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JOURNAL INDUSTRIAL SERVICESS

Industrial Engineering Advance Research & Application

eISSN 2461-0631

# Optimizing worker safety: A case study on lifting load and body posture in rice warehouse operations

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ARTICLE INFO

*Article history:*
Received 1 March 2024
Received in revised form 2 June 2024
Accepted 12 June 2024
Published online 14 June 2024

*Keywords:*
Loading and unloading
MSDs
NIOSH
REBA

*Editor:*
Bobby Kurniawan

*Publisher's note:*
The publisher remains neutral concerning jurisdictional claims in published maps and institutional affiliations.

ABSTRACT

A rice warehouse's operations consist of loading and unloading activities of rice from transport trucks to storage warehouses and vice versa, distributing it to nearby agents. The work at the warehouse is done manually without any tools, with workers lifting rice sacks weighing more than 50 kg onto their shoulders every day. Tasks involving sudden loading pose a risk of musculoskeletal disorders (MSDs). The purpose of this study is to determine the safe weight that can be lifted by workers and to measure body posture to evaluate the risk of MSDs to prevent injuries. The NIOSH (National Institute for Occupational Safety and Health) method is used by measuring the Recommended Weight Limit (RWL) and Lifting Index (LI). The REBA (Rapid Entire Body Assessment) method involves measuring body parts A and B using the REBA worksheet. The study results indicate that the Lifting Index score for rice lifting has a very high risk, as does the REBA work posture score, which also shows a very high risk. Therefore, immediate improvements are needed in the loading and unloading process.

## 1. Introduction

The role of humans in industrial activities is very important, especially in manual material handling. However, humans also have limitations. As individuals with various characteristics, abilities, strengths, and limitations in performing tasks, they significantly impact the success of their work [1]. One common role performed by humans in various industries is manual material handling. However, manual material handling tasks carry a high risk and have the potential to cause accidents and health problems. Improper manual material handling activities can result in losses and workplace accidents [2]. Excessive lifting loads and improper body posture can increase the risk of spinal injuries. Spinal injuries are also known as musculoskeletal disorders. Musculoskeletal disorders (MSDs) are ergonomic problems often found in the workplace, especially those related to human strength and endurance in performing their tasks. This issue is commonly experienced by workers who perform repetitive movements continuously [3].

A warehouse is a critical component of the industry that supports overall industrial activities. It serves as a temporary storage place for finished goods before they are shipped to consumers or sellers to meet demand. A well-managed warehouse can support company operations, thus increasing competitiveness in the industrial world. Therefore, the success of company operations greatly depends on the effectiveness of warehouse management [4].

Krenceng Rice Warehouse is in the Cilegon area, where two main activities are carried out. First, the unloading process, where workers unload rice from transport trucks to the storage warehouse. Second is the loading process, where workers transport rice from the storage warehouse to the transport trucks for distribution to nearby agents.

The loading and unloading tasks carried out at the warehouse are done manually without any assistance, with rice sacks weighing more than 50 kg lifted onto the workers' shoulders each day. Although the loading and unloading activities are not carried out throughout the day, the load lifted at once is very high. The task can lead to injuries if there is sudden loading. Additionally, activities performed repeatedly, unnatural working postures, secondary factors such as pressure, vibration, and microclimate conditions, as well as combined or

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http://dx.doi.org/10.62870/jiss.v10i1.24479

cumulative causes, also contribute to the occurrence of musculoskeletal disorders [5]. Therefore, the lifting of heavy loads must be evaluated to avoid unwanted consequences.

MSDs are muscle injuries to the nervous system involving muscles, tendons, ligaments, joints, cartilage, or blood vessels. They cause various sensations such as stiffness, pain, warmth or burning, tingling, numbness, coldness, and discomfort. MSD complaints vary, ranging from mild muscle complaints to severe pain. Continuous exposure of muscles to repeated loads over a long period of time can lead to damage to joints, tendons, and ligaments [6].

