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The Role of Participatory Ergonomics (PE) in Improving Work Systems in an Effort to Reduce Msds (A Case Study in The Light Steel Industry and Other Manufacturing Industries)

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Abstract: PE programs have been used as the most effective way to reduce or redesign manual tasks to reduce the incidence of work-related musculoskeletal disorders. This review assesses the evidentiary basis for the claim, explains the various approaches that have been taken using PE methods for several industries, and compiles the learnings obtained from implementing these programs to obtain a safe and comfortable working situation for workers.

Keyword: PE; MSDs; Tools; GOTRAK

INTRODUCTION

Musculoskeletal disorders (MSDs) are a common health problem among workers who engage in continuous and intensive physical activity with poor work posture. According to Akbar KA et al. (2023), MSDs often occur due to constant physical stress on the musculoskeletal system involving muscles, joints, and ligaments that cannot withstand the load. As a result, muscles, joints, and ligaments cause pain and mobility limitations and severely decrease worker productivity. MSDs are one of the main causes of absenteeism and increased employee turnover. In the industrial context, Punnett et al. (2013) noted that the main risk factors for MSDs include moving heavy items, lifting weights, unergonomic work posture, and working with repetitive movements that are less ergonomic. Completing the handling of MSDs requires a comprehensive approach through an adequate ergonomics program, where

serious interventions must include risk identification, work posture improvement, and appropriate technology to support worker health.

According to the World Health Organization (WHO), these disorders can affect muscles, joints, ligaments, and nerves, often leading to pain, fatigue, and limitations in doing daily work. If left untreated, these injuries can develop into chronic conditions that require long-term medical care, even resulting in a decrease in productivity and quality of life for workers.

MSDs are diseases related to joints, muscles, bones, ligaments, tendons, and the spine (Oakman J. et al., 2023). Many workers experience MSDs due to repetitive movements with unergonomic postures, such as in Southeast Asia. It was recorded that 80% of farmers experienced MSDs. Workers' MSD disorder causes a decrease in production because workers become unenthusiastic about work; complaints of back pain, neck pain, pain in the shoulders, elbows, and legs; frequent pain permits (Akbar KA et al., 2023). This disorder is significantly related to work and has a multifactorial nature; in other words, risk factors can be more than one, so it can worsen the state of the body (de Kok MJ et al., 2019). MSDS burdens the organization's finances due to the costs associated with medication and care for workers (Dianat I et al., 2020). In addition to the severe impact on workers who experience MSDs continuously (6 to 12 months) causes permanent illness (Charles LE et al., 2018). This problem causes stakeholders to carry out ergonomic interventions so that workers can properly and correctly perform their duties.

One of the ergonomic methods that can improve the risk of MSDs is Participatory Ergonomics (PE). PE is employee involvement in planning and control that using adequate knowledge will result in technology that is ergonomic and can be used to improve current working conditions (Sukapto, 2019), "employee involvement in the company in planning and controlling various key activities, using adequate knowledge and power to influence processes and results to achieve expected goals". The reason is that workers are people who can identify and analyze problems and develop and implement effective solutions in reducing the risk of injury and increasing productivity (Brown, 2005). To realize optimal change, direct participation from employees can make real changes in the workplace (Vink et al., 2006).

PE programs usually involve more than one team, with the aim of improving the work's design. They also involve workers and other potentially affected parties who want to propose changes. The objectives of PE application are the reduction of musculoskeletal injuries, the creation of better jobs (Imada, 2000), the improvement of the organizational climate (Maciel, 1998), and the promotion of health (Punnett et al., 2013).

PE programs have been successfully implemented in various industries, for example, in the mining industry (Burgess-Limerick et al., 2007), civil construction (de Jong & Vink, 2002), small businesses (Straker et al., 2004), and healthcare institutions (Guimaraes et al., 2015).

METHOD

The study used the observation method and was conducted at PT X, Bandung, West Java, Indonesia. Observation is direct observation carried out on processes that the company is allowed to observe and record and document all necessary data.

RESULTS AND DISCUSSION

Application of PE in the Light Steel Industry in ***the Hand Stacker*** **Section.** PT X is a company engaged in the light steel industry in Bandung. PT X experienced problems with the production department's work system. After in-depth research, it was found that there was a risk of *musculoskeletal disorders* (MSDs) experienced by all employees of the production department. The results of Ryan's research (2023) show that work situations have a high potential danger with a high level of risk of MSDs. Research was carried out using the GOTRAK method to eliminate the great potential danger, and mental workload was measured using NASA-TLX. Based on the processing of physical workload data, it is known

that all operators have MSD risks, especially in the lower back, hips, and calves, with a moderate risk level category. Not only that, based on the mental workload data processing carried out, it was found that 5 out of 10 workers experienced a heavy mental workload. Therefore, a proposal for improvement was made using the *participatory ergonomics* (PE) method to improve the operator's posture when operating *the hand stacker*. The application of PE is carried out using FGD, which involves operators, management, and ergonomics. FDG was carried out three times and finally got the concept of improving the work system. The results of the improvements are (a) gymnastics sessions before work, (b) training/*training* for *hand stacker* operators, (c) improving the working position *of hand stacker* operators (Figure 2), and (d) making SOPs for hand *stacker operations*.

