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DESIGN OF AN ERGONOMIC TROLLEY FOR PLATE HANDLING TASK USING OVAKO WORKING POSTURE ANALYSIS AND ERGONOMIC FUNCTION DEPLOYMENT

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ABSTRACT

The appointment of catering dishes at Dian Rasa Catering is currently still done manually by hand. Slouching work posture when lifting plates increases the risk of muscle and spinal injuries in workers. One way that can be done is to design ergonomic plate lifters. The design of an ergonomic trolley uses the Ergonomic Function Deployment (EFD) method. The attributes used are based on ergonomic aspects, which are effective, comfortable, safe, healthy, and efficient. Based on the attributes used, it can be seen the desires and needs of consumers for products which are then integrated with the technical characteristics of the tool. Obtained the results of the design of a catering plate lifter in the form of 3 plate racks with a radius of 21 cm that can accommodate 20 plates and trolleys with a height of 125 cm and the size of the trolley handle that can be adjusted according to the smallest body size (118 cm), on average (125 cm)) and maximum (132 cm). The results of the experimental an ergonomic trolley help the employee to lift the plate, improve time efficiency and reduce the risk of muscle and bone injury to the catering employee. After the use of plate lifting tools catering harvest workers labor posture scores using the OWAS method dropped to 1.

INTRODUCTION

Manual material handling (MMH) tasks, such as lifting, carrying and lowering objects, are still common in various industries, and contribute substantially to both the number of claims for musculoskeletal disorders (MSDs) and their resulting costs (Harari et al., 2020). In order to reduce the number and severity of MMH injuries, many studies have investigated worker motion and biomechanical loads during MMH tasks using Quality Function Deployment (QFD). Other studies using Ergonomic Function Deployment (EFD) to improve productivity at

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work (eg, Pradani et al., 2019; Kurniawan et al., 2019; Wu et al., 2020). Musculoskeletal disorders are injuries affecting muscles, bones, tendons, ligaments, and cartilage. Work-related musculoskeletal disorders (WMSDs) are multi-factorial in nature. Epidemiological studies have found an association between WMSDs and heavy load lifting, forceful exertion, awkward posture, repetition, and whole body vibration (Sarkar et al., 2016).

The proportion of SMEs in manufacturing exports and GDP is still relatively low compared to many companies due to the lack of application of innovative technologies, still relying on tools and traditional methods, the production process is inefficient, skilled workers are limited, not qualified and product standardization unclassified (Ginting et al., 2019). The design of assistive devices in the production process can produce significant benefits. Therefore, the design of work aids that are in accordance with the needs in terms of the production process to support quality, quantity and time, needs to be done in an effort to increase effectiveness and efficiency (Putra et al., 2016; Yuamita and Sary., 2017; Siska, M. and Gunawan, A. 2019). Catering or better known by the name of catering is a service that is in great demand for wedding events and for an agency. Catering or catering services were chosen because they have a lot of experience so they know the conditions, know the situation, know the terrain and know the technicalities of a party concept. Then this experience will be applied to various forms of food presentation. Catering services are experienced about indoor parties, outdoor parties, special guests, family invitations and others, so that various forms of food serving will be adjusted accordingly.

Improper manual material handling activities such as lifting heaps of heavy ceramic plates can cause harm and even accidents to employees. As a result of improper material handling activities, one of them is musculoskeletal complaints. Musculoskeletal complaints are complaints on the parts of the skeletal muscles that are felt by someone ranging from complaints that are very mild to very sick. If the muscle receives a static load repeatedly over a long period of time it can cause complaints in the form of damage to the joints, ligaments and tendons. Factors causing musculoskeletal complaints are excessive muscle stretching, repetitive activities, unnatural work attitudes, secondary causes and combined causes (Trenggonowati., 2017; Anggraini., 2017; Hidayako and Betanursanti., 2017; Sokhibi and Primadasa., 2019; Yamani and Munang., 2019; Siska et al., 2019).

