RESWARA: Jurnal Riset Ilmu Teknik
2026, Vol. 4, No. 3, pp. 502-519
E-ISSN: 3025-9444

Ergonomic Risk and Work Productivity among Manual Material Handling Workers at PT BIELOGA: A REBA-Based Analysis

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Abstract: *Manual material handling activities are commonly associated with awkward working postures, repetitive movements, and excessive physical load, which may increase the risk of musculoskeletal disorders and reduce work productivity. This study aims to assess ergonomic risk levels and analyze their relationship with work productivity among manual material handling workers at PT BIELOGA using the Rapid Entire Body Assessment (REBA) method. This research employed a descriptive quantitative approach. Data were collected through direct observation of workers' postures during manual handling activities, REBA assessment, Nordic Body Map responses, and productivity measurement based on output and task completion efficiency. The findings showed that the observed manual handling activities were classified into moderate to high ergonomic risk categories, with REBA scores ranging from 5 to 9. The highest ergonomic risks were found in material loading activities and material transfer to racks, which involved trunk flexion, reaching posture, repetitive movement, and external load exposure. The analysis indicated a strong negative relationship between REBA scores and work productivity, suggesting that higher ergonomic risk tends to be followed by lower productivity performance. These findings indicate that ergonomic risk is not only related to occupational health concerns but also to operational performance. Therefore, ergonomic interventions such as workstation redesign, adjustment of material placement height, improvement of manual handling procedures, task rotation, and the use of assistive devices are recommended to reduce ergonomic risk and support productivity improvement.*

Article history:
Received: 29 June 2026
Revised: 17 July 2026
Accepted: 20 July 2026
Published: 22 July 2026

Keyword:
ergonomic risk, REBA, manual material handling, work productivity, musculoskeletal disorders

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How to cite: Anugrah, T., & Irwan, H. (2026). Ergonomic Risk and Work Productivity among Manual Material Handling Workers at PT BIELOGA: A REBA-Based Analysis *RESWARA: Jurnal Riset Ilmu Teknik*, *4*(3), 502–519. https://doi.org/10.70716/reswara.v4i3.685

INTRODUCTION

Manual material handling remains an essential component of operational activities in manufacturing, logistics, warehousing, and material-processing industries. These activities include lifting, carrying, lowering, arranging, pushing, pulling, and transferring materials manually as part of production and distribution processes. Although automation technologies have developed rapidly, many industrial operations still rely on human labor because of operational flexibility, lower investment costs, ease of implementation, and the characteristics of work systems that cannot be fully automated. However, this continued reliance on manual material handling exposes workers to ergonomic risks, particularly when tasks involve heavy loads, repetitive movements, prolonged working duration, and awkward or unstable body postures.

From an occupational health and safety perspective, ergonomic risk is a critical issue because it affects worker comfort, physical capacity, and job performance. Manual handling activities that require bending, twisting, reaching, lifting, or maintaining constrained postures for extended periods can increase biomechanical stress on muscles, joints, tendons, and the spine. Deviani (2017) explained that manual material handling contributes significantly to occupational injuries because of

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excessive biomechanical loads on the musculoskeletal system. Therefore, ergonomic risk in manual work should not be assessed solely on the basis of the weight of the handled materials, but also by considering posture, movement frequency, work duration, force exertion, coupling conditions, and the surrounding work environment.

Continuous exposure to non-ergonomic working postures can generate negative consequences for both workers and organizations. At the individual level, such exposure may lead to fatigue, discomfort, pain in specific body regions, and long-term musculoskeletal disorders. At the organizational level, ergonomic problems may reduce work efficiency, slow task completion, increase the likelihood of errors, and decrease overall productivity. These consequences indicate that ergonomic evaluation should be regarded as an important component of industrial work-system management, especially in workplaces where manual material handling activities are still performed intensively.

One of the methods widely used to evaluate ergonomic risk is the Rapid Entire Body Assessment (REBA). This method was developed to assess working postures quickly and systematically by considering major body segments, including the neck, trunk, legs, upper arms, lower arms, and wrists, as well as load, coupling, and activity factors. Sağiroğlu et al. (2015) stated that REBA provides a rapid and accurate quantitative assessment of ergonomic risk levels in various workstations. The main advantage of REBA lies in its ability to classify posture-related risk levels and determine the urgency of corrective actions. Therefore, REBA is considered relevant for assessing ergonomic risk in manual material handling activities because it is practical, field-oriented, and capable of capturing actual working conditions.

Previous studies have shown that manual handling activities are frequently associated with moderate to high ergonomic risk. Widodo et al. (2018), in a study of physical workload in the brick industry, reported that material handling activities generated high physical workloads and had the potential to reduce work efficiency. Similar findings were reported by Primasari and Kurnianingtyas (2022), who found that material transfer activities in a machining workshop resulted in non-ergonomic postures, particularly bending positions and unstable body rotation. Faudy and Sukanta (2022) also found that sorting activities among industrial workers were dominated by postures that did not conform to ergonomic principles, resulting in increased REBA scores. Other studies using posture-assessment methods in industrial work settings likewise reported that packaging, soybean pressing, and operator activities were associated with posture-related ergonomic risk and potential musculoskeletal complaints (Herwanto, 2023; Zuraida & Kasih, 2024; Syafira Hasan, 2025). These findings indicate that ergonomic risk in manual handling is not limited to a specific industrial sector, but is commonly found in work activities involving direct interaction between workers and materials.

