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Application of *Participatory Ergonomics* to Reduce The Risk of *Musculoskeletal Disorders* In *Hand Stacker* and *Material Handling* Operators Using The Gotrak Method at PT X

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Abstract:- Mild steel is a building material widely used today because of its lightweight and relatively cheap material. PT X is one of the companies that produces light steel in Bandung. In the light steel production process, there are several jobs, especially in hand stacker and material handling activities, where the workers have poor posture and are less efficient by using two workers, and hand stacker and material handling activities that can cause MuscleShaped Disorders (MSDs). In the process of eliminating and reducing the risk of MSDs in the workplace, the level of MSD risk experienced by workers is calculated using the GOTRAK method. Discussions were also held with PT X to help reduce the level of MSD risk experienced by workers. The tool's design is carried out to help hand stacker and material handling activities reduce the risk level of MSDs and increase their efficiency. For hand stacker activities, training is designed for hand stacker operators and equipped with PPE for hand stacker operators, as well as making SOPs for hand stacker operations. Meanwhile, material handling activities are designed with two aids in the form of shoulder pads and ramps that can help reduce the level of MSDs experienced by workers. Shoulder pad aids can help operators in charge of pushing movements, and ramp aids can relieve the force emitted by the operator due to the acceleration of the hand truck. In using both assistive devices, the risk level of MSDs was reduced to five, and in carrying out material handling activities, only one operator was needed, and no additional assistance personnel were used. Real improvements are hoped to create a safe, comfortable, and productive workplace.

Keywords: GOTRAK, Musculoskeletal Disorders (MSD), Participatory Ergonomics (PE), Hand Stacker,

Material Handling.

1. Introduction

All industries expect to be a safe, comfortable, and productive workplace to keep up with the increasingly tough competition. PT X is a company in the light steel industry that sells various kinds of light steel roof trusses and is marketed in Bandung and its surroundings. In 2023, Ryan conducted research and showed a risk of musculoskeletal disorders (MSD) experienced by all employees of the production department, especially the most severe ones found in activities such as *Hand Stacker* and *Material Handling*. Improvement efforts using the FGD method (*Focus Group Discussion*) have not given real results, so further research is needed for a better working atmosphere. From initial observations, it was found that the workers were working. They had a poor posture, namely bending over with an angle range of 48°-68°. A good posture of workers is bending or bending forward in the range of 20°-45° [1]. Poor posture when working continuously interferes with the safety and health of workers [2].

The GOTRAK Method measures the physical workload of the operator as a whole to improve the work system's optimality. Improving the work system using *a participatory ergonomics* (PE) approach involves all stakeholders, including the company's management, operators, and ergonomic experts [3].

2. Method

The method used to calculate MSDs is GOTRAK (Occupational Skeletal Muscle Disorder). Primary data was collected by measuring GOTRAK complaints and potential ergonomic hazards related to MSDs, especially workers' posture when carrying out work activities. The data on complaints of skeletal muscle disorders obtained are then categorized based on the level of risk, severity, and frequency experienced by each exposed limb according to SNI 9011:2021. At the risk level of severity, there are several categories, namely no problems (1), discomfort (2), pain (3), and severe pain (4). As for the frequency of complaints, they are categorized into never (1), sometimes (2), often (3), and always 3). The value obtained from the severity and frequency risk level is produced the risk level of GOTRAK complaints, which is divided into three categories, namely (1) Green (1-4) = low-risk level, (2) yellow (6) = medium risk level, and (3) red (8-16) = high-risk level. An overview of GOTRAK can be seen in Figure 1.

