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Prevention of Musculoskeletal Disorder (MSDs) at Kakimoto House Japan Lumber Mill Using the Ovako Working Analysis System (OWAS) Method and Design of Work Facilities

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ABSTRACT

The timber industry heavily relies on its workforce, making worker well-being and posture maintenance essential to prevent musculoskeletal disorders (MSDs) resulting from repetitive tasks, non-ergonomic environments, and constrained working conditions. MSDs significantly impact productivity and worker health, necessitating ergonomic interventions like the Ovako Work Analysis System (OWAS). This anthropometric method evaluates worker postures by categorizing body movements into intervals, focusing on the back, arms, and legs, and identifying postures that pose a high risk of injury. At Kakimoto House Japan, where manual material handling (MMH) is predominant, OWAS was applied to analyze and address workers' physical strain, ensuring comprehensive data collection through sufficiency testing. Data analysis using the 5th, 50th, and 95th percentiles provided valuable insights into posture distribution and workload impact. Implementing a new carriage design enabled workers to carry more wood with less effort, reducing physical strain and improving task efficiency. This ergonomic improvement highlights the potential for enhanced productivity and health outcomes in the timber industry.

Keywords: *Ergonomi*, *OWAS*,*MSDs*

Introduction

The timber industry has various sectors, the most important of which is the workers, without which the production process in the industry would not work.[1] Maintaining workers' posture is also the most important thing so that workers can work without any bone disease.[2] - [5] In industrial activities, workplace stress and risks are usually found in the workplace and employees.[6] Musculoskeletal disorders (MSDs) are complaints felt by skeletal muscles, starting from repetitive tasks, non-ergonomic work environments, and work environment conditions that force workers into working positions.[7], [8]

One ergonomic method is to analyze a worker's posture. OWAS is a method of taking anthropometric measurements.[9], [10] The measurement principle divides the work into several time intervals (seconds or minutes) and repeats this until several work posture samples are obtained from the work cycle or activity. [11], [12]

At Kakimoto House, Japan, manual material handling (MMH) or hand and machine labor is used to produce wood that will be sent to customers. The OWAS helps analyze the bodies of workers who feel pain and prevent musculoskeletal syndromes. [13]-[14]OWAS was chosen because of the heavy workload of the job. OWAS focuses on body analysis and physical condition analysis of the whole body itself. Workers in Kakimoto House, Japan, are tense to work while always bending their backs. That is why OWAS was chosen to analyze the posture of workers' bodies. Workers in Kakimoto House feel pain when pushing the carriage they have used for a long time.

Research Methods

Ovako Working Analysis System (OWAS)

The OWAS is a work posture analysis method that evaluates 4,444 postures that cause musculoskeletal injuries.[15][16] The OWAS method observes the posture of the worker's body parts (back, arms, legs, weights, etc.) during work.[17][18][19] In OWAS, human observers periodically (e.g., every few minutes) evaluate a person's posture based on three categories: arms, back, and legs. [20][21][22]

Data Sufficiency Test

Data sufficiency testing is an analytical procedure aimed at assessing the completeness of the collected data. This method involves examining the dataset to confirm that it fulfills the necessary criteria for thoroughness and reliability.[23] This is accomplished by applying a designated formula, which facilitates the generation of supplementary observations.

$$N' = \left[\frac{k/_S \sqrt{N\sum x^2 - (\sum X)^2}}{\sum X}\right]^2 \quad (1)$$

Description:
N = amount of observation data
N' = theoretical amount of data
S = degree of accuracy
k = level of confidence

Percentile

Data processing aims to analyze products through the lens of the 5th, 50th, and 95th percentiles. This analysis explicitly targets the employee population. Percentile calculations are crucial as they provide insights into the distribution and central points of the data.[24] The target of the survey is employees. The formula for calculating these percentiles is essential for identifying the position of specific values within the data set, enabling a detailed evaluation of the products based on the employees' data

$$P50 = X \quad (2)$$

$$P95 = X + \text{Ki x S} \quad (3)$$

Data Uniformity Test

Conducting a data uniformity test is necessary to achieve consistency and standardization within the dataset. This test uses anthropometric data obtained through personal physical measurements at PT Kakimoto House, Japan. When similar data is available from BKA & BKB, it is deemed homogeneous, signifying that the datasets are consistent and comparable. This homogeneity is essential for ensuring the reliability and validity of the data, facilitating accurate analyses and applications.[25]