The relationship between ergonomic risk and musculoskeletal disorders has also been widely discussed in the literature. Musculoskeletal disorders refer to disorders affecting muscles, tendons, ligaments, joints, nerves, and supporting tissues due to accumulated physical loads and non-ergonomic working postures. Nur and Sadewa (2021) showed that higher REBA scores were associated with an increased incidence of musculoskeletal complaints. Rahmawati and Anggraini (2024) further emphasized that improvements in working posture through ergonomic intervention could reduce the risk of musculoskeletal disorders and improve worker comfort. These findings confirm that ergonomic problems should not only be viewed as occupational health issues, but also as factors that may affect work continuity, performance, and productivity.

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In modern industrial practice, ergonomics is increasingly viewed not only as a strategy for injury prevention, but also as an approach to improving productivity. Workers who perform tasks in uncomfortable postures and experience prolonged fatigue tend to show lower work speed, reduced accuracy, decreased concentration, and limited endurance during working hours. These conditions may influence work output in terms of both quantity and quality. Salsabila et al. (2025) found that posture-related ergonomic risk in the furniture industry was associated with reduced work performance. This indicates that ergonomics is not merely a technical issue concerning body position, but also an important factor in supporting operational effectiveness and efficiency.

Several studies have proposed ergonomic interventions to reduce risk in manual handling activities. Hilmi et al. (2024) demonstrated that ergonomic evaluation combined with work-design improvement could reduce ergonomic risk levels. Agustiningsih et al. (2025) showed that the development of a pallet-delivery system reduced workers' manual handling load and lowered the risk of musculoskeletal disorders. Putra et al. (2023) developed an ergonomic trolley based on anthropometric data and REBA analysis, which proved effective in reducing non-ergonomic working postures. Baeri et al. (2025) also emphasized that ergonomics-based assistive devices can reduce injury risk and improve work efficiency. These studies show that ergonomic assessment has practical value because it can generate applicable recommendations for improving work systems.

A closer review of previous studies reveals a common pattern in ergonomic research. Widodo et al. (2018) focused on physical workload in material handling activities, while Primasari and Kurnianingtyas (2022) emphasized non-ergonomic postures during material transfer. Faudy and Sukanta (2022) examined posture deviation in sorting activities, and Nur and Sadewa (2021) linked REBA scores with musculoskeletal complaints. Meanwhile, Hilmi et al. (2024), Agustiningsih et al. (2025), Putra et al. (2023), and Baeri et al. (2025) highlighted ergonomic interventions to reduce physical risk and improve work conditions. Although these studies provide important insights into ergonomic hazards, worker complaints, and corrective actions, they generally focus on risk identification, health-related outcomes, or intervention design. They do not sufficiently examine whether the level of ergonomic risk is associated with measurable productivity outcomes, such as work output and task completion efficiency.

Despite the widespread use of REBA in ergonomic studies, its application has largely been limited to posture assessment and risk classification. In addition, several studies have applied REBA either independently or in combination with other instruments, such as the Nordic Body Map, RULA, OWAS, and the NIOSH lifting equation, to provide a broader evaluation of ergonomic exposure (Meri et al., 2024; Nadiyah et al., 2025; Rezki et al., 2023; Gloria et al., 2025). However, the integration of ergonomic assessment results with productivity measurement remains limited, particularly in actual industrial settings involving manual material handling activities. As a result, the relationship between ergonomic risk level and operational performance is still insufficiently explained. This gap is important because ergonomic problems do not only affect worker health and comfort, but may also influence work speed, physical endurance, task efficiency, and overall productivity.

Based on this gap, the present study examines ergonomic risk and work productivity among manual material handling workers at PT BIELOGA. The company provides a relevant research context because manual material handling activities remain part of its operational processes. These activities require workers to perform physical tasks that may involve awkward postures, repetitive

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movements, and exposure to physical loads. Therefore, an ergonomic assessment is needed not only to identify the level of risk experienced by workers, but also to understand how such conditions may relate to productivity performance.

This study aims to analyze ergonomic risk levels in manual material handling activities using the REBA method and to examine their relationship with worker productivity at PT BIELOGA. The contribution of this study lies not in the use of REBA as a method alone, since REBA has been widely used in previous research, but in the integration of posture-based ergonomic risk assessment with measurable productivity indicators in a real industrial work environment. Specifically, this study relates REBA scores to work output and task completion efficiency in order to provide a more comprehensive understanding of how ergonomic conditions affect both worker safety and operational effectiveness. Practically, the findings are expected to provide recommendations for improving work systems, including the use of assistive devices, improvements in work methods, adjustments to manual handling techniques, and workstation redesign. Theoretically, this study contributes to ergonomic research by strengthening the perspective that ergonomic evaluation should be linked not only to health-related outcomes, but also to measurable productivity outcomes as part of industrial performance improvement.

RESEARCH METHOD

Research Design

This study employed a descriptive quantitative design to analyze ergonomic risk and its relationship with work productivity among manual material handling workers at PT BIELOGA. This approach was selected because it enables the objective measurement of posture-related ergonomic risk using the Rapid Entire Body Assessment (REBA) method and provides an empirical description of work productivity based on field observation data.

