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Design of Brick Lifting Aids Based on Anthropometric Data to Reduce Physical Complaints in the Production Process at UD Jaya Usaha

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ABSTRACT

This study aims to design an ergonomic lifting aid tool based on anthropometric measurements to reduce physical complaints experienced by workers during the batako (concrete brick) lifting process at UD Jaya Usaha. Preliminary observations and interviews with company owners revealed frequent complaints of pain in the lower neck, waist, and both arms due to manual lifting activities. The research method includes direct field observation, anthropometric data collection, and analysis using data adequacy and uniformity tests. The design process refers to ergonomic principles and utilizes key anthropometric dimensions to ensure the lifting tool suits the workers' body posture and comfort. Results show that the proposed tool effectively reduces physical strain and categorizes the lifting activity as safe. The company is advised to implement the designed tool and re-evaluate its current work posture policy to improve worker health and performance.

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1. Pendahuluan

Technological developments over time have shown significant improvements in various industrial sectors. This progress is basically aimed at increasing the efficiency and effectiveness of the production process in the company. However, the increase in technology is often not balanced with the readiness of human resources (HR) and other supporting components that are the key to the success of technology adoption in supporting productivity (Miarso, 2007). Technology in this context is not only understood as hardware or software, but also as an integral part of a system that is integrated with the overall work process.

One important aspect that influences the progress of a company, in addition to the application of technology, is the capacity of human resources, working environment conditions, and the application of ergonomic principles in the production process. In many companies, manual activities such as transporting and lifting materials are still dominant, both in traditional and modern processes. Activities such as moving bricks, lifting spare parts, or the packing process, are often carried out without paying attention to adequate ergonomic principles, so that they have the potential to cause long-term health problems for workers.

Ergonomics is a science that focuses on human interaction with the work environment, taking into account aspects of human capabilities, limitations, and characteristics in order to increase comfort, safety, and work productivity (Chapanis, 1985). Ergonomic principles emphasize the importance of designing work systems that take into account work posture, physical load, and comfort to prevent health problems such as chronic fatigue and musculoskeletal injuries. These disorders are often known as *musculoskeletal disorders* (MSDs), namely complaints of the muscular and skeletal systems caused by static loads that are repeated over a long period of time (Tarwaka, 2004).

MSDs are one of the main risks in manual work, especially if not supported by ergonomically appropriate tool design. Poor ergonomic working conditions can cause physiological changes in workers, which in the long term have an impact on decreasing productivity and quality of life (Kuswana, 2016). Therefore, the application of an ergonomic approach, especially through anthropometric measurements, is important in designing work aids that are in accordance with the characteristics of the human body (Asy'ari, 2019).

UD Jaya Usaha, a manufacturing company engaged in the production of building materials such as paving, bricks, culverts, and concrete pipes, is one of the companies that still relies on manual labor in its production process. Especially in the finishing process of lifting bricks, work activities are carried out repeatedly and without the support of adequate ergonomic aids. This causes physical complaints such as muscle fatigue, back pain, and potential risks of MSDs in workers.

Based on these conditions, this study aims to formulate ergonomic solutions through the application of brick lifting aids that are adjusted to the anthropometric dimensions of workers. Thus , it is expected to minimize workers' physical complaints and increase work efficiency and safety in the finishing section of brick production at UD Jaya Usaha.

2. Literature Review

Ergonomics is a science that focuses on designing work systems that are in accordance with human characteristics in order to achieve efficiency, effectiveness, and comfort at work. Various international and national organizations have been established to support the development of ergonomics, such as OSHA, NIOSH, MSHA, HFES, IIE, Ergonomics Society, ILO, WHO, and IEA (Pulat, 1992). Research in the field of ergonomics covers various main aspects, including anthropometry, cognitive, musculoskeletal, cardiovascular, and psychomotor.

Anthropometry deals with the measurement of human body dimensions, such as sitting height, arm length, and eye height, to design workstations that accommodate variations in worker body size. Mismatch between work design and body anthropometry can cause discomfort and risk of injury, so that design adjustments or modifications are required (Wignjosoebroto, 1995). In addition, the cognitive aspect of ergonomics includes how information is received, processed, and used by workers. Too high or too low information load can cause disruption to short-term and long-term memory performance, so the use of automation systems or assistive devices is highly recommended to improve work effectiveness.

