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Implementation of Ergonomic-Based Work Procedures Reducing Complaints of Postural Stress and Work Fatigue Resulting in Increased Employee Income and Company Profit

Wahyu Susihono[a,*], Ariesca[a], Lovely Lady[a]

[a]*Industrial Engineering Department, Faculty of Engineering, University of Sultan Ageng Tirtayasa, Banten, Indonesia*
*Corresponding author: *susihono@untirta.ac.id*

***Abstract*— In general, the manufacturing industry relies more on machine-based processes. However, in certain activities, human labor is still needed due to the limitations of the machine function, as humans are faster than the machine. However, the activities using human muscle power are at risk of *postural stress* and early work fatigue. Work fatigue will affect work performance and productivity. The Standard Operating Procedures (SOP), which do not consider work attitude, will result in inconvenience at work and complaints on body parts and decreased performance. Besides, it also causes the inability to meet production targets so that employees cannot reach the maximum wage, and the company suffers losses. The redesign of the Standard Operating Procedures (SOP) is needed to make people as the center of all improvement activities. The design used in this study was *treatment by subject design*. The results showed that there were differences (p <0.05) between pre- and post-intervention results, Decreased postural stress complaints (moment of compressive force) in posture 1 (7.31%), posture 2 (23.09%), and posture 3 (4.74%). In comparison, the reduction of work fatigue was obtained from 81.26±10.85 to 70.87±3.68 (12.78%). After the implementation of ergonomic-based SOPs, there was an increase in employee income by 25.23% or (IDR 2,068,091/month) and an increase in company profits (IDR 51,702,286/month). The implementation of ergonomic-based SOPs was able to reduce postural stress, fatigue, and to increase employee income and company profits.**

***Keywords*— Standard operating procedures; ergonomics; postural stress; fatigue; company profit.**

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I. INTRODUCTION

Manual Material Handling (MMH) Manual Material Handling (MMH) is a transportation activity carried out by one or more workers by lifting, lowering, pushing, pulling, transporting, and moving goods. Manual material handling activities (MMH) include lifting, lowering, pushing, pulling, and carrying, and the workers in this industry are at the risk of having physical hazards [1]. Nowadays, many companies have used modern tools to move materials to achieve efficiency and increase company productivity. Some manufacturing industries in developing countries are still needed to improve their working conditions [2]. Poor working conditions (the potential for injury and occupational diseases) can reduce productivity and work-life [3].

However, there are still activities found within the companies in the process of material transfer carried out manually using human labor (manual material handling). This happens because manual material handling has the advantage in terms of high flexibility and low cost when compared to other means of transportation. However, the manual material handling process cannot always be applied. This is because manual material handling activities in industrial work are at great risk as a cause of postural stress in the body. Postural stress is commonly found in low back pain and musculoskeletal pain in L5/S1.

Postural stress arises from the heavy activities of workers, unnatural work attitudes, inadequate use of tools, and unfavorable work environment conditions in manual material handling activities, either too hot or too cold, causes the non-optimal work performance. Work in the category of heavy activities carried out continuously has a negative impact on the health conditions of workers. Coupled with the release of mechanical energy that is repeated over a long period of time, causing musculoskeletal pain, such as repetitive strain injury, lower back pain, and hand arm vibration syndrome. Static work for a relatively long time can cause muscle and skeletal pains in the body [4].

The arising postural stress can cause the early work fatigue to occur. This fatigue can arise because the work posture is in discomfort. Fatigue is a body's protection mechanism, so that the body is protected from further damage and a signal activity of the body to rest immediately. Fatigue arises as a result of work attitudes and posture in the completion of activities without paying attention to ergonomic work rules. Work activities with process-based standard operating procedures often do not consider ergonomic regulations. Work with an unnatural attitude will affect such complaints in certain body parts. Workers will quickly be at risk of having complaints in the body.

The absence of ergonomic-based Standard Operating Procedures (SOP) will cause fatigue in activities. Physical fatigue arises due to physiological changes caused by continuous stimulation during work, whereas mental fatigue occurs in unstable mental conditions caused by overworking. The early work fatigue affects work productivity because there is a relationship between fatigue and labor productivity. The higher the level of fatigue, the lower the level of productivity. Physical fatigue has an impact on decreasing employee fatigue and productivity [5].