A good intervention to reduce the negative effects is the ergonomic analysis of working postures and the subsequent development and implementation of corresponding corrective measures. The Ovako working posture analyzing system (OWAS) is a practical method for the ergonomic analysis and evaluation of working postures that was developed by the Finnish steel industry in the 1970s. OWAS was designed to be easy to use and is therefore accessible to ergonomically untrained personnel. Even though it uses a simplified sampling technique, OWAS provides reliable and valid results (Brandl et al., 2017; Kee et al., 2020).

Dian Rasa catering is one of the catering services in Pekanbaru where there are 15 permanent employees who have their respective job desks. Dian Rasa Catering usually accepts 400 to 4000 servings in a single order, where in a month Dian Rasa Catering gets an average of 1300 servings. The plates to be used are stacked 20 plates per stack with a weight of 13 kg, the plates are arranged each time they are used and after use. Based on the results of research and interviews with employees *catering*, at the time of the appointment of the plastic plates, there were some problems such as a very heavy stack of plates and the position of the lifting of the plates were still less ergonomic, repeated removal where employees lifted the stack of plates nearly 11 times to 33 times the appointment per person during work, and problems others are employees who must be careful when appointment, this can cause human error for catering employees. Figure 1. shows the stack of plates used for catering that is less ergonomic, namely stacked plates that are only wrapped in plastic so that there are problems with the awkward posture of employees when lifting.

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(a) (b) (c)

Figure 1. Manual Handling of Plate Lifting Process

Based on Figure 1, it can be seen that the employee is lifting the plate where the position of the body is bent with the hand supporting the plate. Figure 1 (b) can be seen the process of changing position from bending to upright position, and bending hand position by lifting plate loads. Figure 1 (c) can be seen after the lifting process and employees are lifting plates to go to the transport car, where the position of the hand bent with a heavy load. This appointment is done manually, repeatedly and is less ergonomic.

From the results of the spread of the Nordic Body Map questionnaire for 15 workers, there are several parts of the body that were complained of very sick by the catering staff, namely at the waist, buttocks, left and right forearms, and at the left and right wrists. Based on this background, it is needed to design of an ergonomic trolley for plate handling task using OWAS (Ovako Working Posture Analysis) and EFD (*Ergonomic Function Deployment*).

RESEARCH METHOD

Data processing using OWAS method.OWAS can be applied in direct observational analysis in the field or in later observational analysis using video records. To identify the working postures, work sampling is applied with a recommended sampling interval of 30 or 60 s (Brandl etal., 2017). After the working postures have been identified, the effects on the musculoskeletal system by the postural load are then evaluated. The OWAS action category is an ordinal scale but is applied to quantitative statistical analysis assuming an interval scale as with the RULA grand and REBA scores for comparing the three techniques (Kee et al., 2020). OWAS by evaluating posture divided into 4 segments, namely back, arm, leg, and weight load.

Validity Test is to determine whether the data obtained is valid or not, starting from the initial data to the last one, a data is said to be valid if r count is greater than r table. Relativity test is a test that is conducted to determine the reliability of the data that we can or get.*Ergonomic Function Deployment*(EFD) is a development of Quality Function Deployment (QFD) by adding a new relationship between consumer desires and ergonomic aspects of the product (Nurdin et al., 2018; Fargnoli et al., 2018; Mamagahani et al., 2019; Mistarihi et al. ., 2020). This relationship will complete the House of Quality matrix form which also translates intodesirable ergonomic aspects. The House of Quality matrix used in EFD was developed into the House of Ergonomic matrix. In this study the EFD method was perfected with an anthropometric approach.

Anthropometric data is used as a basis for designing the size of the product to be made. The data shared here are tables and figures presenting information on anthropometric measurements and the discomfort questionnaire of the human body for physically disabled workers. Also, the data supports a research paper in product design, development and assessment (Mistarihi, 2020). Anthropometry is the science which concerns with the human body dimensions and physical characteristics. Human factors engineers are always in need of. Anthropometry to improve their everyday consumer products to enhance the work environment, making it safer and more

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comfortable. This is done so that the product is designed to be ergonomic for its users and can function optimally.