Figure 2 Improvement of Workers' Posture

The proposed improvement's implementation for three months will reduce physical risks and improve workers' mental well-being.

Application of PE in the Automotive Industry

PT ASI is a company that makes car spare parts in Karawang. During this study, there was an unsafe situation for workers; namely, there were still work accidents, especially in the Welding Department and the Stamping Department. Therefore, it is necessary to design a new K3 system to reduce the level of accident risk in this area. The research method used is the HIRARC Method. The research stage is to conduct interviews on accident data from 2019 to 2024 (especially the Department of Welding and Stamping). The next stage is to identify hazards and risks that can occur. The third stage is to conduct a risk assessment and the consequences of work accidents. The last stage is risk control, which is used to overcome the potential hazards shown in Table 1.

The last stage is risk control to overcome potential hazards. The risks are that the hand is pinched by the stamping machine, the eye is exposed to sparks, and the hand is scratched

To reduce the risk of danger, PE with FGD is implemented. The implementation of PE involves operators from the Stamping Section (5 people) and Welding (6 people), the management, namely the supervisor of each field, and a group of ergonomics. The FGD process was carried out in 4 stages. The first stage discusses the planning of the implementation of PE, the second is the implementation of PE, the next is evaluation, and

the last is the improvement of PE implementation. Two main improvement concepts were produced from the PE implementation results: the replacement of personal protective equipment and the Standard Operating Procedure (SOP).

The results of these improvements have been obtained through in-depth discussions with the company, where the standard operating procedures (SOPs) prepared have proven useful in reducing the accidents experienced by operators. In addition, replacing work aids, such as using Kevlar gloves and *safety* glasses, is also the result of discussions with the company. Currently, the company has started to apply the two new types of assistive devices to some workers because replacing all personal protective equipment (PPE) for all workers at once will require a significant cost. The proposed protective equipment is Kevlar gloves as seen in Figure 3.

Table 1. Hazard Identification *Stage*

It	Department	Activity	Hazard Identification	Risk
1	*Stamping*	Inserting car *parts* into *the stamping machine*	Direct contact with the *stamping* machine *body*	Pressed press
			Direct contact with *the part* to be *pressed*	Scratched *part*
2		Pressing the stamping machine button	Pain when moving limbs	Unable to move freely
3		Picking *up parts* from *the stamping machine*	Contact with *a running* press	Broken finger
				Broken bones
4		Checking *printed* parts	Direct contact with parts	Scratched hands
				Chin scratched
5		Loading *parts* into *the Pallet*	Direct contact with parts	Scratched hands
				Chin scratched
			Pain when moving limbs	The body does not move freely
1	*Welding*	Inspect *parts* before welding	Direct contact with parts	Scratched hands
2		Positioning *parts* on jigs and clamps	Contact with *parts*, jigs, and clamps	Scratched hands
3		Welding process	Gram (iron) flakes, sparks	Eyes exposed to sparks, gram fragments
4		Checking welding results	Contact with *parts*, jigs, and clamps	Scratched hands
5		Loading *parts* into *pallets*	Direct contact with *inspected* parts	Scratched hands
				Chin wound
			Pain when moving limbs	Immobile body freely

Figure 3 Kevlar Gloves

Kevlar gloves have protective properties, can withstand scratches from sharp objects, and are resistant to heat. In addition to gloves, PPE is required in the form of protective glasses for the eyes, as shown in Figure 4.

Figure 4. Safety Over Glass *Glasses*

Table 2. Proposed SOP

PT ABC	**Standard Operating Procedures**		
Date	DD-MM-YYYY		
Made By	AAA	Approved By	AAA
Purpose	Reduce the incidence of work accidents that occur in the Welding *and* Stamping *Department.*		
Procedure	1. The operator must use the Protective Helmet correctly, such as fastening the protective rubber to the chin. 2. The operator must not roll up the sleeves of *the coverall.* 3. Operators are not allowed to work alone in the *Stamping Machine*. 4. During the process of picking *up parts* from the *stamping* machine, the operator is not allowed to pick up and press the machine button at the same time. 5. It is mandatory to use the proposed protective goggles and gloves. 6. During the *welding* process, the operator is required to double-check that the protective glasses are properly installed.		
History of Change			
Date	Forms of Change		
DD-MM-YYYY	AAA		

The advantage of these protective glasses is that they provide comprehensive protection against the risk of sparks and gram fragments during work activities. The second improvement proposal is SOP (*Standard Operating Procedure*) for operators related to work safety.

Application of PE in the Shoe Industry.