In a manufacturing company, some processes still require manual material handling activities because it is not possible to use machines/tools. There are products with drum packs, weighing about 178 kg - 200 kg. Since the weight of the product is impossible to lift, in the manual material handling process, the operator manually moves the drum from one place to another by turning the drum carefully so that it can move. In the product transfer process, it is found that the operator's work attitude is not natural, having forced movement of the body, as well as lifting and holding objects so that this work attitude indicates the risk of postural stress such as musculoskeletal disorders. Some manufacturing industries have taken many initiatives to redesign their workplaces based on ergonomic criteria [6]. The new ergonomic-based design can reduce stress and the possibility of injuries arising, allowing workers to do their jobs easily and comfortably [7]. To avoid the high level of excessive postural stress, the company has made improvements by providing manual material handling tools such as hand forklifts. With the help of a hand forklift, the operator will get it easier to handle the materials. However, the operation of the hand forklift requires a relatively long time (4 minutes), whereas the manual way only requires 1 minute 19 seconds to carry out the transfer activity. Therefore, the operators prefer to do manual material handling activities without using any tool. Eventually, the company made a policy to prohibit the use of these tools in material handling.

However, in carrying out work activities, the operators are working only based on the process-based standard operating procedures without getting new instructions related to the operator's work attitude in conducting their work activities, so that the activities conducted are not standardized. Each operator has its way of working, with the different standard times required to complete a different activity cycle without having a measurable standard of work.

Products weighing 178 kg to 200 kg normally cannot be lifted manually. To be able to be moved manually, we need a design of Standard Operating Procedures (SOP) that is safe and comfortable for the operator, using the ergonomics approach. Ergonomics is considered a discipline that deals with design [8]. The redesign of the Standard Operating Procedures (SOP) improves work and rule compliance [9]. The human factor is still considered in the design of new working mechanisms. The redesign and implementation of Standard Operating Procedures must pay attention to human capabilities and strengths.

There is a need to measure standard time in completing activities in one work cycle, so work can be said to be effective in the use of working time. Standard time can be used as an evaluation of employee performance so that it can simultaneously be used as parameters related to increasing company profits. There is a relationship between working conditions and economic improvement, especially for employees, the right working conditions will affect the sustainability of a company's business [10].

II. Materials and Methods

The design used in this study was treatment by subject design. The research subjects were treatment group I (before intervention) and treatment group II (after intervention).

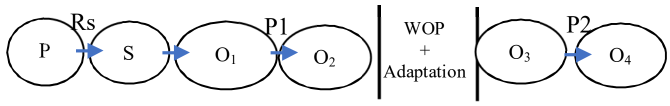


Fig. 1 Research Design

Information : P = Affordable Population, Rs = Random Sampling, S = Sample, P1 = Period I, P2 = Period II, O_1 = Observation of samples before work, before intervention, O_2 = Observation of samples after work, before intervention, WOP = Washing Out Period for removing residual effects, O_3 = Observation of samples before work, after intervention, O_4 = Observation of samples after work, after intervention.

In this study, the computation of the moment of compressive force on the L5/S1 body segmentation with the force biomechanics approach used the Maximum Permissible Limit (MPL) approach. This method started with the data of work attitude, load size, and body dimensions of workers as the subject of research. The calculation of force biomechanics was performed on the palms, forearms, upper arms, and back. The output was in the form of compressive force or compression (Fc) on the L5/S1 lumbosacral joint of the worker's body. The conclusion obtained was to compare with the standard, which was said to be safe when the compressive force is at a level of less than 6500N (L5/S1), while The Action Limit (AL) was 3500 (L5/S). Based on the standard value issued by (NIOSH, 1981), it is said to be safe if (Fc< AL), it is necessary to be careful when working if (AL<Fc<MPL) and it is dangerous if (Fc>MPL).

The work fatigue data were collected using a subjective self-rating test questionnaire consisted of 30 items by the Industrial Fatigue Research Committee (IFRC). The distribution of 30-item subjective self-rating test questionnaires by the Industrial Fatigue Research Committee (IFRC) was conducted at the beginning and end of every working day. The pre-test was conducted before the operators started their work activities in the morning, while the post-test was conducted after the operators completed their work activities in the afternoon. The data were collected before the intervention (working using the old standard operating procedures) and after the intervention (working using the ergonomic-based standard operating procedures). The calculation of Standard Time was done by calculating the value of cycle time, normal time, and allowance. Employee income and company profits were calculated using a simple economic analysis approach by comparing the standard time values, before and after the intervention (Period I and Period II).

The physical environment data were used as a control variable for the implementation of conditions before and after the intervention. The physical environment data collected included lighting, noise, temperature, humidity, and wind speed. The data collection was conducted three times in the morning, afternoon, and evening. The area of data collection was divided into three sub-areas according to the operators' work activities, namely the filling area, conveyor area, and finish a good area. At each sub-area, there were five points around the operators selected to collect the data.

