Analysis of the workload of Dock 16 Ilir workers using Rapid Upper Limb Assessment, Ovako Working Analysis System, and Nordic Body Map Methods: A quantitative case study [version 1; peer review: awaiting peer review]

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Abstract

Abstract: Industry players are encouraged to automate as a result of technological advancements. However, due to lack of finances several businesses continue to require human labor in the production process, particularly in the operation of transferring items. Transportation activities at Dock 16 Ilir in Palembang City, starts with delivering items from the shop to the ship or vice versa by utilizing human strength in less ergonomic work positions with little consideration for the weight of the load. When carrying goods, the body is bent, the neck is bent, and the arms are distant from the body, putting the body at a very high risk of injury. This type of working position causes muscle aches ranging from mild to severe. The personnel seen in this investigation were rice transporters and cement transporters. The aim of this study is to quantify the workload and provide a design tool to help lessen worker concerns. The Nordic Body Map, Rapid Upper Limb Assessment (RULA), and Ovako Working Analysis System (OWAS) methodologies were used in this investigation. The study's findings showed that the five cement transport workers and four rice transport workers were at risk of developing musculoskeletal illnesses, with a risk level of 3 to 4, indicating that the risk category is very high and comprehensive treatment is required as soon as feasible. According to the OWAS technique, the posture of rice transportation employees has a value of 3, indicating that they are at high danger. Meanwhile, the working posture of cement transportation has a score of 7 with a risk level of 4, indicating that the danger of MSDS is very high. The developing aids are projected to lower the danger of Musculoskeletal Disorders in a...
backpack-like style that can resist large loads and reduce the risk of Musculoskeletal Disorders.

Keywords
Nordic body map, RULA, OWAS, Musculoskeletal disorders
Introduction

The industrial world is rapidly evolving and totally automated, making all processes more effective and efficient. However, the usage or role of people as a labor system, particularly in the industrial sector of Indonesia, cannot be avoided or even totally eliminated. One of these is the transfer of commodities at Dock Palembang city that continues to use manual transportation (manual material handling) (Nur et al., 2016; Widiana et al., 2021; Budiman & Setyaningrum, 2006), in which human labor is used to transport commodities ranging from clothing, shelter, and food to be shipped to various regions in South Sumatra. According to M. Fitri and W. Laila (Fitri & Laila, 2017), in Indonesia, the consideration of moving materials directly via Manual Material Handling (MMH) is thought to require lower costs than machines, and MMH has been widely employed in medium to micro scale businesses until now. Meanwhile, according to C. H. D. Kusmini adari et al. (Kusmindari et al., 2020), the solution to maintaining a decent posture while performing MMH activities is to improve the work system in MMH activities, specifically as a concept (Kusminadri & Tian, 2021).

Industry participants sincerely hope that production will operate smoothly and without any challenges, both in terms of human employees and machinery and materials, and that output targets will be met. As a result, human labor and machines can coexist effectively in the long term. However, humans have limitations, unlike machines, which will not fatigue if they are used for a lengthy period of time. As stated by M. A. Wahyudi et al. (Wahyudi et al., 2015) the usage of employees must be supported by ideal work techniques and workplaces that are in agreement with body posture to accomplish work for an extended period of time without causing injury to the workers.

Workers’ complaints of musculoskeletal diseases (MSDs) range from slight problems in the skeletal muscles to very severe case (Gómez-Galán et al., 2020; Dewi, 2020; Factsheet 4 - Preventing Work-Related Musculoskeletal Disorders| Safety and Health at Work EU-OSHA, n.d.). These concerns regarding MSDs must be managed to limit the risk of damage to the movement of the neck (neck), trunk (trunk), and legs (legs), and, most significantly, to preserve the workforce’s concentration at work so that workers feel comfortable. If the workforce is hurt it can effect their health in which case they maybe unable to work or the job they accomplish will be less than optimal causing not only workers but also the industry to suffer.