Musculoskeletal problems include disorders of the muscles, joints, and bones due to prolonged static loads or repetitive movements. These disorders can range from minor injuries to serious cumulative trauma. Meanwhile, the cardiovascular aspect refers to the increased workload on the circulatory system, especially the heart, which can cause high levels of fatigue and decreased work performance. The psychomotor aspect in ergonomics emphasizes the importance of aligning job demands with human motor abilities so as not to cause excessive physical and mental tension (Pulat, 1992).

The impact of implementing a non-ergonomic work system is very significant for worker productivity and health. Some of these impacts include decreased work performance and quality,

increased work accident rates, high work errors, complaints of pain in various parts of the body, fatigue, and low worker commitment and participation. This problem is often exacerbated by the design of work tools or machines that do not fit the worker's body, poor work posture, and an unconducive work environment such as noise, stuffiness, or inadequate lighting.

The ergonomic approach covers various aspects, including work posture and position, work facility arrangement, and work environment conditions. Ergonomics pays great attention to how individuals work, the position of the body while working, the equipment used, and the impact of all these factors on the comfort and health of workers. Risks resulting from ergonomic errors can come from worker behavior or management negligence. Therefore, it is very important to identify work risks and redesign work systems to prevent injuries (Wignjosoebroto, 1995).

Some commonly identified ergonomic risk factors include high repetition of movements, heavy workloads, unnatural postures, static loads, and pressure from tools on the body. Solutions to these risks include redesigning workstations, using mechanical aids , job rotation, and improving work facilities to reduce the physical burden on workers.

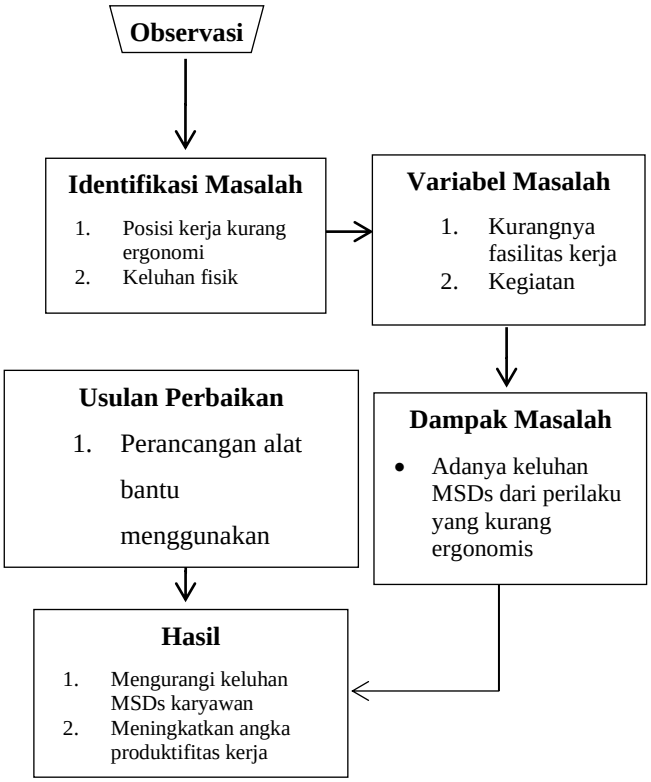
One of the most popular methods of evaluating musculoskeletal complaints is *the Nordic Body Map* . This tool allows the identification of body parts experiencing complaints ranging from mild to severe, and is very useful for ergonomic analysis in industry. In addition, ergonomic control needs to be applied in three main approaches, namely technical, administrative, and work methods . The technical approach includes redesigning equipment and the work environment, administrative involves setting work schedules and training, while work methods focus on educating workers to work with correct posture and technique (Pulat, 1992).

The concept of anthropometry is very important in ergonomics, because the design of work systems and products must be adjusted to variations in human body size which are influenced by age, gender, ethnicity, socio-economic conditions, and body posture. Anthropometric data is used in a variety of applications such as the design of work stations, work equipment, consumer products, and physical work environments. Ideally, the design should cover 90%-95% of the target population so that it can be used comfortably and safely (Wignjosoebroto, 1995).

By understanding the importance of applying ergonomic principles, especially in reducing *Musculoskeletal Disorders* (MSDs) complaints, in this study the researcher attempts to design ergonomic work aids that are implemented in the finishing production process at UD. JAYA USAHA, Pasuruan. The goal is to create a healthier, safer, and more productive work environment through the application of systematic ergonomic concepts.