III. Result and Discussion

Based on age characteristics, the average sample in this study was 33 ± 7.16 years. Based on Law No. 13 the Year 2003 Chapter 1 Article 1 Paragraph 2, it is stated that labor is included in the working or productive age, the working-age or productive age limit that applies in Indonesia is labor aged 15 to 64 years old. The need to know the respondent's age, because age affects the strength of bone and skeletal muscles. As a person ages, there is a decrease in muscle strength and bone strength [11]. So that the sample in this study included in the workforce at work age or productive. Age characteristics can affect the performance or productivity of operators in producing products; it is related to the condition of the human body, which will decrease with age. Activities are needed by adjusting someone's age at work.

Furthermore, based on body weight and height, it can be known the characteristics of the Body Mass Index (BMI) of research subjects of 21.12±1.71 kg/m2. The characteristics of BMI are related to obesity, where obesity can affect operator performance. Furthermore, based on the characteristics of the length of work, the average length of work was 73.90±91.65 months.

Based on the characteristics of education, it was known that 90% of the subject has high school educational background. The level of education will affect the ability of operators to accept new interventions or new ways of working in a working system as well as on the implementation of the ergonomic-based SOP, which will later affect their output and performance in the form of a moment score and compressive force, reduction in the level of fatigue, and decrease in standard time.

A. Physical Environment Data

The physical environment in this study served as a control variable. Since the design in this study was subject to treatment, there was no difference in the physical environment data between the application of period I (before the intervention) and period II (after the ergonomic intervention) with $p>0.05$. The physical environment did not contribute to affecting the results of the study, especially for study on people as research subjects. The physical environment affected the outcome of changes in some moments. The moments are when the compressive force of L5/S1 segmentation, the level of work fatigue and cycle time, normal time, and standard time.

The physical environment used as a control variable in this study consisted of lighting, noise, temperature, humidity, and wind speed. The data on physical environmental factors were taken at three different times, at 09.00 a.m., 12.00 p.m., and 03.00 p.m. The measurement results showed that the lighting level was 837.53±217.54 lux, while the noise level was 86.92±5.30 dB, the temperature was 28.94±1.00 ºC, the humidity was 63.84±0.88%, and the wind speed was 0.48±0.59 m/s.

The measurement results of this physical environment, when compared to the Threshold Value (NAB) of the Decree of Minister of Health of the Republic of Indonesia number 1405 of 2002 concerning the office and industrial work environment health requirements, the lighting level, has met the requirement in NAB of minimum 200 lux.

The noise level (86.92±5.30 dBA) exceeds the threshold value of NAB of 85 dBA. Therefore, there should be further evaluation conducted to avoid workers exposed to noise during work activities. Noise level greatly affects the body's physiological conditions and work productivity. Noise control can be done by reducing work time (reducing the intensity of noise exposure to workers) or the use of personal protective equipment (PPE) on their ears. The temperature of 28.94±1.00 ºC (NAB of 18-28 ºC) is categorized as safe. However, it is better to adjust the room temperature for conditions in Indonesia to be 24-28 ºC, to obtain comfortable and safe working conditions.

The humidity is 59.84±0.88% (NAB of 40-60%). Although the humidity is within the range allowed, but it is still at the upper limit so that there should be an evaluation conducted to control the humidity in the room. The wind speed is 0.18±0.59 m/s (NAB of 15-0.25 m/s). The wind speed in the room is in a safe condition and categorized as allowed to work. The difference test results on physical environmental factors, namely: lighting, noise, temperature, humidity, and wind speed, showed that there is no significant difference between the condition of the physical environment, before and after the intervention.

B. Postural Stress of the Workers

The moment and compressive force magnitude on the spine (L5/S1) are influenced by the load, body weight, length of segment length, and the angle formed by the limb segment. The angle is influenced by the way and position of the worker when lifting or pushing a load.

In order to improve the way and position of workers during the Manual Material Handling (MMH) activity, there is a need of Standard Operating Procedures (SOP) based on operator comfort and safety while working for the operators. The SOP is a series of written instructions documenting routine activities or processes that must be carried out by every worker in completing a work activity. The main purpose of implementing SOP is to avoid mistakes in working on a work process. SOP is a guideline in work activities. Standard Operating Procedures (SOP) are needed to improve performance compliance and improve work safety [12].

A good SOP should be able to provide clear information related to work activity guidelines. Before the intervention, there was only an SOP based on work processes available, without giving detailed instructions on work attitude that must be carried out by the operators. Therefore, there are various body movements found in different operators in completing work. The time needed to complete one unit of product between employees is different, differences in work attitude affect different body complaints. Variation in posture can reduce the burden on the spine [13]. A new SOP is needed to obtain better work standards. The ergonomic redesign can improve user performance [14]. The principle of ergonomic-based SOP is user-based improvement, facilitating user activity and standardizing body movements while still considering work safety and comfort. It is a user-cantered design for safety and comfort [15].