The first approach in this study is to identify the MSDs concerns of freight forwarders, who are rice and cement transporters, using Nordic Body Map (NBM) questionnaire data (Purnomo et al., 2010; Wadhikh, 2019; Putri et al., 2021). Following the collection of data, the next stage is to undertake research to identify and analyze work attitudes in order to assess workload, as well as to measure oxygen consumption using the OWAS Ovako Working Analysis System (OWAS, 2004) and RULA Rapid Upper Limb Assessment (Purwaningsih, 2016) (Bintang & Dewi, 2017).

According to D. P. Restuputri et al. (Restuputri et al., 2017), the OWAS approach is a way for studying individuals in the process of work that is observed with a dynamic dangerous attitude. Based on the work attitudes observed, a work attitude category will be determined, with four category scales in the OWAS technique ranging from no danger to the highest risk of damage. This is to clarify which work posture resulted in the categorization of work attitudes that require improvement. The observed working posture is the movement of the body from the shoulders, back, hands, and feet. According to OWAS, it would be more appropriate to verify the management of MMH. This is due to the fact that OWAS may measure and examine directly while workers are manually handling materials (El Ahmady et al., 2020).

While the RULA technique contains four categories of work attitudes, it also has four categorization scales, ranging from no danger (Safe) to the highest risk of damage. It is possible to determine which work postures result in the categorization of work attitudes that require improvement by watching work postures. (Tiogana & Hartono, 2020).

As a recommendation for workers in Dock 16 Ilir Palembang City, this study aims to analyze the shoulder, arm and leg of workers who experience MSDs using NBM, analyze the workload of transporting rice using the OWAS work posture classification, analyze the load of cement workers using RULA, and analyze the size or design of acute aids to minimize the risk of injury. The concerns that will be raised in this research, among others, are as follows: What are the work postures and workloads that cause MSDs in workers at Dock 16 Ilir Palembang city after studied by NBM? How can the workload be determined based on OWAS and RULA? How can the size or design of a vehicle be determined?

Methods

Research sites

The research location at Dock 16 Ilir Palembang city, which operates as a place to transport goods from shop to ships. In this study four rice transport workers and five cement carrier workers at this location were observed for one month.
Data collection

1. Field study

NBM questionnaire was used to examine the workload of the four rice and five cement transporters. OWAS and RULA methods were used to assess the data for risk category classification “position code” in a combination of positions (back, arms, and legs).

2. Literature study

Industrial Literature Study, which entails gathering data through the study of books that support this research.

Data processing

The data was processed by using a predetermined method, namely the NBM test, followed by RULA and OWAS. Data processing in this study comprised assessing objects before and after improving work posture with NBM, RULA, and OWAS.

The analytical technique employed compares the level of risk of injury to both rice and cement transport employees while employing traditional transportation methods to the suggested transportation methods RULA and OWAS.

Results and discussion

The study was carried out on the rice transportation to ships, where workers continue to use MMH, as well as on the cement transportation section of company. During the initial observation stage, researchers discovered that the method of transporting rice and cement posed a high danger to the physical well-being of the workers. Following this observation stage, the researcher conducted interviews with numerous workers and received data indicating that workers move 100 kg bags of rice and cement 3 times a day with an average weight of 1-3 tons. It causes workers to experience musculoskeletal disorders.

The results of the NBM Questionnaire are as follows:

The NBM is an auxiliary questionnaire that defines body parts from head to toe, which specifically was used in this study for workers who transport grains and cement. The NBM questionnaire is important for gathering feedback from workers who transport rice and cement during the MMH process. There are 28 sections in this questionnaire, ranging from 0-27, with a rating score of 1–3. Several complaints were reported at work in the NBM questionnaire findings for workers delivering rice and cement. Table 1 shows the results of the NBM questionnaire on workers delivering rice and cement.

Figure 1 shows the flowchart research diagram conducted by researcher.