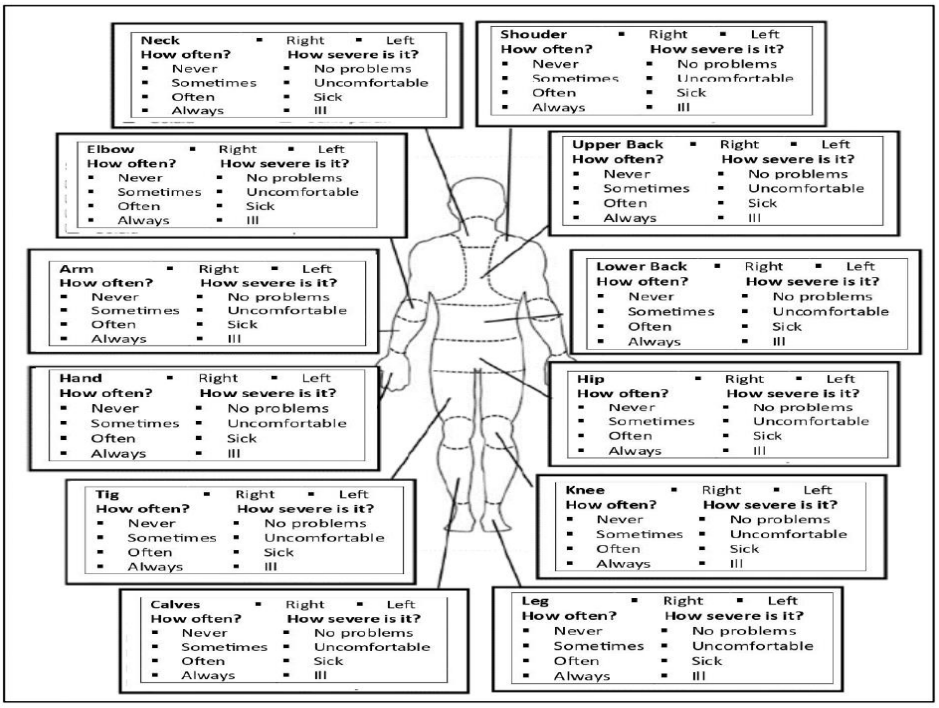


Figure 1 GOTRAK Survey

Source: BSN, 2021

Based on the GOTRAK SNI 9011 complaint identification questionnaire on the five research objects, it is known that the frequency and severity values experienced by each respondent can be seen in Figure 2

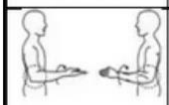
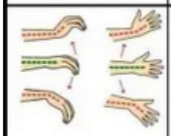
Categories of Potential Hazards	Potential Hazards	Exposure: Does the Potential Danger exist?	Percentage of exposure time (from total hours worked)			If the Total Working Hours > 8 hours, add 0.5 per hour	Score
			0% - 25 %	25% - 50 %	50% - 100 %		
UPPER BODY HAZARD CHECKLIST							
Awkward posture 	1. The neck is twisted or bent. Neck twisting > 20°, and/or neck bent forward > 20° or backward < 5°	Yes No	0	1	2		
	2. Shoulder: unsupported arms or elbows above abdominal height	Yes No	1	2	3		
	3. Rotate the forearm quickly	Yes No	0	1	2		
	4. Wrist bent forward or sideways	Yes No	1	2	3		
Arm movements	5. Medium arm movement: Steady movement with regular pauses	Yes No	0	1	2		

Figure 2 GOTRAK Survey Appendix D

Source: BSN, 2021

The measurement method is to check the potential danger in each limb, the percentage of exposure time to potential danger, and the score of the potential risk experienced by each limb. The intensity of activity, direct pressure on the body, vibrations felt by the body, repeated efforts, and others are also one of the considerations for calculating the level of MSDs risk experienced by workers [4], [5]. After an analysis of the worker's posture during the activity, the entire number of values will be added and become the total hazard factor score.

A.GOTRAK measurement on *Hand Stacker activity*

The production process carried out at PT X is carried out for 8 hours in one working day. The production process takes place from 08.00 WIB to 17.00 WIB with a break that lasts for 1 hour, which starts from 12.00 WIB to 13.00 WIB. The production process can be seen in Figure 3.