C. Changes in Standard Operating Procedures (SOP)

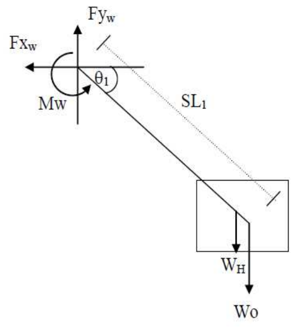
The Standard Operating Procedures (SOP) for the filtration process in the manufacturing industry is divided into two main categories. Table 1 below indicates before and after the ergonomic-based intervention.

TABLE I
THE STANDARD OPERATING PROCEDURES (SOP) FOR FILTRATION PROCESS IN THE MANUFACTURING INDUSTRY.

SOP Before Intervention	SOP After Intervention
Check the drum above the conveyor	Use both hands to move the drum to the conveyor
Check the identity of the drum, if necessary, clean the valve cap.	Use the right hand to clean the dust on the valve cap
Perform the codding process	Use one hand to write the identity of the filling order
Prepare the filling process for the resin	Hold the key with right hand to turn the valve cap, while the left hand holding the hose
Ensure the position of the hole to be aligned with the fill valve, double-check the numeric position on the scale	Use both hands to adjust the position of the hole to make it parallel with the filling valve, the activity is carried out in the position of the drum above the scale to make it numerically stable
Start the engine by pressing the On button	Use the right hand to press the on button
Repeat for the other 5 drums until all drums are filled with resin.	Repeat for the other 5 drums in the same attitudes until all the drums filled with resin
Close the valve, and make sure the valve cap lock is properly installed	Use the left hand to close the valve, while the right hand holding and directing the valve cap lock
Paste seals and clamps on the resin-filled drum, making sure that it is fully closed	Use the left hand to take the seal, while the right hand taking the clamp. Aim both together to the valve
Move the drum to the finish good area	Get the body in upright position (vertical), while both hands pushing the drum together
	Get the right leg in stance position, then roll the drum to the left to the designated area, scroll the next drum with the right sideways position
Take the product samples for checking	Use the left hand to carry the container, while the right-hand carrying tools to take product samples
Send the product samples to the laboratory for checking the clarity and micro gel	Use both hands to carry the samples right in front of the chest, so that the body is balanced in carrying the load

The magnitude of moments and forces can be calculated by evaluating both partially or calculating each segment that makes up the human body—the formula for calculating the compressive force or compression in (L5/S1) [16].

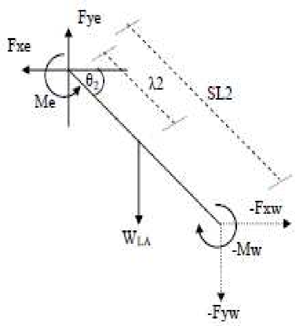
Hand



$\Sigma Fy = 0$
$\Sigma Fx = 0$ (No horizontal Force)
$\Sigma M = 0$
$WH = 0{,}6\% \times W\ body$ (1)
$Fyw = Wo/2 + WH$

$Mw = (Wo/2 + WH) \times SL1 \times \cos \theta 1$

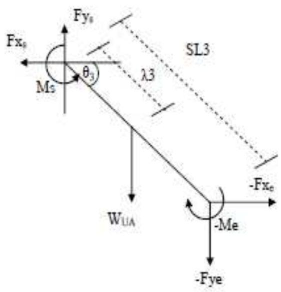
Forearm



$\Sigma Fy = 0$
$\Sigma Fx = 0$ (No horizontal Force)
$\Sigma M = 0$
$\lambda 2\ 0 = 43\%$
$WLA = 1{,}7\% \times W\ body$ (2)
$Fye = Fyw + WLA$

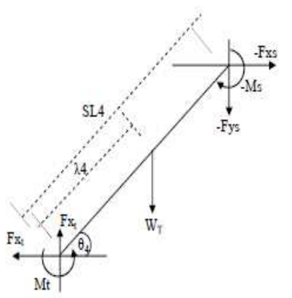
$Me = Mw + (WLA \times \lambda 2 \times SL2 \times \cos\theta 2) + (Fyw \times SL2 \times \cos \theta 2)$

Upper arm



$\Sigma Fy = 0$
$\Sigma Fx = 0$ (No horizontal Force)
$\Sigma M = 0$
$\lambda 3 = 43{,}6\%$
$WUA = 2{,}8\% \times W\ body$ (3)
$Fys = Fye + WUA$
$Ms = Me + (WUA \times \lambda 3 \times SL3 \times \cos\theta 3) + (Fye \times SL3 \times \cos \theta 3)$