Table 1. Rice transport workers NBM questionnaire recapitulation.

| No | Parts of body | Workers | | | No | Parts of body | Workers |
|----|---------------|---------|---|---|----|---------------|---------|
| 0  | Neck          | 3 3 3 3 | 14 | Left Wrist | 3 2 2 3 |
| 1  | Neck Down     | 3 3 3 3 | 15 | Right Wrist | 3 2 2 3 |
| 2  | Left Shoulder | 3 3 3 3 | 16 | Left Hand | 3 3 3 3 |
| 3  | Right Shoulder| 3 3 3 3 | 17 | Right Hand | 3 3 3 3 |
| 4  | Left Upper Arm| 3 2 2 3 | 18 | Left Thigh | 3 3 3 3 |
| 5  | Back          | 2 2 2 3 | 19 | Right Thigh | 3 3 3 3 |
| 6  | Below Waist   | 2 3 3 3 | 20 | Left Knee | 3 3 3 3 |
| 7  | Waist         | 2 2 2 3 | 21 | Right Knee | 3 3 3 3 |
| 8  | Below Waist   | 2 3 3 3 | 22 | Left Calf | 3 3 3 3 |
| 9  | Butt          | 2 2 2 3 | 23 | Right Calf | 3 3 3 3 |
| 10 | Left Elbow    | 3 2 1 3 | 24 | Left Ankle | 3 3 3 3 |
| 11 | Right Elbow   | 3 2 2 3 | 25 | Right Ankle | 3 3 3 3 |
| 12 | Left Forearm  | 3 2 2 3 | 26 | Left Foot | 3 3 3 3 |
| 13 | Right Forearm | 3 2 2 3 | 27 | Right Foot | 3 3 3 3 |
|    | TOTAL         | 81 73 71 83 |

Source: Data Collection.
According to Table 1, the four rice transporters are at risk of MSDs because they have a total score of individual complaints in the range of 63–84, indicating that the risk level is at 3, which is a very high-risk category, and comprehensive treatment is required as soon as feasible. Table 2 shows workers in the cement transport industry.

Figure 1. Research flow chart.

| No | Parts of body   | Workers | | No | Parts of body   | Workers |
|----|-----------------|---------|---|----|-----------------|---------|
|    |                 | 1 2 3 4 5 |   |    |                 | 1 2 3 4 5 |
| 0  | Neck            | 3 3 3 3 3 |   | 14 | Left Wrist      | 1 1 1 1 1 |
| 1  | Neck Down       | 3 3 3 3 3 |   | 15 | Right Wrist     | 1 1 1 1 1 |
| 2  | Left Shoulder   | 3 3 3 3 3 |   | 16 | Left Hand       | 2 1 1 1 2 |
| 3  | Right Shoulder  | 3 3 3 3 3 |   | 17 | Right Hand      | 2 1 1 1 2 |
| 4  | Left Upper Arm  | 3 3 3 3 3 |   | 18 | Left Thigh      | 3 3 3 3 3 |
| 5  | Back            | 3 3 3 3 3 |   | 19 | Right Thigh     | 3 3 3 3 3 |
| 6  | Below Waist     | 3 3 3 3 3 |   | 20 | Left Knee       | 3 3 3 3 3 |
| 7  | Waist           | 3 3 3 3 3 |   | 21 | Right Knee      | 3 3 3 3 3 |
| 8  | Below Waist     | 2 2 2 2 2 |   | 22 | Left Calf       | 3 3 3 3 3 |
| 9  | Butt            | 2 2 2 2 2 |   | 23 | Right Calf      | 3 3 3 3 3 |
| 10 | Left Elbow      | 2 2 1 2 2 |   | 24 | Left Ankle      | 3 3 3 3 3 |
| 11 | Right Elbow     | 2 2 1 2 2 |   | 25 | Right Ankle     | 3 3 3 3 3 |
| 12 | Left Forearm    | 2 1 1 2 2 |   | 26 | Left Foot       | 3 3 3 3 3 |
| 13 | Right Forearm   | 1 1 1 1 1 |   | 27 | Right Foot      | 3 3 3 3 3 |
|    | TOTAL           | 71 68 66 69 71 |

Source: Data Collection.
According to Table 2, the five cement transport employees are at risk of MSDs since they have a total score of individual complaints in the range of 63–84, indicating that the risk level is at 3, which is a very high-risk category, and thorough action is required as soon as feasible.