$$\text{Upper Control Limit (BKA)} = X + k.\sigma \quad (4)$$

$$\text{Lower Control Limit (BKB)} = X - k.\sigma \quad (5)$$

Before proceeding to compute the BKA and BKB values, it is necessary to calculate the standard deviation as an initial step:

$$\sigma = \sqrt{\frac{N.\sum(xi^2) - (\sum xi)^2}{N(N-1)}} \quad (6)$$

Where:
σx = Standard deviation population
N = Data Number
X = Average
k = Trust level index coefficient
namely:
Confidence level 0% - 68% price k =1.
Confidence level 68% - 95% price k = 2.
Confidence level 96% - 100% price k = 3.

Research Flow

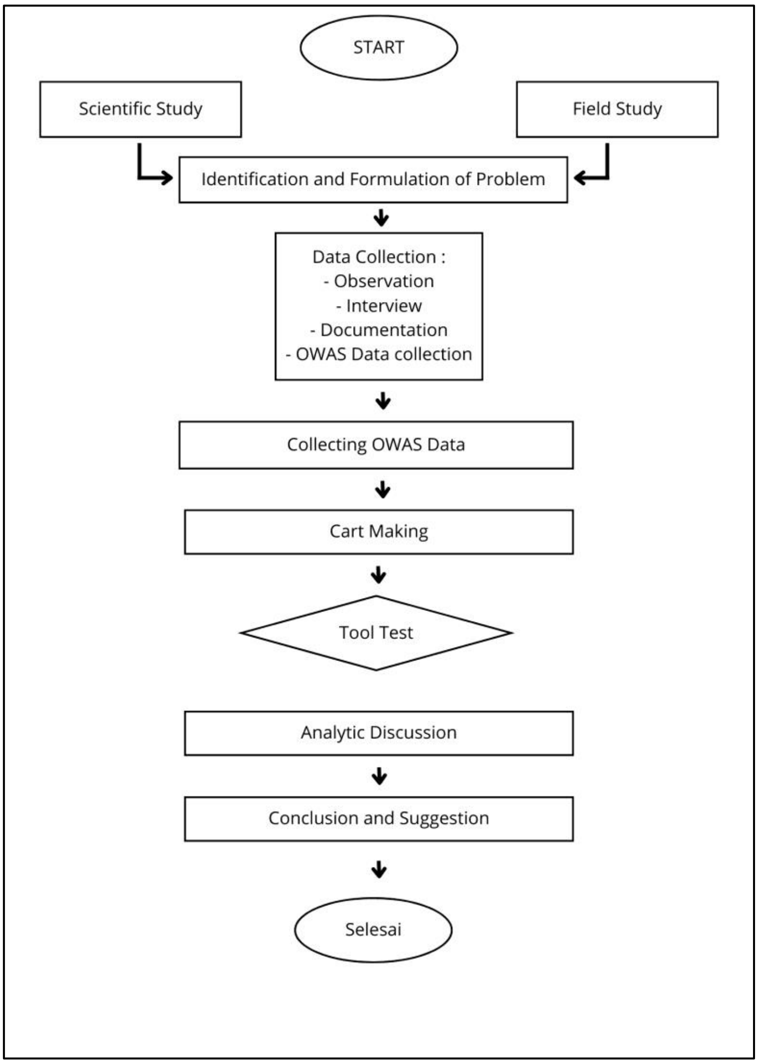

Figure 1. Research Flow

Results and Discussion

Nordic Body Map Questionnaire Results

Data processing of the Nordic Body Map questionnaire was carried out to identify symptoms in workers.

No.	Complaint Level	NP	EP	P	EP
0	Pain at the top of the neck	13	0	0	0
1	Pain under the neck	13	0	0	0
2	Pain in the left shoulder	13	0	0	0
3	Pain in the right shoulder	13	0	0	0
4	Pain in the upper left arm	13	0	0	0
5	Back pain	8	0	3	2
6	Pain in the upper right arm	13	0	0	0
7	Back pain	2	5	3	3