Back



$\Sigma Fy = 0$
$\Sigma Fx = 0$ (No horizontal Force)
$\Sigma M = 0$
$\lambda 4 = 67\%$
$WT = 50\% \times Wbadan$ (4)
$Fyt = 2Fys + WT$
$Mt = 2Ms + (WT \times \lambda 4 \times SL4 \times \cos \theta 4) + (2Fys \times SL4\ v \cos \theta 4)$

By using force balance calculation techniques in each segment of the human body, the resultant moment (L5/S1) was obtained. Furthermore, in lifting activity, the moment (L5 / S1) is balanced by the muscle strength in the spinal erector (FM), which is quite large, and the strength of the stomach (FA). Stomach pressure works to maintain body stability over the influence of moments and forces. The muscle force on the spinal erector is formulated as follows [17]:

$$F_M \times E = M_{(L5/S1)} - F_A \times D \text{ (Newton)} \quad (5)$$

Information:

FM = Muscle style on the Spinal Erector (Newton)
E = Arm Length spinal erector muscle moment of L5 / S1(estimation 0.05 m)
M(L5/S1) = MT; The resultant moment at L5 / S1
FA = Stomach Force (Newton)
D = Distance from abdominal force to L5 / S1 (0.11 m)

So, to find the strength of the abdominal (FA), it is necessary to find the abdominal pressure (PA) with the equation:

$$PA = \left| \frac{10^{-4}[43-0,36(\vartheta_V+\vartheta_T)][M_{L5/S1}]^{1.8}}{75} \right| \text{ (N/cm}^2\text{)} \quad (6)$$

$$FA = PA \times AA \text{ (Newton)} \quad (7)$$

$$W_{total} = Wo + 2W_H + 2W_{LA} + 2W_{UA} + W_T \quad (8)$$

The limit of normal lift (AL) on L5 / S1 is 3500 N, and the limit of the great compressive force (MPL) is 6500 N. Compressive force (L5 / S1):

$$F_C = W_{TOTAL} \times \cos\theta_4 - F_A + F_M \text{ (Newton)} \quad (9)$$

In the skeletal system of the human body, there are several vulnerable points, such as the cervical spine, groin, and L5/S1 vertebrae. The spinal column (L5/S1) is the most vulnerable point to work-related accidents because, at that point, there is a fluid-filled membrane (disc) that serves to dampen the movement between the 5th lumbar and the 1st sacrum. If the pressure is caused by a lifting load or a compressive force that exceeds the Maximum Permissible Limit (MPL), then it can cause the rupture of a fluid-filled membrane (disc), which can also result in dysfunction or often known as paralysis. Body posture analysis is needed to determine the Maximum Permissible Limit (MPL) of each work activity.

The biomechanics of bone is a behavior or response to strengths and moments that are affected by bone mechanical properties, geometric attributes. Bones are anisotropic, formed from viscoelastic material [18]. Based on the figure (Posture 1a), the Force Compression (FC) value of 2359.3829 N was obtained. This score is categorized as safe because it is lower than the Action Limit (AL) value of 3500 N, also lower than the Maximum Permissible Limit (MPL) value of 6500 N, while (Posture b) has a score of FC 2187,0004 N, which is also categorized as safe. The implementation of ergonomic-based SOP can reduce the moment and compressive force (7.31%) in posture 1b. The redesign was able to reduce the risk of work. The ergonomic redesign was able to increase productivity at a significant level [19]. Force, compression center and sacral load, and the combination of independent pelvic rotation and inclination regulated the shear force and compression of the sacral interface [20].