The selection of concepts is done by screening and selecting the concept. Based on predetermined values and criteria. Then designed with product specifications that have been determined. These specifications are what will be used to make prototypes and tools. Making a prototype of a an ergonomic trolley for plate handling tasks is using Sketchup Software that serves to provide further understanding of the physical form of the tool. Then just do the design with real material. The test carried out aims to see the extent to which the design of the plate lifters that have been designed to work, in this case can overcome the problems and complaints experienced by the operator as described in the background. The design can be said to be good if the product has been able to reduce the level of complaints based on perceived by users (workers) as measured using the Nordic Body Map questionnaire. If the product test does not meet the criteria, the re-design concept will be improved

RESULTS AND DISCUSSION

Table 1 is a statement in the expectation level questionnaire given by workers at Dian Rasa Catering.

Table 1. Consumer Expectation Questionnaire

No	Statement
1	The plate lifter is easy to operate
2	The plate lifter is not easily damaged
3	Dishwasher have maximum capacity
4	Dishwasher has a size that is comfortable to use
5	Dishwasher has a good level of security
6	Dishwasher can reduce back, hip and leg pain
7	Dishwasher has an affordable price
8	Dishwasher easy in maintenance
9	Dishwasher has strong and durable (high quality) raw materials

Validity test aims to determine the extent of the accuracy and accuracy of a measuring instrument in carrying out its functions. Test the validity of each statement below is known the value of corrected item-total correlation of 95% confidence amounted to 0.8114. Product attributes are derived based on ergonomic aspects. These product attributes (Table 2) which then become the basis for the product attributes of an ergonomic trolley for plate handling task.

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Table 2. Product Attributes of Plate

Primary Attribute	Secondary Attribute	Tertiary Attribute
Effective	Easy plate lifting tool inside Operation	Simple tool design and work Helping employees lift plates faster
	The plate lifter is not easily damaged	Strong and durable material
	Plate lifter have maximum capacity	Maximum load capacity of 20 plates
Comfortable	Plate lifter has a size that is comfortable to use	The dimensions of the tool are in accordance with the anthropometry of harvest laborers
Secure	Plate lifter has a good level of security	Plate lifters do not harm harvest workers
Healthy	Plate lifter can reduce back, hip and leg pain	The design of the tool is according to the normal posture of the worker
Efficient	Plate lifter has an affordable price	Prices are in accordance with the reliability and quality of the product
	Plate lifter easy in maintenance	Easy to clean tool
	Plate lifter has strong and durable (high quality) raw materials	Material made of iron

Developing the House of Ergonomic (HOE), Based on the data that has been obtained, then the HOE matrix is made. Figure 2 is the results of the data processing recapitulation using the (EFD) method