**Calculation of working posture of rice transport workers using OWAS**

**Rice receipt process**

Based on Figures 2 to 4 which show the posture of workers when transporting rice, the results of the OWAS calculation can be seen in Table 3.

![Figure 2: Rice receipt process.](image)

![Source: Personal Documentation](image)

**Table 3. Worker posture risk categories when receiving rice.**

| Sikap     | Keterangan                                                                 | Kode OWAS |
|-----------|-----------------------------------------------------------------------------|-----------|
| Back      | Bending, with the body in flexion, may be considered for inclusion if the angle is more than 20° | 2         |
| Arm       | The worker's arms are above shoulder height                                  | 3         |
| Leg       | One leg is straight and the other leg is bent with the weight balanced between the two legs | 3         |
| Load Weight | >20 kg (±80 kg s/d 100 kg)                                                   | 3         |

Source: Data Collection.

**Rice transfer process**

![Figure 3: Rice transfer process.](image)

**Table 3. Worker posture risk categories when receiving rice.**

| Sikap     | Keterangan                                                                 | Kode OWAS |
|-----------|-----------------------------------------------------------------------------|-----------|
| Back      | Bending, with the body in flexion, may be considered for inclusion if the angle is more than 20° | 2         |
| Arm       | The worker's arms are above shoulder height                                  | 3         |
| Leg       | One leg is straight and the other leg is bent with the weight balanced between the two legs | 7         |

Source: Data Collection.
Table 4 shows the OWAS risk assessment for rice transfer workers.

**Table 4. Activity level score.**

| Activity   | OWAS | Description                                                                                                                                 |
|------------|------|----------------------------------------------------------------------------------------------------------------------------------------------|
| Rice Transfer | 4    | The risk level is a 4. A position with a very high risk category, a position having a particularly negative impact on the MSD system. As soon as feasible, corrective action is essential. |

Source: Data Collection.

**Rice laying**

![Rice laying process](image)

Source: Personal Documentation

**Figure 4. Rice laying process.**

Table 5 shows the OWAS risk level for rice laying workers.

**Table 5. Score for activity level.**

| Activity   | OWAS | Description                                                                                                                                 |
|------------|------|----------------------------------------------------------------------------------------------------------------------------------------------|
| Rice Laying | 4    | The risk level is a 4. A position with a very high risk category, a position having a particularly negative impact on the MSD system. As soon as feasible, corrective action is essential. |

Source: Data Collection.

**Table 6 summarizes the results of data processing from day one onwards:**

**Table 6. Summary of OWAS calculation results for rice transport workers.**

| Worker | Activity   | Risk level per day | 1 | 2 | 3 | 4 | 5 | 6 | Total | Average |
|--------|------------|--------------------|---|---|---|---|---|---|-------|---------|
| 1      | Rice Reception | 3 3 3 3 3 3 18 3  |   |   |   |   |   |   |       |         |
|        | Rice Transfer  | 4 4 4 4 4 4 24 4  |   |   |   |   |   |   |       |         |
|        | Rice Laying    | 4 4 4 4 4 4 24 4  |   |   |   |   |   |   |       |         |
| 2      | Rice Reception | 4 3 3 3 3 3 18 3  |   |   |   |   |   |   |       |         |
|        | Rice Transfer  | 4 4 4 4 4 4 24 4  |   |   |   |   |   |   |       |         |
|        | Rice Laying    | 4 4 4 4 4 4 24 4  |   |   |   |   |   |   |       |         |
| 3      | Rice Reception | 3 4 4 3 4 3 21 3,5|   |   |   |   |   |   |       |         |
|        | Rice Transfer  | 4 4 4 4 4 4 24 4  |   |   |   |   |   |   |       |         |
|        | Rice Laying    | 4 4 4 4 4 4 24 4  |   |   |   |   |   |   |       |         |
| 4      | Rice Reception | 4 3 3 4 3 4 21 3,5|   |   |   |   |   |   |       |         |
|        | Rice Transfer  | 4 4 4 4 4 4 24 4  |   |   |   |   |   |   |       |         |
|        | Rice Laying    | 4 4 4 4 4 4 24 4  |   |   |   |   |   |   |       |         |

Source: Data Collection.
As a result of calculating the work posture of rice transportation workers using the OWAS approach, an average degree of risk of 3–4 was determined.