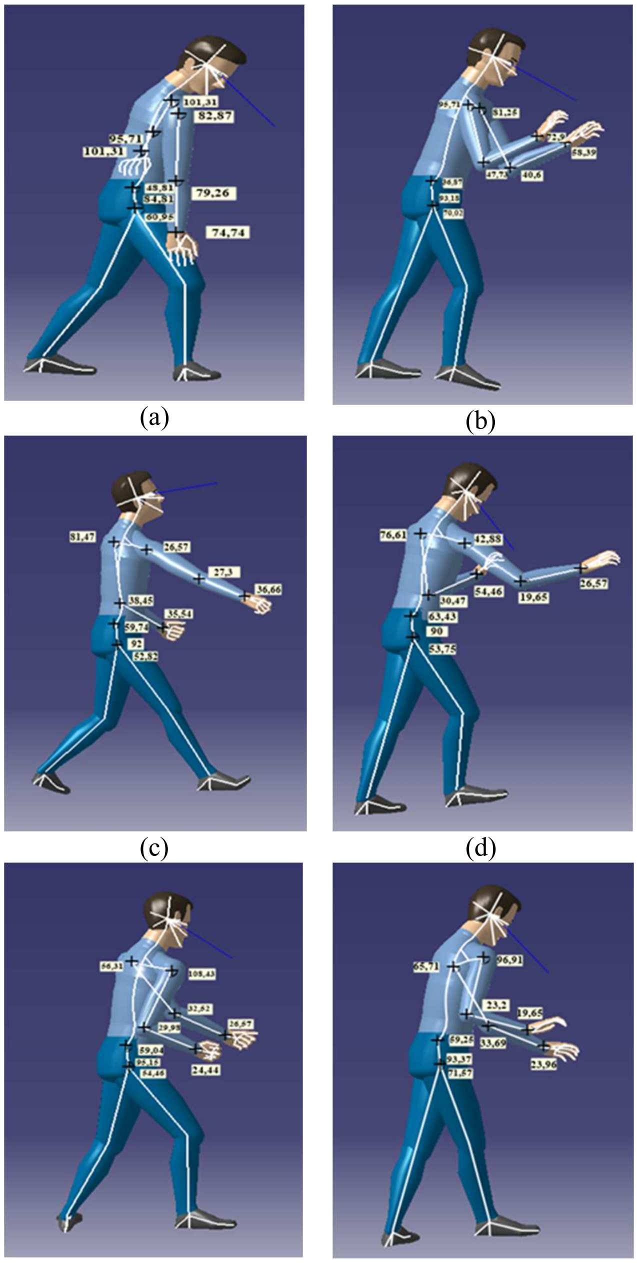


Fig 2. The Posture of the Body Before and After the Intervention. Posture 1 (Fig. a; before Intervention, Fig. b; after intervention).The activity of the operator pulling the drum from the filling machine to the end of the conveyor using the left hand, as far as 2 meters. Posture 2 (Fig. c; before Intervention, Fig. d; after intervention). The activity of the operator pulling the drum down from the conveyor to the floor using both hands with the help of a leg to hold the drum, avoiding it getting slipped. Posture 3(Fig.e; before Intervention, Fig. f; after intervention). The activity of the operator rotating the drum from the conveyor to the good finish sub-area using both hands with a vertical tilt angle of ±45°

The MPL (Maximum Permissible Limit) method requires input data of the posture range or angle of activity position, load size, and the evaluated human size. The analysis process was started by calculating the forces that occurred on the palms, forearms, upper arms, and back. The resulting output was in the form of compressive force (Fc) on L5/S1. The Action Limit (AL) of normal lift limit is 3500 at L5/S1. In details, the dimensions of the worker's body to obtain the results of work activity recommendations can be seen in (Figure 1), and the Size of the Worker's Body Segment (Table 2 and 3).

TABLE II
WORKER'S BODY DIMENSIONS

Body Segmentation	Length (m)	Angle		Cos	
Posture (1)		Right	Left	Right	Left
Hand (SL1)[a]	0.18	74.74	101.31	0.263	-0.196
Hand (SL1)[b]		72.9	58.39	0.290	0.524
Forearm (SL2)[a]	0.24	79.26	95.71	0.186	-0.099
Forearm (SL2)[b]		47.73	40.6	0.672	0.759
Upper arm (SL3)[a]	0.29	82.87	101.31	0.124	-0.196
Upper arm (SL3)[b]		95.71	81.25	-0.099	0.152
spine (SL4)[a]	0.47	48.81		0.658	
spine (SL4)[b]		36.87		0.799	
Stomach Inclination[a]		84.81		0.090	
Stomach Inclination[b]		93.18		-0.055	
Thigh Inclination[a]		60.95		0.485	
Thigh Inclination[b]		70.02		0.341	

Body Segmentation	Length (m)	Angle		Cos	
Posture (2)		Right	Left	Right	Left
Hand (SL1)[a]	0.18	36.66	35.54	0.802	0.814
Hand (SL1)[b]		26.57	54.46	0.894	0.581
Forearm (SL2)[a]	0.24	27.3	38.45	0.889	0.783
Forearm (SL2)[b]		19.65	30.47	0.941	0.861
Upper arm (SL3)[a]	0.29	26.57	81.47	0.894	0.148
Upper arm (SL3)[b]		42.88	76.61	0.732	0.231
spine (SL4)[a]	0.47	59.74		0.504	
spine (SL4)[b]		63.43		0.447	
Stomach Inclination[a]		92		-0.035	
Stomach Inclination[b]		63.43		0.447	
Thigh Inclination[a]		90		0	
Thigh Inclination[b]		53.75		0.591	