The study was designed to identify ergonomic risk levels in manual material handling activities and to examine how these risks relate to productivity performance in an actual industrial work environment. The descriptive quantitative design was considered appropriate because the study focused on measuring, classifying, and interpreting ergonomic risk scores and productivity indicators obtained from field conditions.

Research Setting and Participants

The study was conducted in the production area of PT BIELOGA during January–February 2026. Data collection was carried out during the company's regular production schedule, particularly during the morning shift, because manual material handling activities were performed intensively during this period. Field observations were conducted for five consecutive working days, with an observation duration of approximately four hours per day, resulting in a total effective observation time of approximately 20 hours.

The production area was selected because it involved intensive manual material handling activities, including lifting, carrying, transferring, lowering, and arranging materials as part of the production process. These activities require workers to perform repetitive physical tasks that may involve awkward postures, exposure to physical loads, and prolonged work duration.

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The population of this study consisted of all workers involved in manual material handling activities in the production area. The sample was determined using purposive sampling, because the study required respondents who were directly and routinely exposed to manual material handling tasks and were therefore the most relevant subjects for ergonomic risk assessment using REBA and productivity analysis. Not all workers in the production area performed the same type or intensity of manual handling tasks; therefore, purposive sampling was considered more appropriate than random selection.

The selection of respondents was based on several considerations. First, workers had to be directly involved in routine manual material handling activities as part of their daily work. Second, they had to perform tasks involving lifting, carrying, transferring, lowering, or arranging materials within one work cycle. Third, they had to have sufficient work experience in the same task so that the observed postures reflected regular working patterns rather than temporary adaptation. Based on these criteria, a total of 20 workers were selected because they met the inclusion criteria and represented the workers actively involved in the observed manual material handling activities during the data collection period.

The inclusion criteria were workers who were directly involved in manual material handling activities, had worked in the same task for at least three months, were present during the observation period, and were willing to participate in the study. Workers who were temporarily assigned to non-manual tasks or had acute injuries during the data collection period were excluded from the study.

To provide a clearer profile of the study participants, respondent characteristics were documented, including the number of workers, age, length of service, type of job, and characteristics of their work activities. The respondents were involved in production-support tasks such as lifting, carrying, transferring, arranging, and loading materials. Their age ranged from 22 to 46 years, with a mean age of 31.5 years. Their length of service ranged from 1 to 12 years, with an average of 4.8 years. In general, the respondents performed repetitive physical activities involving manual lifting, carrying loads, bending, reaching, and material transfer during one work cycle.

Table 1. Characteristics of Respondents

Variable	Description
Number of workers	20
Age range	22–46 years
Mean age	31.5 years
Length of service range	1–12 years
Mean length of service	4.8 years
Main job activities	Lifting, carrying, transferring, arranging, and loading materials
Work characteristics	Repetitive manual handling, awkward postures, physical load exposure

Data Collection Procedure

Data were collected through direct observation of workers while performing manual material handling activities under normal operating conditions. The observation process was carried out in the actual work setting without interrupting the production flow, so that the postures and work activities recorded reflected the real working conditions of the workers.

During the initial stage of observation, the researcher identified 12 manual material handling activities performed in the production area. Each activity was observed to document the sequence of

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movements involved in one work cycle, including lifting, carrying, transferring, lowering, and placing materials. The observation focused on workers' body postures, particularly the position of the neck, trunk, legs, upper arms, lower arms, and wrists. In addition, the external load handled by workers, the quality of hand grip or coupling, and the frequency or repetition of the activity were recorded to support the REBA assessment.

The observation process was conducted systematically in several stages. First, the researcher observed the workflow and identified all manual material handling activities carried out by workers in the production area. Second, each identified activity was documented and classified based on its task characteristics, frequency of occurrence, and physical demands. Third, the researcher selected the most representative postures from each activity, especially those showing the greatest deviation from neutral body posture and the highest potential ergonomic risk. These representative postures were then assessed using the REBA worksheet.

From the 12 observed activities, five main representative activities were selected for detailed REBA and productivity analysis. The selected activities were lifting light materials, lifting medium-weight materials, transferring materials to racks, arranging materials on the floor, and loading materials onto vehicles. These five activities were selected purposively because they were the most frequently performed, represented the main stages of the production material-handling process, involved different levels of physical load, and showed clear variations in posture and movement patterns. Therefore, these activities were considered representative of the overall manual material handling process in the production area.

The postures selected for REBA assessment were those considered most representative of each task and those showing the highest potential ergonomic risk, particularly during lifting, carrying, lowering, and material placement activities. Direct observation was used because it allows researchers to capture actual working postures and identify ergonomic risk factors in real time.

Research Instruments

The main instrument used in this study was the Rapid Entire Body Assessment or REBA worksheet. REBA was used to assess ergonomic risk systematically based on workers' body postures, movement characteristics, external load, coupling, and activity factors. The REBA assessment considers several body segments, including the neck, trunk, legs, upper arms, lower arms, and wrists. The final REBA score was used to determine the ergonomic risk category and the urgency of corrective action.

The REBA risk classification used in this study is presented in Table 2.