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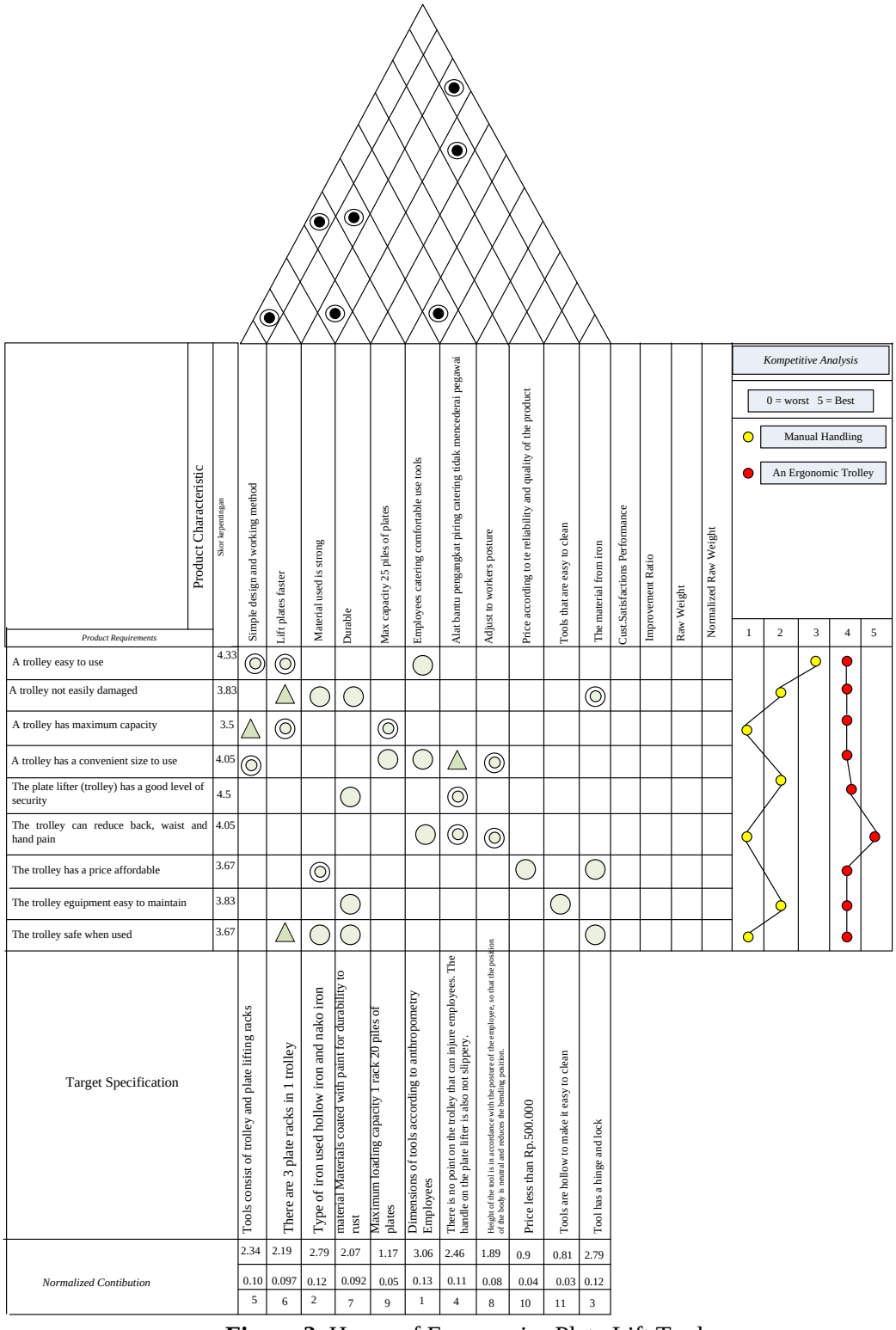

Figure 2. House of Ergonomics Plate Lift Tools

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The anthropometric data used in the design of an ergonomic trolley are in Table 3.

Table 3. Anthropometric Data

Anthropometric data	Use	Percentile	Size (cm)
Elbow Height Stand	Trolley height	5 th 50 th 95 th	118 125 132
Hold hand	Trolley Grip Hand diameter	5 th	4.5
Palm Width (up to thumb)	Hand Grip Length	95 th	10.8
Hold hand	Diameter of Hand Grip plate rack	5 th	4.5

The design of the an ergonomic trolley aims to provide an understanding of the physical form of the device (Figure 3).

Figure 3. An Ergonomic Trolley for Handling Task

Figure 4. describes the posture of Dian Rasa Catering's employees when lifting and moving plates.

Figure 4. Body Posture when Lifting a Plate

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From Figure . 4 the data of work postures carried out by workers on the activity of lifting plates by taking pictures when employees do the work, it can be seen that the pattern of activities carried out by these workers is very un ergonomic. The risk of spinal deformities such as kyphosis is very possible and can result in a decrease in the health quality of the workers themselves. Table 4 is a recapitulation of the assessment of catering employee posture when lifting piles of plates manually.

Table 4. Recapitulation of OWAS Calculation (Before Repair)

SKIP	CODE	INFORMATION
Back	2	Bend forward
Arm	1	Both arms are under the shoulders
Legs	7	Employees move or move
Load weight	2	the burden lifted by employees is 10 kg - 20 kg (10 kg <W ≤ 20 kg)

The results of the OWAS work attitude analysis are one of the four levels of the work attitude scale obtained from the OWAS code entered in the OWAS table in Table 5.