**Calculation of working posture of cement transport workers using RULA**

**Cement receiving position**

At this point, the labor operator collects cement from other workers seated on the cart/push wheel in charge of distributing cement.

![Figure 5: Posture of labor in receiving cement posture. Source: personal documentation.](image)

**Group A:**

- **Figure 6.** depicts a worker’s posture while transporting something.

The load lifted by the worker is greater than 10 kg. The RULA score is +3, whereas the change score is 0 because the load does not encounter an unexpected increase in load. The posture of cement lifting workers is shown in Figures 5 to 7.

As a result, the Group A score is shown in Table 7 below:
A score of 4 after looking for a value for group A. Then, by combining the muscle use score and the force/load score, a final score search is performed to determine whether the operator’s posture contains a level of hazard or not. It can be made using the following formula:

\[ \text{Score of Group A} = \text{muscle use score} + \text{force/load score} \]

Therefore, Score A is 7.
**Group B:**

**Muscle Use Score**

Workers who undertake permanent labor in less than 10 minutes have an RULA score of 0, with the additional score of +1 since the posture is static and repeated.

**Force/Load Score**

If the load lifted by the workforce is greater than 50 kg – 100 kg, the RULA score is 3, while the change score is 0, because the load does not encounter a sudden increase in load.

**Score of Group B**

The B score table depicts the neck, trunk, and legs positions is shown in Table 8. The blue color represents the neck at position 3, the green represents the trunk at position 3, and the yellow represents the leg at position 1. The value of this B score is calculated by where the three variables intersect.

When a value of 4 is found after searching for a value for group B, a final score search is performed to determine whether the workers' body posture is in a level of risk or not, by combining the muscle usage score with the force/load score, following the formula:

\[
\text{Score} \text{ B} + \text{muscle use score dan force/load score group B} = \text{Score B} \\
4 + 0 + 3 = 7
\]

**Score of Group C**

The Table 9 C score is the result of adding the A and B scores. The overall score of A is 4, and the total score of B is 7. As a result, the score of Table A and the score of Table B decide the column and value in group C.

![Table 8. Score of Group B.](image)

![Table 9. Score of Group C.](image)
Table A of the RULA score table above displays the position of the upper arm, lower arm, wrist, and wrist twist, all of which receive a score of 4, in addition to the score for muscle use (1), and the load score (3), the total score A would be 8. Table B displays a score of 4 for the position of the neck, trunk, and legs, with a score of 1 for muscle use, a score of 3 for load, and a total score of 8 for A. The total RULA score is 7 based on the table C score, which is a composite of the outcomes of the A and B scores.

An RULA score of 7 was obtained with a high danger level and an action level of 4 after performing the calculations using the RULA worksheet. This signifies that immediate action is required. Table 10 shows the outcomes of data processing for the five cement transport personnel from day one onwards.

| Worker | RULA score | Risk level | Action level | Action          |
|--------|------------|------------|--------------|-----------------|
| 1      | 7          | High       | 4            | Action now      |
| 2      | 7          | High       | 4            | Action now      |
| 3      | 7          | High       | 4            | Action now      |
| 4      | 7          | High       | 4            | Action now      |
| 5      | 8          | High       | 4            | Action now      |

Source: Data Collection.

According to Table 18, the average level of action experienced by the workforce is 4, indicating a high level of harm, therefore, a need for immediate action. The results of the RULA method assessment of cement transportation activities revealed that the level of risk from posture and workload in the activities performed could result in the risk of MSD injury.