Table 2. REBA Risk Level Classification

REBA Score	Risk Level	Action Category
1	Negligible risk	No action required
2–3	Low risk	Action may be needed
4–7	Medium risk	Action is needed
8–10	High risk	Action is needed soon
11–15	Very high risk	Action is needed immediately

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In addition to REBA, the Nordic Body Map (NBM) questionnaire was used as a supporting instrument to identify workers' subjective complaints in specific body regions. The NBM was used to obtain information regarding discomfort or pain experienced by workers in areas such as the neck, shoulders, back, waist, arms, wrists, thighs, knees, and legs. The use of the NBM was intended to strengthen the ergonomic analysis by comparing posture-based risk assessment results with workers' perceived musculoskeletal complaints.

The REBA assessment was conducted based on direct observation of workers' postures using the standard REBA worksheet procedure. The evaluator identified the most representative posture in each activity, particularly postures showing the greatest deviation from neutral posture and the highest potential ergonomic risk during lifting, carrying, lowering, and material placement. Each posture was scored systematically by assessing the neck, trunk, and legs to obtain Score A, and the upper arms, lower arms, and wrists to obtain Score B. The load or force score, coupling score, and activity score were then added according to the standard REBA procedure to produce the final REBA score.

The REBA scoring in this study was performed by the researcher as the main evaluator. To reduce subjectivity, the scoring process followed the same procedure for all observed activities and referred consistently to the standard REBA posture-classification criteria. Each body segment was assessed separately, and the scoring sequence from Table A, Table B, and Table C to the final activity score was checked carefully to ensure calculation accuracy. In addition, posture documentation from field observations was reviewed repeatedly to improve scoring consistency and reduce assessment bias.

Measurement of Work Productivity

Work productivity in this study was assessed using two indicators: daily work output and task completion efficiency. Daily work output referred to the number of materials handled or work tasks completed by each worker during one working day. Meanwhile, task completion efficiency referred to the time required by workers to complete one cycle of manual material handling activity.

Productivity was calculated by comparing the total output produced with effective working time. The formula used to calculate productivity is as follows:

`Productivity = Total Output / Effective Working Time`

In addition, task completion efficiency was calculated by comparing standard time and actual completion time. The formula used is as follows:

`Efficiency (%) = (Standard Time / Actual Time) × 100`

Higher productivity was indicated by a greater number of completed tasks or handled materials within the same effective working time. Higher efficiency was indicated by a shorter actual completion time compared with the standard time, while still maintaining the expected work output. These productivity indicators were used to describe worker performance and to examine the relationship between ergonomic risk levels and productivity outcomes.

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Research Variables

Table 3. Research Variables and Indicators

Variable	Indicator	Measurement Method	Output
Ergonomic risk	Working posture, load, coupling, and activity frequency	REBA worksheet	REBA score and risk category
Musculoskeletal complaints	Discomfort in body regions	Nordic Body Map questionnaire	Complaint level by body region
Work productivity	Total output and effective working time	Field observation and production records	Output per working time
Task efficiency	Standard time and actual time	Time observation	Efficiency percentage

Data Analysis

Data analysis was carried out in several stages. The first stage involved identifying and documenting workers' postures during manual material handling activities. The documented postures were then assessed using the REBA worksheet to obtain ergonomic risk scores for each observed activity.

The second stage involved classifying the REBA scores into ergonomic risk categories. Each observed task was categorized based on its final REBA score to determine whether the activity was included in the negligible, low, medium, high, or very high risk category. This classification was used to identify the priority level of corrective action required for each manual handling activity.

The third stage involved analyzing workers' productivity based on daily output and task completion efficiency. Productivity data were calculated using the formulas for productivity and efficiency. The results were then compared with REBA scores to describe the relationship between ergonomic risk and work productivity.

The fourth stage involved statistical analysis using Spearman's rank correlation and simple linear regression. Spearman's rank correlation was used to examine the direction and strength of the relationship between REBA scores and productivity. Simple linear regression was used to describe the pattern of association between REBA scores and productivity performance within the observed activities.

However, the statistical results were interpreted with caution because the analysis was based on a limited number of observed activity categories. Therefore, the correlation and regression results in this study should be understood as evidence of association within the observed work context, rather than as proof of a direct causal relationship. The analyses were used to support interpretation of the observed pattern, not to establish broad cause-and-effect conclusions.

Validity and Reliability of Data

To improve the credibility of the findings, this study applied data triangulation by comparing the results of field observation, REBA assessment, NBM responses, and previous research findings. Field observation was used to obtain actual posture data, while REBA was used to quantify ergonomic risk levels. The NBM was used to support the analysis by identifying workers' subjective musculoskeletal complaints.

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The comparison between REBA scores and NBM results was intended to determine whether activities with higher ergonomic risk were consistent with workers' reported discomfort. In addition, the findings were compared with previous studies discussing ergonomic risk in manual handling activities. This step was conducted to ensure that the observed ergonomic conditions were theoretically consistent with existing research.

To minimize subjectivity in posture assessment, the REBA scoring process was conducted according to the standard REBA assessment procedure. Each posture component, including the trunk, neck, legs, upper arms, lower arms, wrists, load, coupling, and activity score, was assessed systematically using the REBA worksheet. The same scoring framework was applied to all observed activities, and the results were reviewed carefully to maintain internal consistency in the assessment process.

Ethical Considerations

All observations were conducted with attention to research ethics. The data collected in this study were used solely for academic purposes. Worker identities were kept confidential and were not disclosed in the research report. The observation process was carried out without interfering with normal production activities or disrupting workers' responsibilities.