3. Methodology

This research was conducted at UD. JAYA USAHA located in Pasuruan, with a focus on planning aids in the production process, especially at the finishing stage of lifting bricks. The research method used is descriptive quantitative with a field study approach. The study began with direct observation in the field to identify actual problems faced by the company. This observation aims to observe the production process directly and review the work activities of operators in lifting bricks. After obtaining the main problems from the observation results, the researcher continued by interviewing the business owner to dig deeper information regarding the obstacles faced, especially in the aspects of planning and implementing the production process (Sugiyono, 2018).



Gambar 1. Diagaram Alur Penelitian

The data collection stage in this study was carried out through two types of data sources, namely primary data and secondary data. Primary data was obtained directly from observations of production activities, measurements of workers' body dimensions (anthropometric data), and interviews with company owners. Meanwhile, secondary data was obtained through literature studies by reviewing various literature sources such as work ergonomics books, scientific journals, engineering magazines, and relevant internal company documents (Wignjosoebroto, 1995; Pulat, 1992).

Data collection methods used include observation, interviews, and documentation. Observations were conducted to observe work activities directly in the field to obtain a real picture of working conditions and potential ergonomic risks. Interview techniques were conducted with owners and workers to obtain qualitative data related to work experiences, physical complaints, and obstacles experienced during the production process. Documentation was used to collect historical or administrative data from the company that was relevant to the research process, such as production data and work area layout (Moleong, 2017).

After the data is collected, the data processing stage is carried out. Data processing begins with a data adequacy test to ensure that the amount of data collected is sufficient and can represent actual conditions. This adequacy test is carried out based on a statistical approach by considering the desired level of precision and confidence level. The higher the level of precision and confidence, the more data will be needed . Furthermore, a data uniformity test is carried out to ensure that the data collected comes from the same work system and is not affected by external factors that can cause bias in measurement (Wignjosoebroto, 1995).

In the process of analyzing anthropometric data, percentile data is used as the basis for designing ergonomic aids. The three percentiles used in this study include the 5th percentile (P5), 50th percentile (P50), and 95th percentile (P95). These three values represent the smallest, average, and largest body sizes of the target worker population, which are the basis for designing work systems or aids to cover most of the user population (Pheasant & Haslegrave, 2005). Thus, the design of the

resulting aids is expected to improve comfort, efficiency, and work safety for workers at UD. JAYA USAHA. The Percentile Calculation formula is as follows:

$$P_i = X + K_i.S$$

P_i = Calculated percentile value
X = Mean
K_i = Multiplier for the desired percentile
S = Standard deviation / SD
mean =x2N SD=X2N –(X)2N
K value (factor for percentile extraction used)

Table 1. Percentile Formula

Percentage	P5	`P10	P50	P90	P95
Formula	x-2 αx	X – 1.28 αx	X	X + 1.28 αx	X + 2 αx

4. Results and Discussion

UD. Jaya Usaha is a company engaged in the manufacturing sector which produces daily equipment such as bricks. Paving. Culverts etc. However, the results of the author's interview there is a complaint felt by employees, especially in the field of lifting bricks, where the complaint can be said to be a complaint of MSD's (*Muscular skeletal disorde*). Therefore, the author proposes the design of an aid to reduce complaints of MSD's (*Muscular skeletal disorde*) which cause knee pain. Back pain, etc.

Therefore, the author proposes the design of ergonomic aids with anthropometric calculations by taking 10 samples in the company to determine the data adequacy test. Data uniformity. As well as percentile data.

Arm reach measurement in a standing position is an important part of the study of work anthropometry, especially for the purpose of designing ergonomic work aids or facilities. In this study, arm reach measurement was carried out by measuring the distance from the shoulder reference point (acromion) to the tip of the middle finger when the arm is extended straight forward. This measurement reflects how far workers can reach or reach work objects without having to lean over, so it can be used as a basis for determining the optimal dimensions of a safe and comfortable work area.

From the research data, the total number of all arm reach values (∑X) was obtained as 644 cm. With a sample size of 10 people, the average (mean) arm reach value can be calculated as follows :

$$\dot{X}=\sum XN/N=644/10= 64.4 \text{ cm}$$

This average value shows that in general workers have a forward arm reach of 64.4 cm when in a standing position. This information will then be used in the design of a brick lifting aid, to suit the physical capabilities of workers and prevent the risk of injury due to overreaching or non-ergonomic working positions (Wignjosoebroto, 1995; Pheasant & Haslegrave, 2005).

Data Adequacy Test

Data adequacy tests are conducted to ensure that the amount of data collected is sufficient to represent the actual conditions of the observed population. In this context, measurements were made on the anthropometric dimensions of the worker's arm reach. The calculation uses the data adequacy test formula with a confidence level of 95% (K = 2) and an error rate (α) of 5% or 0.05 .