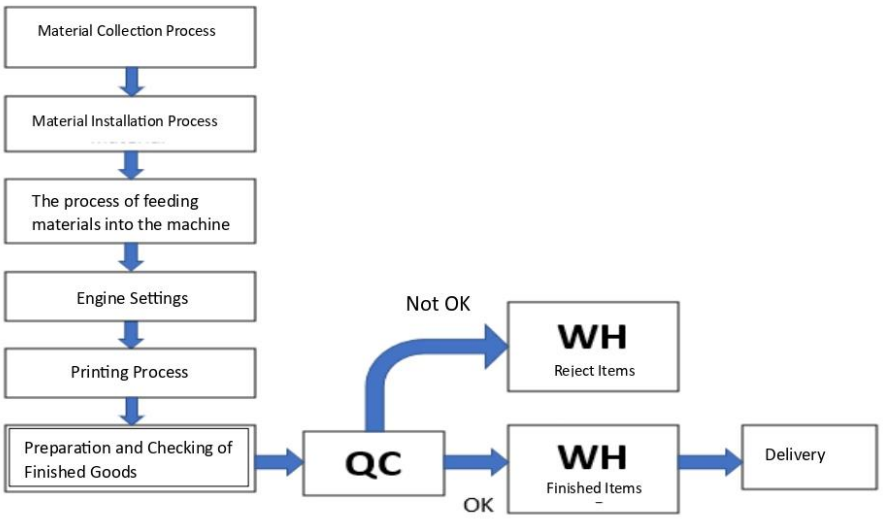


Figure 3 Production Process Flow Diagram

Figure 3 shows that there are at least seven stages in the production process that must be passed during the light steel manufacturing process at PT X. The initial stage that must be carried out is the process of picking up materials using material handling coils to the uncoiler machine which will be carried out with a hand stacker. Then, the operator will install the coil material using a hand stacker by pumping the hand stacker until the coil enters the uncoiler machine. Next, the operator will input the material into the product printing machine, where the coil material plate that has been installed will be inserted into the machine for printing. After that, the coil material will be set to adjust the length and thickness of the product as well as the amount of production output to be printed. This process will take place with a cycle time of about 5 minutes. After that, the finished product will enter the stage of preparing and checking finished product, where the finished product will be arranged and stored around the production area to be carried out by a product inspection process by Quality Control (QC) officers to see if the finished product produced is by the desired specifications. If there is a defective product/reject, the product will be rejected, and no repair process will occur. Finally, the Quality Control officer will send the finished product that has passed the check to the consumer.

Furthermore, a data collection process will be carried out, with the data collected in this study being GOTRAK questionnaire data. Table 1 shows the results of the recapitulation of the GOTRAK calculation.

Table 1 Assessment of Complaint Risk Level Using the GOTRAK Method

Part of Body												
Name	**Neck**	**Shoulder**	**Upper back**	**Elbow**	**Arm**	**Hand**	**Lower back**	**Hip**	**Tig**	**Kne**	**Calf**	**Leg**
Adi Rahmat Hidayat	0	0	0	0	4	6	6	6	0	0	6	4
Andi Ahmad Dani	0	0	0	0	4	0	8	6	0	0	8	4
Arif Rahman Hakim	0	0	0	0	4	0	6	4	0	0	6	4
Ariffin Saputra	0	0	0	0	4	4	8	4	0	0	8	6
Asep Permana	0	0	0	0	4	6	8	4	0	0	6	0
Kamaludin Hasan	0	0	0	0	4	4	8	6	0	0	6	0
Kiki Damiki Muharam	0	0	0	0	4	0	6	4	0	0	4	6
Ridki Ardiansah	0	0	0	0	4	0	6	4	0	0	6	0
Said Hermawan	0	0	0	0	4	0	6	4	0	0	4	0
Yoga Swara	0	0	0	0	4	0	6	4	0	0	8	0
Total Score	**0**	**0**	**0**	**0**	**40**	**20**	**68**	**46**	**0**	**0**	**62**	**24**
Average Score	**0**	**0**	**0**	**0**	**4**	**2**	**6.8**	**4.6**	**0**	**0**	**6.2**	**2.4**
Risk Level					**Low Risk Level**	**Low Risk Level**	**Medium Risk Level**	**Medium Risk Level**			**Medium Risk Level**	**Low Risk Level**

In the GOTRAK questionnaire, respondents will fill in the level of complaints and the frequency of complaints experienced in body parts. The body parts observed include the neck, shoulders, upper back, elbows, arms, hands, lower back, hips, thighs, knees, calves, and feet. Each body part measured is divided into two parts, namely the left and right parts. The following is a table recapitulating the assessment of the level of complaint risk in all workers.