Before data collection, workers were informed about the purpose of the study and the type of data to be collected. Participation in the study was conducted with the consent of the workers and the permission of the company. The study did not involve physical intervention or experimental treatment that could endanger workers.

RESULTS AND DISCUSSION

Results of Ergonomic Risk Assessment Using REBA

The ergonomic risk assessment of manual material handling activities at PT BIELOGA was conducted using the Rapid Entire Body Assessment (REBA) method. The assessment considered workers' postures, load handling, coupling conditions, and activity characteristics during manual material handling tasks. The observed activities included lifting, transferring, arranging, and loading materials in the production process.

The results indicate that the assessed manual material handling activities fell into moderate to high ergonomic risk categories. This finding suggests that several work activities require ergonomic improvement, particularly those involving awkward trunk posture, repetitive movement, and physical load exposure. The REBA assessment results are presented in Table 4.

Table 4. REBA Assessment Results for Manual Material Handling Activities

No.	Type of Manual Material Handling Activity	REBA Score	Risk Category	Action Level
1	Lifting light materials	5	Moderate	Improvement needed
2	Lifting medium-weight materials	7	Moderate	Improvement needed
3	Transferring materials to racks	8	High	Immediate action needed
4	Arranging materials on the floor	6	Moderate	Improvement needed
5	Loading materials onto vehicles	9	High	Immediate action needed

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Table 4 shows that REBA scores ranged from 5 to 9, indicating that all assessed activities required ergonomic attention. Activities categorized as moderate risk were lifting light materials, lifting medium-weight materials, and arranging materials on the floor. Meanwhile, transferring materials to racks and loading materials onto vehicles were categorized as high risk, indicating the need for more urgent corrective action.

The highest REBA score was observed in loading materials onto vehicles, with a score of 9. This activity generally involved greater physical load, trunk flexion, reaching movement, and repetitive lifting. The second-highest score was found in transferring materials to racks, with a score of 8, indicating that workers were exposed to awkward postures when moving materials to storage areas. These findings suggest that activities involving a combination of bending posture, load handling, and repetitive movement tend to generate higher ergonomic risk.

These findings are consistent with previous studies showing that material transfer and industrial handling tasks performed in non-neutral postures tend to produce higher ergonomic risk scores. In this study, posture deviation, external load, and task repetition were the main observable factors associated with higher REBA scores. Therefore, the ergonomic risks identified at PT BIELOGA appear to reflect not only worker posture, but also the physical demands of the task and the characteristics of the work system.

Distribution of Ergonomic Risk Levels

The distribution of ergonomic risk levels shows that the observed manual material handling activities were dominated by moderate and high-risk categories. Of the five assessed activities, three activities (60%) were categorized as moderate risk and two activities (40%) were categorized as high risk.

Table 5. Distribution of Ergonomic Risk Categories

Risk Category	Number of Activities	Percentage
Low	0	0%
Moderate	3	60%
High	2	40%
Very high	0	0%
Total	5	100%

The predominance of moderate and high-risk categories indicates that ergonomic problems at PT BIELOGA should not be treated as isolated conditions. Rather, they reflect recurring work-system issues in manual material handling activities. Workers are repeatedly exposed to postural conditions that may contribute to fatigue, discomfort, and musculoskeletal complaints if corrective actions are not implemented.

Although moderate-risk activities do not require immediate emergency action, they still require improvement because prolonged exposure to non-neutral posture may increase cumulative physical strain over time. In contrast, high-risk activities require more urgent intervention because they involve greater biomechanical load and a higher potential for musculoskeletal disorders. From an ergonomic perspective, this finding highlights the importance of prioritizing improvement efforts on tasks with the highest REBA scores, particularly loading materials onto vehicles and transferring materials to racks.

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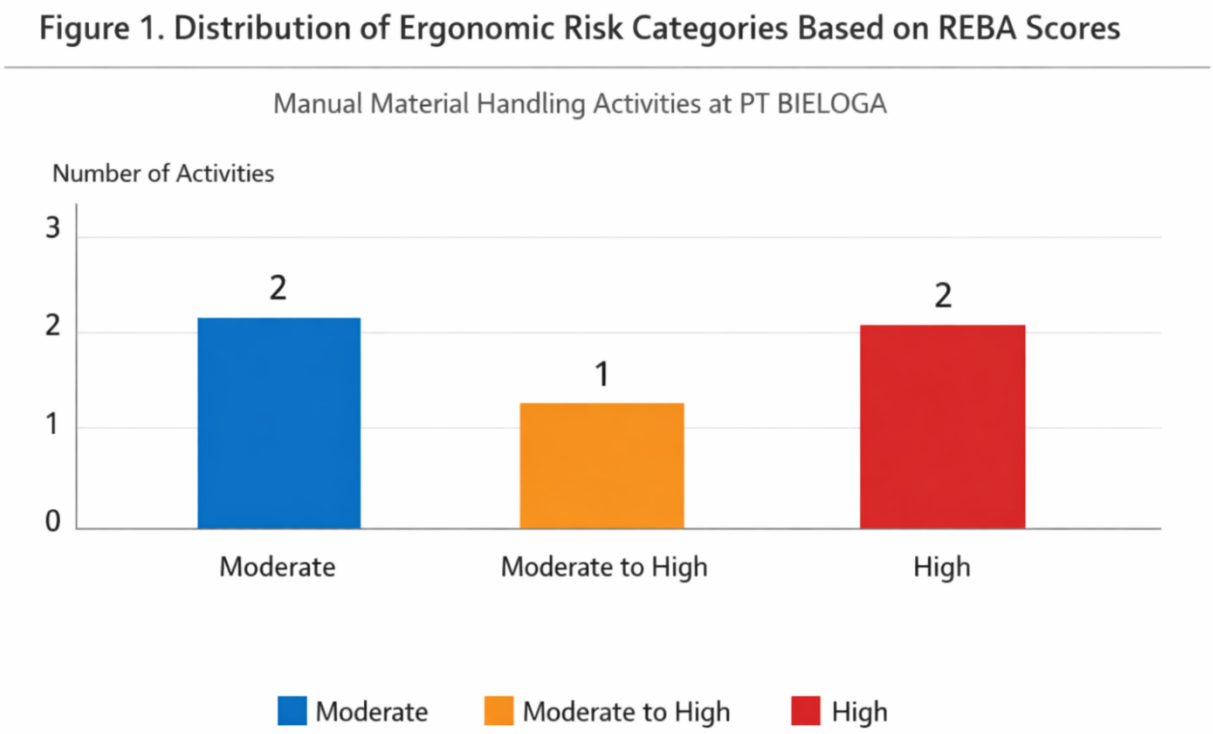