Data Uniformity Test

Data uniformity test is conducted to ensure that the data obtained comes from a uniform system or condition, without any influence that can cause significant deviations to the measurement results. The uniformity test result value shows that the data has a low level of diversity , so it can be concluded that the data is uniform and suitable for use in the further analysis process.

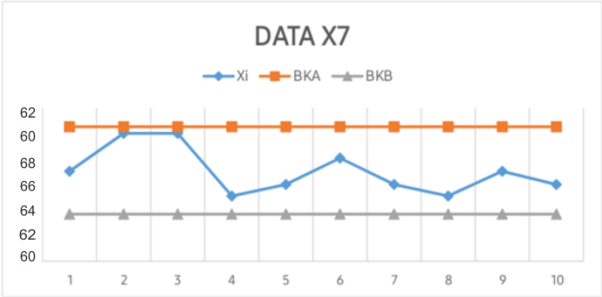


Figure 2. Anthropometric Graph of Hand Reach Distance

Table 2. Interval Class Data

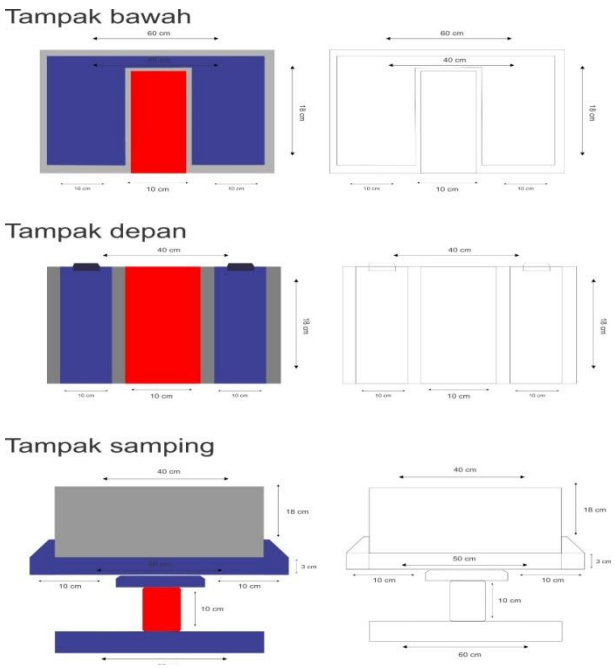
No.	Interval class	Frequency (f)	Cumulative Frequency (F)	Relative cumulative frequency (%)
1	63 – 63.9	3	3	3
2	64 – 64.9	3	6	3
3	65 – 65.9	2	8	2
4	66 – 67	2	10	2

Note: Frequency distribution table of the distance of the hand extended forward measured from the shoulder to the tip of the fingers.

This size is used as a reference so that the brick lifting tool at the distance of the hand reach that extends forward is measured from the shoulder to the tip of the finger can reach the brick to be taken during the lifting process.

Design of Assistive Devices

The activity of taking the bricks from the pressing machine and moving them to the drying area is done manually, which increases the risk of musculoskeletal disorders. Therefore, a new work facility design needs to be proposed to reduce these problems. The proposed work facility is in the form of automatic brick lifting with a shape and working principle that resembles the working principle of a dynamo so that employees can carry bricks together with brick pallets without bending and lifting bricks manually so that it is expected to reduce the risk of manual musculoskeletal disorders, and the shape of the pallet is also designed to be integrated with automatic brick lifting so that the pallet does not shift when the bricks are carried from the pressing machine to the drying machine. Determination of anthropometric data is carried out to design work facilities in brick moving activities. The dimensions of the employee's body that have been calculated will be the basis for designing brick moving aids in the form of automatic brick lifting tools.



Gambar 3. Perancangan Alat Bantu

5. Conclusion

Based on the results of research conducted at UD Jaya Usaha, it is known that the main complaint often experienced by employees during brick lifting activities is intense pain in the lower neck, waist, and both arms (right and left hands). This complaint arises due to a working position that is not ergonomic and not adjusted to the worker's body dimensions.

As a solution to this problem, a work facility design was carried out in the form of a brick lifting aid designed based on the principles of ergonomics and anthropometric measurements of workers. After the implementation of the aid design , the activity of moving bricks from the first stage drying station to the second stage showed a significant increase in the aspect of work safety. This activity has been in the safe category, both in terms of physical workload and body position while working.

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