Body Segmentation	Length (m)	Angle		Cos	
Posture (3)		Right	Left	Right	Left
Hand (SL1)[a]	0.18	24.44	26.57	0.910	0.894
Hand (SL1)[b]		19.65	23.96	0.941	0.913
Forearm (SL2)[a]	0.24	29.98	32.52	0.866	0.843
Forearm (SL2)[b]		23.2	33.69	0.919	0.832
Upper arm (SL3)[a]	0.29	108.43	56.31	-0.316	0.555
Upper arm (SL3)[b]		96.91	65.71	-0.120	0.411
spine (SL4)[a]	0.47	59.04		0.514	
spine (SL4)[b]		59.25		0.511	
Stomach Inclination[a]		95.19		-0.090	
Stomach Inclination[b]		93.37		-0.058	
Thigh Inclination[a]		54.46		0.581	
Thigh Inclination[b]		71.57		0.316	

The figure (Posture 2c) has a value of Fc 3670.4730 N, which is categorized as a caution because it exceeds the value of the Action Limit (AL). Posture 2c has an FC value of 2822,6994 N, which is categorized as safe. The implementation of ergonomics-based SOP was able to reduce the moment and compressive force (23.09%) in posture 2d. Based on the figure of Posture e, the Fc value is 3147.02 N, and Posture f has an Fc value of 2998.0162 N; both results are categorized as AL (FC <AL), means that the two postures are in the safe category. The implementation of ergonomic-based SOP was able to reduce the moment and compressive force (4.74%) in posture 3f. When a process is not functioning, a new Standard Operating Procedure is needed in order to obtain a better chance of success [21].

TABLE III
WORKER'S BODY DIMENSIONS

Body Segmentation	Right Body Segment			Left Body Segment			
	Hd	Fr	Ua	Hd	Fr	Ua	Ss
F_{YW}[a] (N)	107	116		107			
F_{YW}[b] (N)	107	116		107			
M_W[a] (Nm)	5	10		-3.8			
M_W[b] (Nm)	5	23		10.2			
F_{YS}[a] (N)			132			132	
F_{YS}[b] (N)			132			132	
Ms[a] (Nm)			14			-13	
Ms[b] (Nm)			20			35	
F_{YE}[a] (N)					116.7		
F_{YE}[b] (N)					116.7		
M_E[a] (Nm)					-6.4		
M_E[b] (Nm)					29.7		
F_{YT}[a] (N)							539
F_{YT}[b] (N)							539
P_A[a] (N/cm^2)							-0.1
P_A[b] (N/cm^2)							-0.1
F_c[a] (N)							2359
F_c[b] (N)							2187
Posture (1)							
Rc[a]				FC<AL<MPL			
Rc[b]				FC<AL<MPL			
Posture (2)							
Rc[a]				AL<Fc<MPL			
Rc[b]				FC<AL<MPL			
Posture (3)							
Rc[a]				FC<AL<MPL			
Rc[b]				FC<AL<MPL			

The ergonomic-based SOPs consider the natural movements of the operator's body. Postural movements which are made not naturally result in discomfort for the operators [22]; therefore, after the intervention, the value of the moment and the compressive force decreases. If there is still lower-back pain felt by the worker, this is more due to long-term work effects [23].

D. Work Fatigue

Work fatigue affects work performance. Fatigue can be caused by activities that are not safe and comfortable. Unnatural work postures can cause early fatigue. Fatigue is generally felt in the muscles [24]. Early fatigue causes workers to experience a decrease in work performance and productivity, especially for companies that apply for shift work until night. Shift work can cause interference with circadian rhythms [25]. In this study, the workers work for 8 hours, from 8.00 a.m. to 3:00 p.m. (with a 1-hour break). There was no shift to work in this company. The use of non-ergonomic SOP can cause work fatigue. Work fatigue can be in the form of general fatigue and fatigue in aspects of the activity, motivation, and physical condition. Changes in work fatigue before and after the intervention can be seen in Table 4. Based on Table 4, it can be concluded that the level of fatigue after the intervention experienced a very significant change ($p<0.05$). Fatigue before work between the conditions of treatment I (before the application of ergonomic-based SOP) with the level of fatigue before working on condition II (after the application of ergonomics-based SOPs) is the same or not significant ($p > 0.05$). The new SOP can improve the results of improvements in all system working conditions [26].