Analysis of manual lifting loads and ergonomic posture measurements has been conducted by several researchers in manufacturing and SMEs. For example, ergonomic posture measurements for lifting water gallons were conducted by [7] using the RULA and REBA methods, measurements in the construction industry using RULA and NIOSH [8], and measurements using RULA and REBA for rickshaw drivers [9]. OWAS, REBA, and NIOSH were used to analyze complaints, postures, and reduce injury risks for water gallon delivery personnel [10]. NIOSH is utilized across various sectors to reduce lower back pain resulting from manual lifting tasks in the workplace [11], while REBA has been proven to provide risky posture results to reduce the workload of manual material handling processes [12]. REBA is often used in combination with various other methods and has experienced significant increases in usage [13].

Based on activities in the rice warehouse, this study will measure the lifting load index and body posture using the NIOSH approach and REBA method with the aim of determining the safe weight that can be lifted by workers and assessing body posture to evaluate the risk of musculoskeletal disorders (MSDs) to prevent injuries. Research on lifting loads in rice warehouses is expected to address existing issues and be implementable to enhance worker health and safety. Broadly, this research is expected to provide innovation and interventions in manual material handling activities.

## 2. Material and method

The research sample consists of the loading and unloading workers at Krenceng Rice Warehouse. Measurements were conducted on a single worker, as the loading and unloading activities, as well as the load and posture involved, are the same for all workers. The selected load and work posture were when the worker lifts rice onto their shoulders.

### *2.1. NIOSH (National for Occupational Safety and Health)*

NIOSH, or the National Institute for Occupational Safety and Health, is a federal agency in the United States that operates under the Centers for Disease Control and Prevention (CDC) within the U.S. Department of Health and Human Services. It is responsible for conducting research, making recommendations, and providing guidance aimed at preventing work-related injuries, illnesses, and fatalities.

One of NIOSH's primary focuses is on occupational safety and health, particularly in identifying and addressing workplace hazards. NIOSH conducts research to develop knowledge and tools that can be used to improve workplace safety practices. This includes studying the causes of injuries and illnesses, evaluating the effectiveness of safety measures, and developing guidelines and recommendations for preventing workplace hazards.

In the context of ergonomic research, NIOSH has developed methods and tools to assess ergonomic hazards and risks in various industries. For example, NIOSH has developed the Lifting Equation, which is used to evaluate the risk of lifting-related injuries and to determine safe lifting practices. NIOSH also provides guidance on ergonomics and musculoskeletal disorders, helping employers and workers understand and mitigate the risks associated with manual material handling tasks.

The research using NIOSH involves several steps. Firstly, it begins with observing work activities to understand the context. Next, specific lifting activities are selected for analysis. The distance of displacement, horizontal multiplier, and vertical multiplier are then measured to assess the lifting task's characteristics. Asymmetrical values are also measured to account for any imbalances. Coupling factors, which can affect the difficulty of the lifting task, are identified. Using this data, the Recommended Weight Limit (RWL) is calculated using Eq. (1) to determine the maximum safe weight that can be lifted [14]. Finally, the Lifting Index (LI) is determined using Eq. (2), which compares the actual load lifted to the RWL to assess the risk of injury [15].

$$RWL = LC \ x \ HM \ x \ VM \ x \ DM \ x \ AM \ x \ FM \ x \ CM \quad (1)$$

$$LI = Load / RWL \quad (2)$$

where

- $CM$: Coupling Multiplier. CM is considered good if the optimal packaging shape is square with a non-slip, easy-to-grip handle, and contents that are not prone to spillage. It is acceptable if the shape of the object is not optimal but still has a handle, albeit less ideal, resulting in the need for the hand to rotate when carrying it. Table 1 shows the value of several coupling multipliers.

**Table 1.**
Coupling Multiplier

| Type of Coupling | Coupling Multiplier | |
|---|---|---|
| | V < 75 | V > 75 |
| Good | 1.00 | 1.00 |
| Fair | 0.95 | 1.00 |
| Poor | 0.90 | 0.90 |