Table 1 shows a recapitulation table of assessing the risk level of body part complaints. Based on this information, it was found that the workers' body parts that had a moderate risk level were the lower back, hips, and calves, while the body of the arms, hands, and legs had a low risk of complaints. Thus, some parts of the body have the potential to experience MSD disorders, especially in the lower back, hips, and calves.

B. GOTRAK Measurement on Material Handling Activities

The calculation of the risk level of MSDs is carried out for workers who are carrying out material handling activities using the GOTRAK method can be seen in Table 2

Table 2 GOTRAK Calculation Score

Posture Score	5
Load Lifting Score	1
Total Score	**6**

The calculation results show that a value of 6 is obtained, which is included in the medium risk level category. This is because in carrying out material handling activities, workers must pull and grasp the hand truck to be able to move and direct the direction of movement of the hand truck.

3. Discussion

A. Proposed improvements to *Hand Stacker activities*.

Based on the results of the first focus group discussion (FGD), the researcher said that there is a need to improve the posture of workers when operating the hand stacker because the operator's posture is very bent and not by the standard working posture, where the worker's posture is too bent with an angle range of 48°-68°. Workers' good posture when they have to bend or bend forward is in the range of 20°-45° [1]. Research poor posture at work can interfere with workers' safety and health; in this case, the health of workers who are disturbed is the skeletal muscle health of workers. Therefore, the work system that can be improved is to improve the operator's posture by eliminating the habit of bending over from the operator himself. At this stage of the discussion, the ergonomist recommends good posture for the operators of the hand stacker machine. The recommended posture is a firm body position so that it is perpendicular to the floor surface. In addition, the researcher also advised that the distance between the operator and the hand stacker machine is not too far during the operation of the hand stacker. The following are postures that have been improved [2].

Figure 4. Improvement of Workers' Posture

The results of the posture improvement are expected to make it easier for operators to pump *coils* on the *hand stacker*, considering that the posture improvement presented by the researcher can make it easier for the operators' feet to pump *the* coils on the *hand stacker*. In addition, the operator also easily grasps the handle on the *hand stacker* so that workers can more easily control the movement of the hand stacker machine. Based on discussions with management, workers will be accustomed to an upright posture when pumping *coils* on the *hand stacker*. The results of the posture improvement are expected to make it easier for operators to pump *coils* on the *hand stacker*, considering that the posture improvement presented by the researcher can make it easier for the operators' feet to pump *the* coils on the *hand stacker*. In addition, the operator also easily grasps the *handle* on the *hand stacker* so that workers can more easily control the movement of the hand stacker machine. After this posture improvement is carried out and further discussed by the company, this improvement proposal is believed to reduce the risk of MSD on the body of *the hand stacker* operator.

Furthermore, to maintain the operator's posture while operating *the hand stacker* machine, it is necessary to have an assistive device to support the posture so that the assistive device can encourage/maintain a good operator posture. Therefore, a tool, namely a back support belt, will be recommended. *A back support belt* is an ergonomic aid designed to provide additional support to the lower back, which helps maintain proper posture when lifting heavy weights or standing for long periods. Using a back support belt can help reduce the risk of muscle injury and back fatigue, especially in jobs involving intense physical activity [6]. The recommended type of *back support belt* is *a contoured back support belt.* The following are the recommended *contoured back support belt* aids.