Table 5. OWAS Results Before Work Improvement

Back	Arms	1			2			3			4			5			6			7			Legs
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	Use Of Force
1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	
	2	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	
	3	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	
2	1	2	2	3	2	2	3	2	2	3	2	3	3	3	3	3	2	2	2	2	3	3	
	2	2	2	3	2	2	3	2	3	3	3	4	4	3	4	4	3	3	4	2	3	4	
	3	3	3	4	2	2	3	3	3	3	3	4	4	4	4	4	4	4	4	2	3	4	
3	1	1	1	1	1	1	1	1	1	2	3	3	3	4	4	4	1	1	1	1	1	1	
	2	2	2	3	1	1	1	1	1	2	4	4	4	4	4	4	3	3	3	1	1	1	
	3	2	2	3	1	1	1	2	3	3	4	4	4	4	4	4	4	4	4	1	1	1	
4	1	2	3	3	2	2	3	2	2	3	4	4	4	4	4	4	4	4	4	2	3	4	
	2	3	3	4	2	3	4	3	3	4	4	4	4	4	4	4	4	4	4	2	3	4	
	3	4	4	4	2	3	4	3	3	4	4	4	4	4	4	4	4	4	4	2	3	4	

The final score obtained on the Employee's posture is = 3. This means that this attitude is dangerous for the musculoskeletal system (work attitude results in a very significant tension effect). Need repairs as soon as possible. Furthermore, the employee's work posture after work improvement uses a plate lifting tool in Figure 5.

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Figure 5. Posture of the employee's body after using the Plate Lifting Tool

Table 6. Recapitulation of OWAS Calculation (After Improvement)

SKIP	CODE	INFORMATION
Back	1	Stand upright
Arm	1	Both arms are under the shoulders
Legs	7	Employees move or move
Load weight	2	the burden lifted by employees is 10 kg - 20 kg (10 kg <W ≤ 20 kg)

The results of the OWAS work attitude analysis are one of the four levels of the work attitude scale obtained from the OWAS code entered in Table 7.

Table 7. OWAS table

Back	Arms	1			2			3			4			5			6			7			Legs
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	Use Force
1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	
	2	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	
	3	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	
2	1	2	2	3	2	2	3	2	2	3	2	3	3	3	3	3	2	2	2	2	3	3	
	2	2	2	3	2	2	3	2	3	3	3	4	4	3	4	4	3	3	4	2	3	4	
	3	3	3	4	2	2	3	3	3	3	3	4	4	4	4	4	4	4	4	2	3	4	
3	1	1	1	1	1	1	1	1	1	2	3	3	3	4	4	4	1	1	1	1	1	1	
	2	2	2	3	1	1	1	1	1	2	4	4	4	4	4	4	3	3	3	1	1	1	
	3	2	2	3	1	1	1	2	3	3	4	4	4	4	4	4	4	4	4	1	1	1	
4	1	2	3	3	2	2	3	2	2	3	4	4	4	4	4	4	4	4	4	2	3	4	
	2	3	3	4	2	3	4	3	3	4	4	4	4	4	4	4	4	4	4	2	3	4	
	3	4	4	4	2	3	4	3	3	4	4	4	4	4	4	4	4	4	4	2	3	4	

The final score obtained on the Employee's posture is = 1. This means that in this attitude there is no problem in the musculoskeletal system (harmless). There is no need for improvement.

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CONCLUSIONS

After analyzing the working posture of workers using the Ovako Method Working posture Analysis (OWAS) comparison of work posture scores when before using a lifting device is 3 and after using a lifting tool that is 1 Employee posture can be categorized as ergonomics which at first bent to stand upright.

After designing an ergonomic plate lifter, the results are in the form of a trolley and a plate rack. Obtained the results of the design of a catering plate lifter in the form of 3 plate racks with a radius of 21 cm that can accommodate 20 plates and trolleys with a height of 125 cm and the size of the trolley handle that can be adjusted according to the smallest body size (118 cm), on average (125 cm)) and maximum (132 cm).

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