**Table 2.**
Frequency Multiplier

| Frequency (Lift/Minute ) | Work duration | | | | | |
|---|---|---|---|---|---|---|
| | ≥ 1 hour | | ≥ 1 and ≤ 2 hour | | >2 and ≤8 hour | |
| | V < 75cm | V ≥ 75cm | V < 75 cm | V ≥ 75 cm | V < 75cm | V ≥ 75 cm |
| ≤ 0,2 | 1,00 | 1,00 | 0,95 | 0,95 | 0,85 | 0,85 |
| 0,5 | 0,97 | 0,97 | 0,92 | 0,92 | 0,81 | 0,81 |
| 1 | 0,94 | 0,94 | 0,88 | 0,88 | 0,75 | 0,75 |
| 2 | 0,91 | 0,91 | 0,84 | 0,84 | 0,65 | 0,65 |
| 3 | 0,88 | 0,88 | 0,79 | 0,79 | 0,55 | 0,55 |
| 4 | 0,84 | 0,84 | 0,72 | 0,72 | 0,45 | 0,45 |
| 5 | 0,80 | 0,80 | 0,60 | 0,60 | 0,35 | 0,35 |
| 6 | 0,75 | 0,75 | 0,50 | 0,50 | 0,27 | 0,27 |
| 7 | 0,70 | 0,70 | 0,42 | 0,42 | 0,22 | 0,22 |
| 8 | 0,60 | 0,60 | 0,35 | 0,35 | 0,18 | 0,18 |
| 9 | 0,52 | 0,52 | 0,30 | 0,30 | 0,00 | 0,15 |
| 10 | 0,45 | 0,45 | 0,26 | 0,26 | 0,00 | 0,13 |
| 11 | 0,41 | 0,41 | 0,00 | 0,23 | 0,00 | 0,00 |
| 12 | 0,37 | 0,37 | 0,00 | 0,21 | 0,00 | 0,00 |
| 13 | 0,00 | 0,34 | 0,00 | 0,00 | 0,00 | 0,00 |
| 14 | 0,00 | 0,31 | 0,00 | 0,00 | 0,00 | 0,00 |
| 15 | 0,00 | 0,28 | 0,00 | 0,00 | 0,00 | 0,00 |
| > 15 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |

**Table 3** .
Classification of risk levels based on LI values

| LI | Risk Level | Improvement Description |
|---|---|---|
| < 1 | Low | The lifting task does not encounter any obstacles, so no improvements are needed, but it continues to receive attention to maintain LI values < 1 |
| 1- <3 | Medium | There are several issues with some lifting parameters, so immediate checks and redesigns are needed for parameters causing high RWL values. Efforts should be made to improve so that RWL values are < 1 |
| ≥ 3 | High | There are numerous issues with lifting parameters, thus thorough checks and immediate comprehensive improvements are required on parameters causing high values. Striving for improvements to ensure RWL values are < 1 |

- It is considered poor if the packaging design is not optimal, with sharp edges, no handles, difficult to grip (slippery, sharp), containing unstable items (easily breakable, prone to falling or spilling), and requiring gloves to handle [15].
- $LC$: (Lifting Constant) Lifting constant = 23 kg
- $HM$: (Horizontal Multiplier) horizontal multiplier factor = 25/H
- $VM$: (Vertical Multiplier) vertical multiplier factor = 1 - 0.003 [$V$ – 75]
- $DM$: (Distance Multiplier) displacement multiplier factor = 0.82 + 4.5/D
- $AM$: (Asymmetry Multiplier) asymmetry multiplier factor = 1 - 0.0032 A(0)
- $FM$: (Frequency Multiplier) frequency multiplier factor. For FM, short duration ≤ 1-hour, moderate duration between 1-2 hours, and long duration between 2-8 hours.

### 2.2. *Rapid Entire Body Assessment (REBA)*

The Rapid Entire Body Assessment (REBA) is an ergonomic tool used to assess the risk of musculoskeletal disorders associated with various job tasks. It systematically evaluates the posture, movement, and force exerted by different body parts during work activities, offering a detailed view of the ergonomic risks involved. REBA is particularly effective in dynamic and complex work settings where employees frequently shift positions and perform diverse tasks. The assessment process involves scoring the posture of body parts such as the neck, trunk, and upper and lower limbs during specific tasks. These scores are then combined to generate a final risk score, which helps guide the implementation of suitable ergonomic interventions. By identifying high-risk postures and activities, REBA enables organizations to prioritize ergonomic adjustments, enhancing worker comfort, productivity, and overall occupational health.