8	Pain in the buttocks	13	0	0	0
9	Pain in the lower part of the buttocks	13	0	0	0
10	Pain in the left elbow	13	0	0	0
11	Pain on the right elbow	13	0	0	0
12	Pain in the left forearm	13	0	0	0
13	Pain in the right forearm	13	0	0	0
14	Pain in the left wrist	9	4	1	0
15	Pain in the right wrist	4	7	2	0
16	Pain in the left hand	11	2	0	0
17	Pain in the right hand	6	4	3	0
18	Pain in the left thigh	13	0	0	0
19	Pain in the right thigh	13	0	0	0
20	Pain in the left knee	12	1	0	0
21	Right knee pain	11	2	0	0
22	Pain in the left calf	13	0	0	0
23	Pain in the right calf	13	0	0	0
24	Pain in the left ankle	13	0	0	0
25	Pain in the right ankle	12	1	0	0
26	Pain in the left leg	6	7	0	0
27	Pain in the right leg	11	2	0	0
	Jumlah	**313**	**35**	**12**	**5**

Information:
NP = No Pain
EP = Enough Pain
P = Pain
VP = Very Painful

Survey data on the severity of employee complaints showed 12 complaints of pain (S) and 5 complaints of being unwell (SS). Therefore, machine design is determined based on anthropometric data, including hip height (HH), height reach (HR), and shoulder width (SW). The result is ergonomics obtained from anthropometric calculations to create a design.

Ovako Working Analysis System (OWAS) Results

Table 1. Ovako Working Analysis System (OWAS) Results

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	Load
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	3	2	2	3	1	1	1	1	1	2	
2	1	2	2	3	2	2	3	2	2	3	3	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	X
	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

Table 2. Body Part Description

Body Part	Description
Back	Bending forward or backward
Arm	Both hands are above shoulder level
Leg	Moving or moving
Load	Load weight above 20 kg

While delivering small amounts of wood, categorized as category 3. This attitude indicates musculoskeletal disorder. So there is a need for justification in work.

Anthropometric Data

The workers are measured to collect anthropometric data on employees of PT Kakimoto House Japan in Nara, Japan, and the sample amounted to 13 employees. Data processing was done from this data.

Table 3. Anthropometric Data

No.	Name	Gender	HH (Hip Height)	HR (High Reach)	SW (Shoulder Width)
1	Sazali	P	87	71	41
2	Wawan	P	86	73	43
3	Uemina	P	89	75	45
4	Tokunaga	P	88	74	44
5	Nakahara	P	90	75	44
6	Iwamoto	P	89	73	43
7	Sugimoto	P	87	70	43
8	Kobayashi	P	90	72	44
9	Nakani	P	88	70	42
10	Yamada	P	89	71	42
11	Ueda	P	87	69	41
12	Simobayashi	P	89	72	42
13	Amito	P	88	71	43

Data Sufficiency Test

Table 4. Data Sufficiency Test

No.	Dimension	N	N’	Hasil
1	Hip Height	13	0.1156	N’<N, Data cukup
2	Height Reach	13	0.1738	N’<N, Data cukup
3	Shoulder Width	13	0.069	N’<N, Data cukup

Percentile

Table 5. Percentile

No.	Dimension	Percentile 5	Percentile 50	Percentile 95
1	Hip Height	86.21	88.23	90.25
2	Height Reach	68.85	72	73.13
3	Shoulder Width	37.79	39.78	41.77

Data Uniformity Test

Table 6. Data Uniformity Test

No.	Dimension	N	N’	Result
1	Hip Height	13	0.1156	N’<N, Enough
2	Height Reach	13	0.1738	N’<N, Enough
3	Shoulder Width	13	0.069	N’<N, Enough

Design and Model

Following the completion of data collection and processing, the subsequent phase is to ascertain the dimensions of the shopping cart that will serve as a benchmark for crafting wooden carts. This size determination is grounded in the analyzed anthropometric data, which includes detailed measurements of human body dimensions alongside the sizes of various relevant tools, as illustrated in the table below.

Table 7. Size determination

No.	Anthropometric Data	Design Size	Size	Description
1	Hip Height (HH)	Cart Height (90cm)	5	Workers with larger bodies can use the carts that are created
2	High Reach (HR)	Cart Length (110cm)	50	Ensure the machine is not too long and restricts workers' freedom of movement.
3	Shoulder Width (SW)	Cart Width (110cm)	95	When doing work, the cart is wide enough so you can do work comfortably.