**Transportation tool design**

Based on the results of the body posture calculations by utilizing the OWAS and RULA methods in Tables 14 and 18, it is advised that transportation aid be expected to lessen the load on workers as well as the risk of MSDs for workers. The recommended assistive equipment is a traditional transportation aid made of wood and equipped with a load-bearing rope. The conveyance tool’s design is shown in Figures 8 and 9.

Workers can use this transport during rice transportation duties. It is believed that workers who utilize this tool will have a safe body posture based on OWAS and RULA estimates. However, there are various constraints that have an impact on the work of rice transport personnel. The following are the constraints:

a. **The center of gravity and stability of the human body**

The weight of the load carried by the rice transport employees, which ranges between 80 and 100 kg, prevents the body posture from remaining straight. Because of the weight of the load carried, the body posture will bend forward to prepare for absorption (Yadi, 2012).

![Transport equipment](source)

**Figure 8. Transport equipment.** Source: Data Collection.
b. Regulation of the minister of manpower, transmigration and cooperatives No. PER.01/Men/1978

According to the Regulation of the Minister of Manpower, Transmigration, and Cooperatives No. PER.01/Men/1978 concerning Occupational Health and Safety in the Field of Aviation and Wood Transport (Per.01/Men/1978, 1978), there is a legal lifting limits for workers to create a safe and healthy working environment, namely the lifting load is determined based on the calculations of 5/7 body weight. The weight of the load hoisted by the rice transport workers exceeds the predetermined limit, indicating that the impact is clearly hazardous to the workers’ health and safety. (Per.01/Men/1978, 1978).

c. Mayor’s regulation No. 7 Tahun 2009 of Palembang city

A review of the mayor’s regulations controlling environmental management in the vicinity of Dock 16 Ilir Palembang City, particularly Palembang City Mayor Regulation Number 7 of 2009 about the Establishment of the River Port Service Technical Implementation Unit (UPTD). Based on these regulations, it has been explained in Chapter III that the Position of the main duties and functions is contained in Article 4 that the Sungai Port UPTD has the task of carrying out some of the Transportation Service’s tasks, particularly in managing, regulating, maintaining, providing services, supervising and collecting user fees for services, and river port utilization. As a result, it is envisaged that this policy will facilitate loading and unloading activities, as well as the improvement and growth of river ports (Walikota, 2009).

Conclusions and suggestion

According to the results of the NBM questionnaire calculation, the four rice transporters are at risk of MSDs because they have a total score of individual complaints in the range of 71–83, indicating that the risk level is at a score of 3, which is in a very high-risk category, and comprehensive action is required as soon as possible. The five cement transport employees were also at danger of MSDs since they had a total score of individual complaints in the range of 63–84, indicating that the risk level was at a score of 3, as such complete action is required as soon as feasible.

Based on the results of the workers’ posture and workload calculation on the activities of receiving rice, transporting rice, and laying rice from day 1 to day 6, an OWAS score of 3–4 is obtained, which is included in the high to very high risk category, so that the results of the assessment of rice transportation activities using OWAS are obtained. MSDs may be injured as a result of this action. While calculating work posture and workload on 5 cement transportation workers using RULA, it was discovered that workers 1 to 5 received an RULA score of 7, which is included in the action level 4 with...
high risk level, thus action is required as soon as feasible. The assessment of cement transportation activities using RULA also revealed that the level of risk from posture and workload in the activities performed could result in MSD injury. The transport tools’ design is projected to lower the risk of MSDs but not totally remove it because there are numerous restrictions that effect the results of the rice transport workers.

Data availability
Underlying data
Figshare: Data Base NBM, RULA, OWAS. https://doi.org/10.6084/m9.figshare.19545670.v1.

This project contains the following underlying data:

Data 1 eng.docx. (NBM data dan OWAS.)

Data 2 eng.docx. (NBM data and RULA.)

Data are available under the terms of the Creative Commons Zero “No rights reserved” data waiver Attribution 4.0 International (CC BY 4.0).

Author contributions
Christofora Desi Kusmindari: Conceptualization, Formal Analysis, Methodology, Data Curation, and Writing – Review & Editing

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