The research using the Rapid Entire Body Assessment (REBA) begins with observing activities in the warehouse and selecting work postures to be evaluated. The next steps involve measuring the posture of various body parts: the neck, back, legs, upper arms, lower arms, and wrists. Each of these measurements helps to determine the overall ergonomic risk associated with the work tasks performed in the warehouse. By analyzing these postures, researchers can identify which movements and positions are most likely to contribute to musculoskeletal disorders. This detailed assessment enables the formulation of targeted interventions to mitigate these risks, such as redesigning tasks, introducing ergonomic tools, or providing training on proper body mechanics. The goal is to enhance worker safety, reduce the incidence of work-related injuries, and improve overall workplace efficiency.

## 3. Results and discussions

This section presents the results from NIOSH and REBA calculations based on observations in a rice warehouse where loading and unloading operations are performed manually by workers.

### *3.1. Results of NIOSH*

Table 4 shows the results of NIOSH. Using the RWL formula, the initial RWL is found to be 16.24, and the final RWL is 11.057. If the movement frequency is 0.5 minutes and the work duration is more than 2 hours, and the value of V is greater than 75 cm, then the FM value is 0.92. As for the coupling multiplier (CM), if the type of coupling or handle used on the load falls into the category of less than optimal and the value of V is greater than 75 cm, because the design of the rice sack does not have a handle or is difficult to grip, then the CM value is 0.90. Once the RWL value is known, the next step is to calculate the Lifting Index (LI) to determine if the lifting index poses a risk of spinal injury. The LI is used to assess whether the lifting activity poses a risk of causing spinal injuries, such as lower back pain and musculoskeletal disorders [16].

With a heavy load of 150 kg, the LI values for the initial and final stages were obtained. The lifting load calculation in the NIOSH equation was performed twice to determine the comparison of potential risk levels that may occur during the lifting process. From the calculation results, the Lifting Index value for the initial lift was 9.23, and the Lifting Index value for the final lift (destination) was 13.56.

**Table 4.**
NIOSH equation variable

| Variable | Initial | Final |
|---|---|---|
| Horizontal Distance | 20 | 35 |
| Vertikal Distance | 160 | 55 |
| Displacement Distance | 187 | 187 |
| Asymetric Angle | 0 | 0 |
| Frequency | 0,5/m | 0,5/m |
| Duration | < 2 hour | < 2 hour |
| Coupling | Poor | Poor |

**Figure 1.** The body posture of the worker while carrying rice sacks

These results indicate that the lifting process performed by the rice transporter workers can be categorized as high-risk, thus posing a considerable risk of injury, especially in the spinal area. The Recommended Weight Limit is the load limit that a worker can lift without risk of injury, even if the task is repetitive and prolonged [16].

### *3.2. Results of REBA*

REBA is a method used to analyze work posture during manual material handling activities. In ergonomics, the REBA method quickly assesses the posture of the neck, back, arms, wrists, and legs of a worker [16]. In the posture illustration above, the neck position during load handling has an angle of approximately 20 degrees, resulting in a score of 2 for neck movement. A similar neck posture with a score of 2 was observed in seamstresses in Tanjungpinang City [17]. The back position during load handling has an angle of approximately 20 to 60 degrees, resulting in a score of 3 for back movement. The leg position during load handling has an angle of approximately 60 degrees, resulting in a score of 1 for leg movement. Based on the REBA table, the scores for the neck, back, and legs are 5, then added to the lifted load of 150 kg with a score of 2, resulting in a total score for body part A of 7.

Work posture in workers handling a heavy load, as indicated by the LI value obtained, can pose risks of musculoskeletal disorders (MSDs). Complaints associated with MSDs include pain in the wrists, neck, back, elbows, and knees [6].

In Fig. 1, the upper arm position during load handling is approximately 90 degrees, resulting in a score of 4 for upper arm movement. The lower arm movement during load handling ranges from approximately 0 to 60 degrees, resulting in a score of 2 for lower arm movement. The wrist position during load handling is at approximately 15 degrees, resulting in a score of 2 for wrist movement. These results are consistent with the findings of the study [18], which also observed similar upper arm posture.

From Fig. 7, it is observed that the hand grip condition on the load is considered poor due to the lack of a handle on the carried load, resulting in a score of 2. This poor coupling condition is also noted in WIP transfer operators [19]. According to the REBA table, the scores for the upper arm, lower arm, and wrist are 6. When added to the hand grip position score on the load, which is 2, the total score for body posture Part B is 8.