PT Primarindo Asia Infrastruktur Tbk is a company engaged in the shoe industry in Bandung and wants to evaluate the occupational safety system. Initial observation results show that in the production section, especially in the Catting, Sewing, Asembling, Technical, and Press sections, there is a risk of MSDs for which improvements need to be made. JSA (Job

Safety Analysis) is one method for measuring hazard risk. The results identified in more depth at the Emboss Station can be seen in Table 3.

Table 3. JSA *Emboss Workstation*

JOB SAFETY ANALYSIS		
Division: *Production*	Machine/Operation : *Emboss machine*	
Task Steps	*Potential Hazards*	*Safety Control*
1. Starting the *embossing machine*	-	-
2. Putting the shoe material onto the machine workbench	Heat generated from the metal in the engine	Create additional buttons for safety
3. Performing the *embossing* process,	Heat generated from the metal in the engine	Create additional buttons for safety
4. Removing the embossed shoe material	Heat generated from the metal in the engine	Create additional buttons for safety

The next step is to measure potential hazards by calculating *risk scores*. The calculation of *the risk score* for each potential hazard will determine *the consequences* (C), *exposure* (E), and *probability* (P) values. For example, the risk *score calculation for* an embossed *workstation* is as follows:

Risk Score (R) = 5 x 3 x 6 = 90

Table 4 shows the risk score for workstations *Emboss*, including medium zones, and the results of other workstation calculations.

Table 4. Workstation Repair Priorities

Priority	**Workstation**	**R**
1	Gluing	300
1	*Primering*	300
1	Laundering	300
2	Screen printing	180
2	*Universal*	150
2	Heating screen printing	135
2	*Emboss*	90
2	*Pounching*	90
2	Button	90

In Table 4, three workstations are the main priority to be repaired, and six workstations are the second priority. The improvement process for each station uses a PE approach that involves three parties: workers, management, and an OSH expert. FGD implements PE three times, and the concept of improvement can be seen in Table 5.

Table 5. Repair Solutions

It	Workstation	Proposed Improvements
1	Gluing	Mandatory PPE (mask)
		Adding a facility to suck indoor air (*exhaust fan*)
		Added a tool to store latex liquid
2	*Primering*	Mandatory PPE (mask)
		Adding a facility to suck indoor air (*exhaust fan*)
		Added a tool to store 001 KA rubber primer gleco liquid
3	Laundering	Mandatory PPE (mask)
		Adding a facility to suck indoor air (*exhaust fan*)
		Added tools to store MEK fluids
4	Screen printing	Mandatory PPE (mask)
		Adding a facility to suck indoor air (*exhaust fan*)
		Modifying screen printing work tools
5	*Universal*	Create additional buttons for safety
6	*Heating Screen Printing*	Installing the machine cable on a cable winder
7	*Emboss*	Create additional buttons for safety
8	*Pounching*	Modifying the machine, the tool is made attached to the machine
		Modify the engine, by adding an obstacle to the press part of the machine
9	*Button*	Created 1 additional button to replace the pedal function

One method that can be used to solve MSD problems is the *participatory ergonomics* method. In principle, this method solves an existing problem by involving three main factors: the operator, the management, and the ergonomics. The three parties held intensive discussions continuously until a final agreement was reached. They are in the discussion in the form of FGD. In this FGD, they openly sought various best solutions for improving a working system, which was the focus to be completed. This *participatory ergonomics* method is one of the problem-solving methods suitable for use in various Indonesian companies. This method has a way of solving problems that is per the prevailing culture in Indonesian society, namely deliberation for consensus. With deliberation for consensus, this can be applied to improve the work system by how the operators, management, and ergonomic experts are inattentive to make these improvements. The results of the application of PE can produce an improvement, namely:

1. Light Steel Industry at PT Eka Karya Sinergi in the Material Handling section, namely *shoulder pads* and *ramps;*
2. The Steel Industry at PT X in the ***Hand Stacker Section****, namely* gymnastics sessions before work, (b) training/*training* for *hand stacker* operators, (c) completing PPE for *hand stacker* operators, and (d) making SOPs for hand *stacker operations;*
3. The automotive industry at PT ASI Karawang is the replacement of personal protective equipment and Standard Operating Procedure (SOP);
4. The shoe industry at PT PAI is the presence of PPE, indoor air sucking, and barriers to the press machine.

The PE method can produce the best improvement concept for operators, management, and ergonomic experts, ensuring operators' comfort while working.

CONCLUSION

Employees carrying out tasks require high energy, long time (within 1 hour), and less ergonomic work posture, increasing the risk of musculoskeletal disorders in the parts of the body related to the job. Reducing or redesigning hazardous work will likely reduce the risk of musculoskeletal disorders. PE can provide an optimal solution in realizing workplace improvement. The successful implementation of the PE program certainly requires continuous management commitment so that employees continue to participate sincerely, as well as other parties affected by the proposed changes. In addition, the PE program needs to be supported by ergonomic training, and adequate facilities and infrastructure are needed to create a safe, comfortable, and conducive workplace.

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