Figure 1. Distribution of ergonomic risk categories based on REBA scores for manual material handling activities at PT BIELOGA

Work Productivity Measurement

Work productivity was measured using two indicators: daily work output and task completion efficiency. Productivity was calculated by comparing total output with effective working time, while task efficiency was calculated by comparing standard time with actual completion time. In this study, productivity performance was expressed as a percentage to enable comparison across different manual handling activities.

The productivity data showed that activities with higher REBA scores tended to display lower productivity performance. This pattern suggests that ergonomic risk may be associated with workers' ability to complete tasks efficiently. Workers who performed activities with higher postural risk were more likely to experience physical fatigue, slower movement, and reduced task efficiency during manual material handling tasks..

Table 6. REBA Scores and Work Productivity

No.	Manual Material Handling Activity	REBA Score	Productivity (%)
1	Lifting light materials	5	101.02
2	Lifting medium-weight materials	7	83.37
3	Transferring materials to racks	8	74.40
4	Arranging materials on the floor	6	91.78

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5	Loading materials onto vehicles	9	64.90

Based on Table 6, the highest productivity was observed in the activity with the lowest REBA score, namely lifting light materials. Conversely, the lowest productivity was found in loading materials onto vehicles, which had the highest REBA score. Overall, the observed pattern indicates an inverse association between ergonomic risk and productivity performance in the assessed manual material handling activities.

From an ergonomic perspective, this tendency is reasonable because activities with higher postural demands generally require greater physical effort and may reduce movement efficiency. When workers are required to bend more frequently, reach farther, or handle heavier loads, more time and energy are needed to complete the task. As a result, productivity may decline even when the work is performed within the same general working period..

Relationship between Ergonomic Risk and Work Productivity

The relationship between ergonomic risk and work productivity was examined using Spearman's rank correlation analysis. The analysis showed a strong negative relationship between REBA scores and work productivity, indicating that higher ergonomic risk tended to be associated with lower productivity performance in the observed activities.

The Spearman correlation coefficient was r_s = -0.974, indicating a very strong inverse relationship between ergonomic risk and productivity in the observed dataset. The negative direction of the correlation means that, as REBA scores increased, work productivity tended to decrease. In practical terms, tasks with greater postural risk, higher physical load, and more demanding movement patterns tended to be associated with lower efficiency in completing manual material handling tasks.

This finding supports the argument that ergonomic risk is related not only to workers' physical comfort and health, but also to operational performance. Workers who perform tasks in awkward postures may experience fatigue more quickly, which may be associated with slower task completion and reduced output. This condition is particularly relevant in manual material handling activities because such tasks depend heavily on workers' physical capacity and movement efficiency.

The observed relationship is also in line with previous ergonomic studies showing that higher posture-related risk is commonly accompanied by greater physical complaints and reduced work performance. However, this relationship should be interpreted carefully within the scope of the present study. The correlation was derived from a limited number of observed activity categories; therefore, it should be understood as evidence of a strong observed association rather than proof of a broad causal relationship.

Regression Analysis of Ergonomic Risk and Productivity

A simple linear regression analysis was conducted to further examine the relationship between ergonomic risk and work productivity. In this analysis, the REBA score was used as the independent variable, while work productivity was used as the dependent variable. The regression result showed that ergonomic risk was negatively associated with productivity.

The regression equation obtained in this study is as follows:

$$`Productivity = 145.371 - 8.871 \times REBA\ Score`$$

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The negative regression coefficient indicates that each one-point increase in the REBA score is followed by a decrease in productivity of approximately 8.871 percentage points. This means that higher ergonomic risk is associated with lower work productivity. The coefficient of determination showed $R^2 = 0.936$, indicating that 93.6% of the variation in work productivity could be explained by ergonomic risk as measured by REBA scores.

Table 7. Simple Linear Regression Result

Variable	Coefficient	Interpretation
Constant	145.371	Estimated productivity when REBA score is zero
REBA score	-8.871	Negative predictor of productivity
R^2	0.936	93.6% of productivity variation described by REBA score

This result suggests that ergonomic risk was strongly associated with productivity within the observed manual material handling activities. Activities with higher ergonomic risk tended to require greater physical effort, create greater postural strain, and reduce movement efficiency. As a result, workers may need more time to complete tasks, experience faster fatigue, and produce lower output within the same working time.