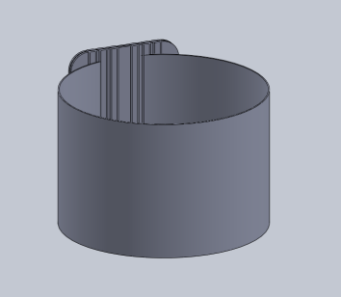


Figure 5. ***Contoured Back Support Belt***

Based on Figure 3, *the Contoured Back Support Belt* is the most suitable choice for maintaining the operator's posture while bending. The belt's ergonomic design follows the natural curve of the back, providing targeted support to the lower back that is most susceptible to injury during lifting or physical activity. The center of the belt is equipped with thicker support panels, providing extra support to critical areas of the lower back.

Furthermore, the participatory ergonomics *process will be carried out* through the second *focus group discussion* (FGD) session, which discusses the level of mental workload of workers and the improvements that can be made. This FGD process will be carried out on June 12, 2024. In this discussion session, the parties involved in *participatory ergonomics* are representatives of *production managers*, operators 2 and 3, and researchers in ergonomics. The second *stage of focus group discussion* ensures the implementation of programs and concepts agreed upon by the three parties. Two proposals have been agreed upon, namely facilitating *training* for *hand stacker* operators and making *standard operating procedures* (SOPs) for *hand stacker operators*.

B. Proposed Improvements at *Material Handling Stations*

Repairs made using the PE Method produced two Shoulder Pad Aids and Ramp Aids that can increase the company's efficiency in areas where no helper assistance is needed and only one worker is needed to carry out material handling activities.

The aid in the form of *a Shoulder Pad* can be seen in Figure 6.

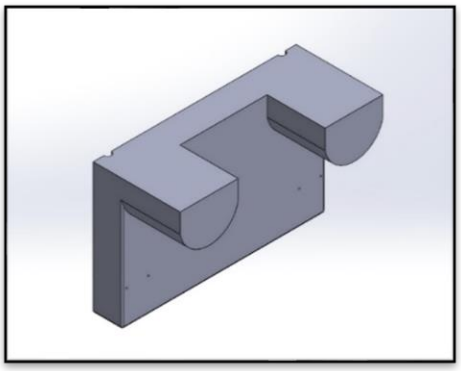


Figure 6 Shoulder *Pad Aids*

Figure 6 is a three-dimensional shape of one of the design aids for activities *material handling*, that is, a *shoulder pad.* This tool assists operators in carrying out material handling activities and can push the load of the iron coil from the hand truck *to make it* easier. This is because, in pushing movements, the operator uses the help of body weight, pushes using feet, pushes using hands, and pushes using the shoulders to move the *hand truck.* The design uses data from the D3 shoulder height 95th percentile of 156.99 cm minus the D5 hip height 95th percentile of 119.27 to determine the size of the torso of Indonesians. The calculation results were 37.72 and rounded upwards so that the body size of Indonesians was obtained at 40. The length of the aid of 45 cm is the value of the size of the torso of Indonesians plus a few additional centimeters that function as additional cushioning in the aid.

Ramp Aids

An overview of this tool can be seen in Figure 6.

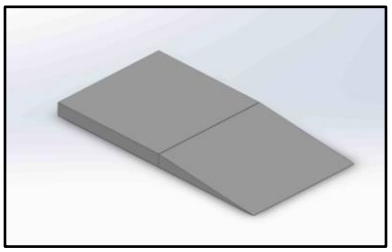


Figure 7. Ramp Aids

In the Ramp aid, the basic principle of inertia is used where an object remains stationary or moves straight and regularly to maintain its position or state [7]. By using a heavy slope, the load can be moved to a higher place more efficiently, meaning that the force we output becomes smaller when compared to not using a slope [8]. By raising *the hand truck on the tool ramp, less energy can be used to move the hand truck that has* lifted the iron roll. It is designed with a height of 20 cm and with a tilt of 80 to ensure that the operator can feel the advantages of using the inclined plane but not so great that it results in the Hand Truck, which is carrying the iron coil, *being* subjected to too high an acceleration and cannot be controlled by the operator. On the design of the tool ramp, a flat plane length x width is used for the tool of 160 cm x 160 cm. Sized at 160 cm in length and width to ensure there is enough space to rotate the tool Hand Truck and also for operators to push the *hand truck.*

The next stage is the evaluation of *the Shoulder pads* and Ramp Aids that have been made using simulations. In this evaluation, four operators were tested using the two tools, and then the GOTRAK value was measured. The average results of the four operators can be seen in Table 3.