TABLE IV
LEVELS OF WORK FATIGUE BEFORE AND AFTER INTERVENTION

Fatigue type	Before intervention		After intervention		Change (%)
	Before work	After work	Before work	After work	
General Fatigue	66,8±5,4	81,3±10,9	66,8±2,5	70,9±3,7	12.8
Activity fatigue aspects	2,2±0,2	2,8±0,5	2,2±0,2	2,4±0,3	12.6
Motivation fatigue aspects	2,2±0,4	2,5±0,3	2,3±0,4	2,2±0,2	11.3
Physical fatigue aspects	2,2±0,3	2,9±0,6	2,2±0,4	2,5±0,4	14.3

The condition of general fatigue after the implementation of the intervention decreased by 12.78%; the highest contribution was in the aspect of physical fatigue (14.34%). This is very reasonable because the work completion process involves great muscle or physical energy, while the smallest contribution of change is in the aspect of motivational fatigue (11.29%). This is because the re-design is analytic to the posture image. The involvement or participation in the SOP redesign process was still minimal. Improving working conditions in the future requires participatory work for each employee to be more dominant, so they will feel valued for their existence, and the impact of this participatory level of motivation fatigue will decrease. Another reason is that workers are not only the subject of the perpetrators but are directly involved in providing input or new concept ideas. Sufficient training is also needed so that they will understand the new work patterns correctly. The implementation of Standard operating procedures needs to be complemented with training [27].

E. Standard Time and Financial Analysis of the Workers and Company

Standard time is needed for each industry to find out the work performance of each individual operator. Operators with performance above the standard time mean that that they have an advantage over the average work performance of employees in the industry. Standard time can be used as an initial benchmark in the selection of new employees in completing a work activity. Standard time can be used as a basis for improving the organization of a company's work. The choice of the organization that is comfortable with workers impacts the level of benefits (production efficiency) obtained [28].

There are some steps and formulas for calculating standard time with the stages of the process. The initial step is by determining the amount of data to collect (n), the level of confidence, and the degree of accuracy, followed by calculating the adjustment factor and the normal time and adding Allowance and Standard Time:

$$Wn = Ws \times p \tag{10}$$

$$Wn = Ws \times [1 + (f_1+f_2+f_3+f_4+f_n\ldots)] \tag{11}$$

$$\text{Standard Time} = \text{Normal Time} + \text{Allowance} \tag{12}$$

There were 30 cycle time data in this study. The collection of cycle time data was carried out using direct work time measurement techniques.

TABLE V
TIME, BENEFITS AFTER AN INTERVENTION

Time	Before intervention	After intervention	Change (%)
Cycle Time (seconds)	41.3±7.1	32.9±2.8	20.5
Normal Time (seconds)	41.5±6.5	33.0±0.4	20.5
Standard Time (seconds)	42.2±6.5	33.7±0.4	20.2
Worker's income (IDR / month)	8.199.288	10.267.380	25.23
Company Benefits (IDR / month)	204.982.206	256.684.492	

Based on Table 5, that the Standard Time before the intervention was 42.15±6.48 seconds, it decreased to 33.66±0.35 (20.15%) after the intervention, the implementation of ergonomic-based SOP. This decrease in standard time had an impact on the process of finishing work faster, reducing work fatigue, and decreasing workload, so workers have a better quality of work-life then. Having good working time can help employees manage work and personal demands, thereby increasing health and work-life balance [29,30], while redesigning standard operating procedures can improve effective production processes and improve standard production time [31]. This time reduction has a very significant impact. In treatment I, before the application of SOP of transferring materials in one day, it was on an average of 683 drums/day. After using the ergonomic-based SOP, the material transfer could reach 856 drums/day or having an increase in employee productivity in completing MMH activities with a difference of 172 drums/day. It provides benefits for workers and the company.

Based on Table 6, employee wages increased by 25.23% or IDR 2,068,091/month, and company profits increased by IDR 51,702,286/month after using the ergonomic-based SOP. All activities to improve working conditions and aim to increase employee productivity, can also be in line with improving the company's financial condition. Funds and incentives to employees and even managers support performance improvement [32,33].

Employee productivity can be seen from improving health by decreasing the level of postural stress and work fatigue complaints and increasing income for employees. As seen from the company, the company's profitability is part of the obligation to continue meeting the target, so that the company's productivity can be seen from the large profits achieved or the large savings of funds incurred from each financial accounting period. The company is obliged to protect all employees from maintaining safety to improve work productivity [34].

IV. CONCLUSIONS

The compressive strength of the L5 / S1 segmentation before the intervention was in posture 2 (3670.47 N), causing work attitudes to be unsafe. After the intervention, all work attitudes were categorized as safe, namely: 1. decreased postural stress complaints (moment of compressive force) at posture 1 (7.31%), posture 2 (23.09%) and posture 3 (4.74%); 2. reduced work fatigue from 81.26 ± 10.85 to 70.87 ± 3.68 (12.78%), and 3. decrease in fatigue from the aspect of the activity is 12.54%, the motivational aspect is 11.29%, and the physical aspect is 14.34%. This resulted in a change in standard time (33.66 ± 0.35 seconds), thereby increasing employee income by 25.23% or Rp 2068091 / month and increasing company profits by IDR 51702286 / month.

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