Nevertheless, the regression result should be interpreted with caution. The analysis was conducted using a limited number of observed activity categories, and productivity may also be associated with other factors not directly measured in this study, such as worker experience, age, physical fitness, task familiarity, work environment, equipment availability, workload distribution, motivation, and production target pressure. Therefore, the regression model should be understood as a description of the observed pattern rather than as evidence of a direct causal effect.

Discussion

The findings of this study indicate that manual material handling activities at PT BIELOGA involved moderate to high ergonomic risk, with the highest scores observed in loading materials onto vehicles and transferring materials to racks. These activities required workers to perform physically demanding movements involving trunk flexion, reaching, lifting, and repetitive motion. Such movement patterns are widely recognized as important contributors to posture-related ergonomic risk in manual work.

The results also showed that activities with higher REBA scores tended to have lower productivity values. This pattern strengthens the argument that ergonomic conditions should be considered not only in relation to occupational health and safety, but also in relation to operational performance. In labor-intensive work systems, awkward posture, repetitive movement, and physical load exposure may reduce movement efficiency and increase fatigue, which in turn may be associated with lower output and longer task completion time.

A closer interpretation of these findings suggests that ergonomic risk at PT BIELOGA should not be viewed solely as an individual worker issue. Rather, it should be understood as part of a broader work-system problem involving task design, material placement, transfer distance, work height, and the availability of handling aids. In other words, the observed posture risk is closely linked to how the work is organized and how the material handling process is structured.

These findings are consistent with previous studies indicating that ergonomic intervention through work-design improvement can reduce physical load and support better work performance.

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The present study similarly suggests that improvements in storage height, loading position, transfer pathways, and the use of assistive devices may help reduce posture-related risk. In the context of PT BIELOGA, devices such as trolleys, hand pallet trucks, lift tables, adjustable racks, or loading aids may reduce excessive trunk bending, repetitive lifting, and extended reaching.

However, work productivity in manual material handling activities should not be explained solely by REBA scores. Productivity is a multidimensional outcome that may also be associated with several other factors. One important factor is work experience. Workers with longer experience may perform tasks more efficiently because they are more familiar with workflow patterns, material characteristics, and practical handling techniques. In contrast, workers with less experience may require more time to perform the same activity even under similar ergonomic conditions.

Another relevant factor is individual physical capacity, including body strength, fatigue tolerance, and general fitness. Two workers performing the same task may show different productivity levels because of differences in physical endurance and work capacity. This means that posture-related risk and individual capability may interact in shaping work performance.

In addition, environmental conditions may also be associated with productivity performance. Workspace layout, available movement space, floor condition, lighting, temperature, and ventilation may affect workers' comfort and speed during manual handling activities. For example, narrow transfer paths or poorly arranged storage areas may increase the need for twisting and reaching, thereby reducing task efficiency even when the physical load itself remains unchanged.

Organizational factors should also be considered. These may include work targets, task allocation, work-rest schedules, supervision, availability of equipment, and production pressure. Even when ergonomic conditions are relatively similar, differences in task organization may influence the pace of work and the resulting productivity. Therefore, the relationship observed in this study should be interpreted as part of a broader work-system context rather than as a simple one-variable relationship.

From a theoretical perspective, this study contributes to ergonomic research by linking posture-based risk assessment with productivity indicators. Many ergonomic studies focus primarily on identifying posture-related risk and musculoskeletal complaints. This study extends that discussion by showing that ergonomic risk may also be associated with operational productivity indicators, particularly in the context of manual material handling.

From a practical perspective, the findings provide a basis for PT BIELOGA to develop ergonomic improvement programs. Priority should be given to high-risk tasks, especially loading materials onto vehicles and transferring materials to racks. Potential interventions include workstation redesign, improvement of material placement, application of safer manual handling techniques, use of assistive devices, and task rotation to reduce prolonged exposure to repetitive and physically demanding tasks.

Pattern of the Relationship between Ergonomic Risk and Productivity

The pattern of the relationship between ergonomic risk and productivity can be illustrated through a scatter plot showing REBA scores on the horizontal axis and productivity on the vertical axis. The expected trend shows that productivity decreases as REBA scores increase.