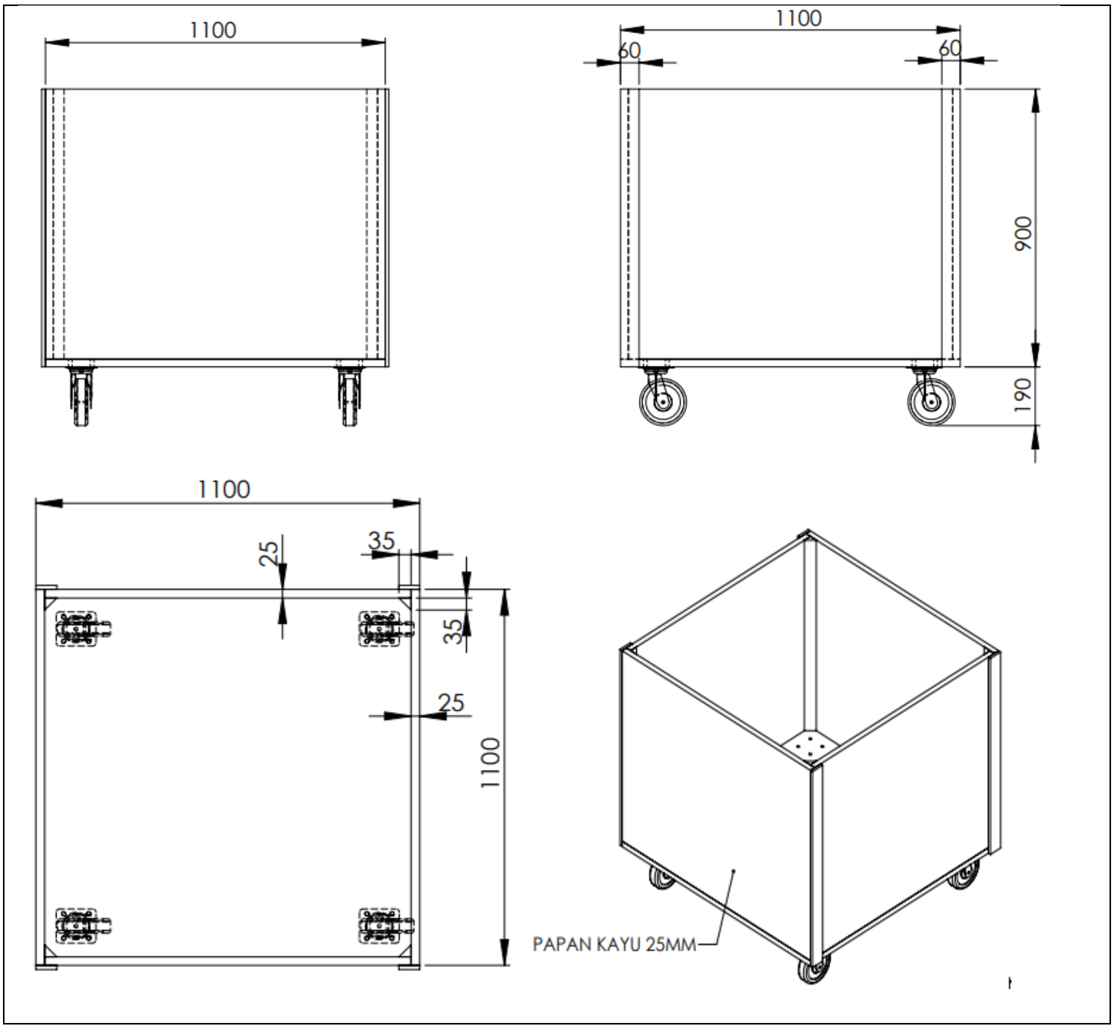

Figure 2. Design Crafting Wooden Cart

Comparison after with the OWAS method

Table 8. Comparison after with the OWAS method

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	Load
1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	X

	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	3	2	2	3	1	1	1	1	1	2
	1	2	2	3	2	2	3	2	2	3	3	3	3	3	3	3	2	2	2	2	3	3
2	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
	1	1	1	1	1	1	1	1	1	2	3	3	3	4	4	4	1	1	1	1	1	1
3	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
	1	2	3	3	2	2	3	2	2	3	4	4	4	4	4	4	4	4	4	2	3	4
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 data shows that from Category 4, it drops to Category 1.

Picture of the finished tool

Figure 3. finished tool

Conclusion

Before the new carriage design was constructed, workers often bent their backs, and almost all Kakimoto House Japan workers hurt their backs. After using the new carriage design, the worker can easily push the carriage without hurting their back. The carriage itself also provides better movement; it can move all around. It is also lighter than the old carriage. With the new carriage, the worker can easily move. The new carriage can also carry more wood than the old one. Workers can also work faster and more efficiently while using the new carriage

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