### *3.3. Discussions*

Injury risks due to very heavy loading can occur to workers at Krenceng rice warehouse, such as injuries to sheet metal manufacturing operators who use NIOSH, which are at the waist [20]. According to [21], to reduce the lifting index and make the job safer, the load should be kept close to the employee's body, which decreases the horizontal distance (H) and increases the horizontal multiplier (HM). Elevating products also helps reduce the vertical multiplier (VM) value. With these adjustments, both the initial and final lifting indexes decrease below 1. It is also recommended to use mechanical devices for transportation.

For rice transporter workers, a body part A score was obtained, consisting of neck, back, and leg movements, with a value of 7. Then, in the calculation of body part B, which consists of upper arm, lower arm, and wrist movements, a score of 8 was obtained. Thus, based on the REBA worksheet C, the obtained score is 10. With the addition of an activity score of 1, the REBA score is 11. From these REBA scores, it can be categorized that the work performed has a very high-risk level, which can lead to serious injuries, thus requiring immediate improvement.

Although in this study the workers' body posture is upright, [22] found in their study that lifting loads without an initial squatting position can endanger the back, as the back becomes the main support when lifting. Several improvement steps can be taken, such as improving the work environment and facilities, which can help reduce the risk of muscle injuries while working [23]. Additionally, it is recommended for workers to regularly perform movement variations to improve their work posture [24]. The REBA analysis results in the packaging process suggest changes in work posture and the use of aids aimed at reducing the risk of MSDs [25]. The design of ergonomic aids can reduce the risk of injury [26].

## 4. Conclusions

The research results on the rice transportation process at Krenceng Rice Warehouse indicate a very high risk, potentially causing injuries. The REBA score reaching 11 in the transportation of rice sacks indicates a very high level of risk, potentially leading to serious injuries to workers. Moreover, improper transportation processes over time can result in changes in body anatomy. Therefore, immediate improvements are needed in the loading and unloading process. However, this study did not cover measurements of workers' body anatomy aspects and the design of necessary aids. For more comprehensive results, the research needs to involve measurements of other postures in rice loading and unloading activities.

## Declaration statement

Nustin Merdiana Dewantari: **Conceptualization, Supervision, Writing - Review & Editing**. Creavilian Taqdisillah: **Original Draft, Resources**. Reefly Yoshea Mangaranap: **Original Draft, Resources**. Ade Sri Mariawati: **Validation, Investigation**. Lely Herlina: **Writing, Reviewing**.

## Acknowledgement

The authors wish to thank anonymous referees for their constructive feedback.

## Disclosure statement

The authors report there are no competing interests to declare.

## Funding statement

The author(s) received no financial support for the research, authorship, and/or publication of this article.

## Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article or its supplementary materials.

## References

[1] A. Afandy and A. E. Nurhidayat, “Pengukuran Risiko Musculoskeletal Disorders pada Kegiatan Manual Material Handling Menggunakan Metode SOFI dan OWAS di PT. XYZ,” *JENIUS : Jurnal Terapan Teknik Industri*, vol. 3, no. 2, pp. 90–102, Oct. 2022, doi: 10.37373/jenius.v3i2.306.

[2] D. Lesmana, “Analisis Beban Kerja menggunakan Metode Recommended Weight Limit dan Lifting Index,” *J Teknol*, vol. 12, no. 1, pp. 21–26, Jun. 2022, doi: 10.35134/jitekin.v12i1.66.

[3] L. L. Karliman and E. Sarvia, “Perancangan Alat Material Handling untuk Mereduksi Tingkat Risiko Cedera Tulang Belakang Operator pada Aktivitas Pemindahan Semen di Toko Bangunan X,” *Journal of Integrated System*, vol. 2, no. 2, pp. 170–191, Dec. 2019, doi: 10.28932/jis.v2i2.1609.

[4] M. Rafli, “Pengaruh Tata Letak, Material Handling Equipment dan Warehouse Management System Terhadap Efektivitas Pengelolaan Gudang,” *Jurnal Bisnis, Logistik dan Supply Chain (BLOGCHAIN)*, vol. 2, no. 2, pp. 78–84, Nov. 2022, doi: 10.55122/blogchain.v2i2.548.

