment will improve their quality of life [9]. Ergonomic interventions to improve worker conditions (e.g., through workstation design and work organization) can reduce the high prevalence of MSDs among these worker groups [10].

Design of work-system improvements in the suspending agent workstation was done by simulation using software, due to the limited time, cost, and location. The results from these simulations have been encouraging, and this has led us to a new perspective on developing established ergonomics topics using artificial software and tools [8].

Results of this research can be used as one of the foundations to enact policies related to improvements in the field in suspending agent workstations, so that the atmosphere and work environment are more effective, efficient, safe, comfortable, and healthy.

Posture and fatigue analysis can be made one of the broader components (human processes) of models to assess the complexity of manual and semiautomatic production systems [12].

5. Conclusion

Ergonomic interventions using CATIA software simulations for implementing conveyors, jack-adjustable tables, and ergonomic concepts for pedal-operated mechanisms can reduce the potential risk of awkward work postures in suspending agent workstations. The statistical hypothesis tests using the RULA/REBA method show that these improvements would decrease the risk of workers developing MSDs.

The study also results in three image designs: (a) conveyor, (b) a jack-adjustable table, and (c) an ergonomic operating mechanism using foot pedals.

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