Table 3. GOTRAK Calculation Score Proposed Improvement

Posture Score	4
Load Lifting Score	1
Total Score	**5**

Table 3 is the result of GOTRAK calculations that have been carried out on the proposed work posture of the activity *Material Handling* Using the Aids *Ramp* and *shoulder pad*. In measuring GOTRAK, it can be seen that the movements made by the operator's limbs during activities *Material Handling* With the conduct of the simulation. As a result of the observation, a value of four was obtained for the worker's posture, and one was obtained for the manual weight lifting. A value of four was obtained in the calculation of posture risk because several limbs move unusually when doing activities.

In determining the level of GOTRAK risk experienced by workers, observations are made of the worker's posture when carrying out activities. In determining the GOTRAK score value, the length of time the limb is exposed to activities that cause the limb to move is also not generally considered. A situation that can simulate actual working conditions in the field is used to calculate the risk level of MSDs using GOTRAK. The simulation was carried out using a bearing that functions as an aid and is used by a machine for sports *Treadmill*, which is simulated as the part of the handle where the tool is placed and the part of the iron rod that the operator will hold when performing the tivity *material handling.*

Figure 8. Posture Simulation Using Tools

Figure 8 can be seen as a situation simulation for GOTRAK calculations regarding the proposed design of workers' postures using assistive devices. In the proposed design, the worker's wrist does not bend forward or sideways, reducing the risk of MSDs on the worker's limbs.

Using tools reduces the risk level of MSDs and streamlines the work *of Material Handling so that activity Material Handling alone without help Helper and with a tolerable level of MSD* risk. The following will be presented with photos of the use of both aids and workers' postures.

Figure 9. Design of Proposed Improvements Using Assistive Devices

Figure 9 is a draft improvement proposal that will be calculated using GOTRAK to reduce the level of risk experienced by workers.

Improvements need to be made from the results of measurements using the GOTRAK method. To make the right improvements, it is necessary to have discussions with stakeholders, namely *Participatory Ergonomics* [9],[10],[11]. Deployment process *participatory ergonomics* done by the *Focus Group Discussion* (FGD) two times, namely, the first discussion session will be discussed related to the physical workload of the workers and the improvements that can be made for the workers. The second discussion session will focus on the mental workload of workers and how to overcome these problems. The application of participatory ergonomics involves the company's management, hand stacker machine workers/operators, and researchers as ergonomics.

The FGD process, the first participatory ergonomics application, was carried out on June 11, 2024. The first participatory ergonomics process discussed the main problem of the company's workers' physical workload. At this stage, ergonomics experts introduced the concept of Participatory Ergonomics (PE) to the workers and then presented the results of the GOTRAK data processing that the researcher had carried out.

3. Conclusion

Based on the problems faced at the *hand stacker station, the work system that can be implemented* is to improve workers' posture when operating the hand stacker and use contoured back support belt aids. Meanwhile, at the *Material Handling Station*, the design of two assistive devices, namely the shoulder pad and ramp, can reduce the risk level of MSDs experienced by workers and improve working conditions in the company. Shoulder pads and ramps in *material handling* activities are better for workers than helpers because the risk level of MSDs is lower, and one worker can carry out material handling activities. *Helper* and get a score of 5 when using the tool in the *material handling activity.*

Based on the results of discussions with the management, after ten days of implementation, the improvement proposals for the workers experienced an improvement in performance and mental well-being. Not only that, but by creating a work environment that supports and implements the right solutions, companies can help workers work more optimally so that they can reduce the risk of physical and mental fatigue and increase worker productivity and welfare.

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.**Conflicts of Interest** Deceleration of Interest – None.

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