[5] A. D. Pratiwi, N. Nurmaladewi, and N. Nasruddin, “Hubungan Pekerjaan Manual Material Handling dengan Keluhan Musculoskeletal Disorders pada Pengantar Galon,” *IKESMA*, vol. 18, no. 1, p. 19, Mar. 2022, doi: 10.19184/ikesma.v18i1.23851.

[6] S. Salimatusadiah and N. R. As’ad, “Perancangan Fasilitas Kerja pada Operator Pemasangan Accesories di CV. X untuk Mengurangi Risiko Musculoskeletal Disorders (MSDs),” *Jurnal Riset Teknik Industri*, vol. 1, no. 1, pp. 28–35, Jul. 2021, doi: 10.29313/jrti.v1i1.93.

[7] A. Suhendar, A. B. Sinaga, A. Firmansyah, S. Supriyadi, and W. Kusmasari, “Analisis Risiko Musculoskeletal Disorders (MSDs) pada Pekerjaan Pengangkutan Galon Air Mineral,” *Jurnal INTECH Teknik Industri Universitas Serang Raya*, vol. 9, no. 1, pp. 71–78, Jun. 2023, doi: 10.30656/intech.v9i1.5641.

[8] R. Ucan, A. Gul, M. E. Özay, M. E. Qzay, and O. Cakır, “Application of RULA and NIOSH Ergonomic Risk Assessment Methods: A Case Study in Construction Industry in Turkey,” *International Journal of Engineering Reserach & Technology (IJERT)*, vol. 9, no. 9, pp. 306–312, 2020, [Online]. Available: https://www.researchgate.net/publication/348735448

[9] F. Kurnia and M. Sobirin, "Analisis Tingkat Kualitas Postur Pengemudi Becak Menggunakan Metode RULA dan REBA," *Jurnal Engine: Energi, Manufaktur, dan Material*, vol. 4, no. 1, pp. 1–5, 2020, doi: 10.30588/jeemm.v4i1.708.

[10] D. Maharsayani and E. Sarvia, "Usulan Perbaikan Postur Tubuh & Perancangan Alat Material Handling untuk Petugas Pengantar Air Galon dengan Metode OWAS, REBA & LI-NIOSH (Studi Kasus: PT Z – Depok, Meruyung)," *Prosiding Seminar Nasional Teknik dan Manajemen Industri*, vol. 1, no. 1, pp. 128–135, Dec. 2021, doi: 10.28932/sentekmi2021.v1i1.48.

[11] R. Shahu, "The NIOSH Lifting Equation for Manual Lifting and Its Applications," *Journal of Ergonomics*, vol. 06, no. 02, pp. 1–10, 2016, doi: 10.4172/2165-7556.1000159.

[12] G. B. HM and N. Narto, "Usulan Perbaikan Postur Kerja untuk Mengurangi Beban Kerja Proses Manual Material Handling dengan metode RULA REBA QEC (Studi Kasus Pengemasan Herbisida di PT. Petrokimia Kayaku Pabrik 3)," *Jurnal Ilmiah Teknik Industri*, vol. 8, no. 3, pp. 203–213, 2020, doi: 10.24912/jitiuntar.v8i3.7806.

[13] M. Hita-Gutiérrez, M. Gómez-Galán, M. Díaz-Pérez, and Á. J. Callejón-Ferre, "An overview of reba method applications in the world," *Int J Environ Res Public Health*, vol. 17, no. 8, Apr. 2020, doi: 10.3390/ijerph17082635.

[14] US Departement of health and Human Services, "NIOSH Work Practices Guide for Manual Lifting, NIOSH Technical Report No 81-122."

[15] D. Andianingsari, A. Rahman, and B. N. Kuncoro, "Pengukuran Ergonomi Metode Recommended Weight Limit (RWL) Lifting Index (LI) di PT X," *IMTechno: Journal of Industrial Management and Technology*, vol. 3, no. 2, 2022, doi: 10.31294/imtechno.v3i2.1229.