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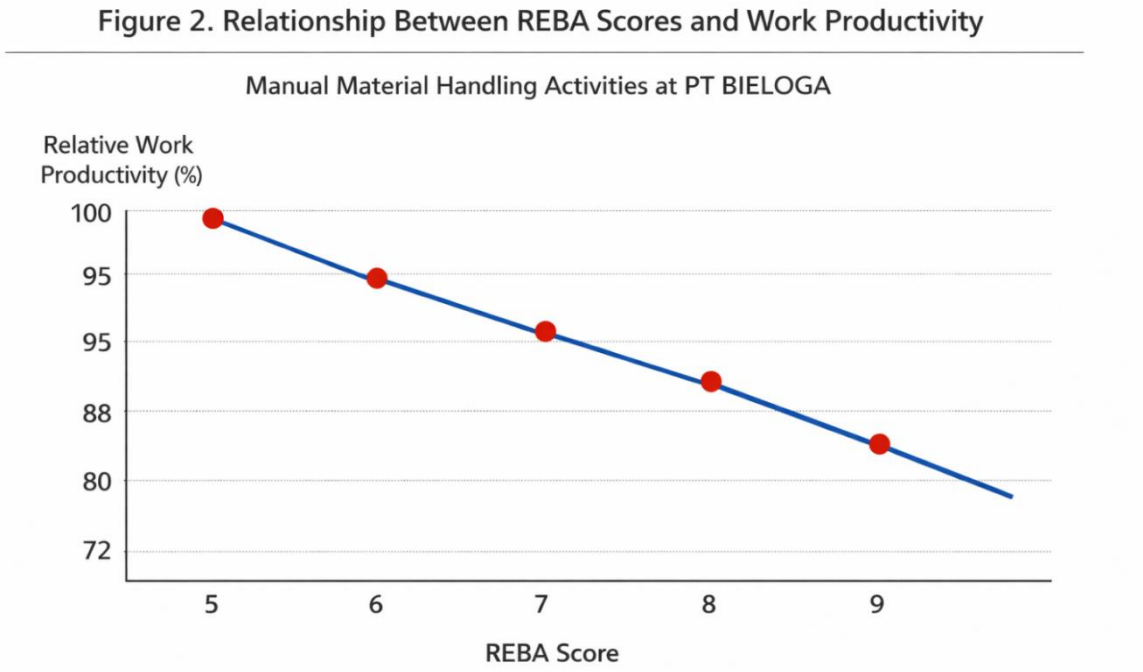

Figure 2. Relationship between REBA scores and work productivity in manual material handling activities at PT. BIELOGA

Figure 2 should show a declining trend line, indicating a negative relationship between ergonomic risk and productivity. Activities with lower REBA scores tend to have higher productivity, while activities with higher REBA scores tend to have lower productivity. This visual pattern is consistent with the correlation and regression results, which indicate that ergonomic risk is negatively associated with productivity.

The practical implication of this pattern is that productivity improvement should not be separated from ergonomic evaluation. If productivity improvement programs focus only on speed, output targets, or work scheduling without considering ergonomic risk, they may fail to address one of the key causes of performance decline. Therefore, ergonomic assessment should be integrated into productivity improvement strategies.

General Discussion

Overall, the findings of this study indicate that manual material handling activities at PT BIELOGA involve moderate to high ergonomic risk. The highest risk was found in loading materials onto vehicles and transferring materials to racks. These activities require workers to perform physically demanding movements involving trunk flexion, reaching, lifting, and repetitive motion.

The statistical analysis showed that ergonomic risk was negatively related to work productivity. The Spearman correlation coefficient indicated a very strong negative relationship, while the regression analysis showed that REBA scores could explain a large proportion of productivity variation. These findings provide quantitative evidence that ergonomic conditions are closely related to productivity performance in manual material handling tasks.

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From a theoretical perspective, this study contributes to ergonomic research by linking posture-based risk assessment with productivity indicators. Many ergonomic studies focus mainly on identifying risk levels and musculoskeletal complaints. This study extends the discussion by showing that ergonomic risk also has implications for operational productivity.

From a practical perspective, the findings provide a basis for PT BIELOGA to develop ergonomic improvement programs. Priority should be given to high-risk tasks through workstation redesign, use of assistive devices, improvement of material handling procedures, and worker training. These interventions are expected to reduce physical burden, minimize musculoskeletal risk, and improve work productivity.

In summary, ergonomic evaluation should be viewed not only as an occupational safety and health measure, but also as a strategic approach to improving industrial performance. By reducing ergonomic risk, companies can support worker well-being while simultaneously improving operational efficiency and productivity.

CONCLUSION

This study found that manual material handling activities at PT BIELOGA were generally associated with moderate to high ergonomic risk levels based on the REBA assessment. The main risk factors identified in the observed activities included awkward trunk posture, repetitive movement, lifting load, reaching posture, and non-neutral upper-limb positions. These conditions indicate that several manual handling tasks require ergonomic improvement to reduce physical strain and minimize the potential for musculoskeletal complaints.

The analysis showed a negative association between ergonomic risk and work productivity. Activities with higher REBA scores tended to show lower productivity performance. The Spearman correlation result indicated a very strong negative relationship between REBA scores and productivity, while the regression analysis showed that REBA score was negatively associated with productivity in the observed activities. However, these findings should be interpreted carefully, as the study was observational in nature and the statistical analysis was based on a limited number of activity categories. Therefore, the results should be understood as evidence of association within the observed work context rather than as proof of a direct causal relationship.

Based on these findings, ergonomic improvement should be integrated into the company's productivity improvement strategy. Recommended improvements include redesigning workstations, adjusting the height of material storage and loading areas, improving manual handling procedures, providing assistive devices, and implementing worker training on safe lifting techniques. These interventions are expected to help reduce ergonomic risk exposure and support better work efficiency.

This study contributes to ergonomic research by demonstrating the importance of linking REBA-based posture assessment with productivity indicators in an industrial work environment. Nevertheless, the findings are limited to the observed work context at PT BIELOGA. Future research should involve broader samples, more diverse work activities, and additional variables such as physical workload, fatigue, work environment, worker characteristics, and musculoskeletal complaints in order to strengthen the analysis of the relationship between ergonomic risk and productivity in manual material handling work.

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