[16] A. A. Saputra, W. Wahyudin, and A. E. Nugraha, "Evaluasi Aktivitas Manual Material Handling Dengan Menggunakan Metode Biomekanika Kerja Pada Pengangkatan Thiner di Bagian Warehouse," *Jurnal Sistem Teknik Industri*, vol. 23, no. 2, pp. 233–244, Jul. 2021, doi: 10.32734/jsti.v23i2.6273.

[17] M. Y. Mf, M. Febiyanti, R. Kurnia, and G. D. N. Kusuma, "Studi Risiko Ergonomi dan Keluhan Subjektif Work-Related Musculoskeletal Disorders (WMSDs) pada Penjahit di Kota Tanjungpinang," *Jurnal Teknologi dan Manajemen Industri Terapan (JTMIT)*, vol. 2, no. 3, pp. 224–233, 2023, doi: 10.55826/tmit.v2i3.271.

[18] L. Yuliana, I. Zulfikar, and M. Yumna Faiq, "Musculekeletal Disorders pada Pekerja Kuli Panggul di Pasar Pandan Sari Kota Balikpapan," *IDENTIFIKASI: Jurnal Keselamatan, Kesehatan Kerja dan Lindungan Lingkungan*, vol. 8, no. 2, pp. 639–648, 2022, doi: 10.36277/identifikasi.v8i2.244.

[19] E. Evita and E. Sarvia, "Perbaikan Postur Kerja pada Operator Stasiun Two For One Atas Menggunakan Metode REBA," *Journal of Integrated System*, vol. 2, no. 1, pp. 37–50, 2019, doi: 10.28932/jis.v2i1.1716.

[20] J. Chin, H. Herlina, H. Iridiastadi, L. Shu-Chiang, and S. Fadil Persada, "Workload Analysis by Using Nordic Body Map, Borg RPE and NIOSH Manual Lifting Equation Analyses: A Case Study in Sheet Metal Industry," in *Journal of Physics: Conference Series*, Institute of Physics Publishing, Dec. 2019, pp. 1–6. doi: 10.1088/1742-6596/1424/1/012047.

[21] B. K. Kirci, M. Ensari Ozay, and R. Ucan, "A Case Study in Ergonomics by Using REBA, RULA and NIOSH Methods: Logistics Warehouse Sector in Turkey," *Hittite Journal of Science & Engineering*, vol. 7, no. 4, pp. 257–264, Dec. 2020, doi: 10.17350/HJSE19030000194.

[22] A. H. Wibowo and A. Mawadati, "The Analysis of Employees' Work Posture by using Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA)," in *IOP Conference Series: Earth and Environmental Science*, IOP Publishing Ltd, Apr. 2021, pp. 1–10. doi: 10.1088/1755-1315/704/1/012022.

[23] J. A. Pradana, I. F. Fahmi, E. P. S. Indiarto, S. Nindia, and M. Haristanti, "Fuzzy Sugeno-Biomekanika-NIOSH-NBM: Penialain Risiko Aktivitas Penyaringan Bubur Kedelai," *Jurnal Ilmiah Teknik dan Manajemen Industri*, vol. 2, no. 1, pp. 26–36, 2022, doi: 10.46306/tgc.v2i1.

[24] A. S. Rezki, A. H. Maksum, D. Herwanto, and M. T. Rahmat, "Analisis Risiko Postur Kerja dengan Metode Nordic Body Map, RULA dan REBA pada Proses Manual Material Handling Pabrik Kecap," *Jurnal Media Teknik dan Sistem Industri*, vol. 7, no. 2, p. 86, Sep. 2023, doi: 10.35194/jmtsi.v7i2.2677.

[25] L. Nabil and S. S. Dahda, "Risk Analysis of The Packing Process at The Departement of PT.XYZ Used REBA Method," *Journal of Applied Engineering and Technological Science*, vol. 4, no. 1, pp. 325–332, 2022, doi: 10.37385/jaets.v4i1.1119.

[26] G. D. Rembulan and S. Maratama, "Perancangan Alat Bantu dengan Metode Conjoint Analysis dan Quality Function Deployment (QFD) Berdasarkan Prinsip Ergonomi," *Jurnal of Industrial Engineering and Management Systems*, vol. 15, no. 1, pp. 35–44, 2022, doi: 10.30813/jiems.v15i1.3602.