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RESEARCH ARTICLE

Ergonomic Risk Assessment in Heavy Equipment Manufacturing: A REBA-Based Analysis in a Crane Production Facility

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ABSTRACT

The health and efficiency of workers in heavy equipment manufacturing environments are critically influenced by ergonomic factors. This study aims to assess ergonomic risks in a crane manufacturing facility using the Rapid Entire Body Assessment (REBA) method. Eight key workstations—such as welding, grinding, cylinder assembly, and turning—were analyzed to identify postures that may lead to musculoskeletal disorders (MSDs). The REBA analysis revealed that tasks like welding and foot frame assembly carry moderate to high ergonomic risk levels, requiring immediate intervention. The REBA score for welding operations was found to be 9 (high risk), while foot frame assembly yielded a score of 6 (medium risk). Compared to similar studies in the automotive and shipbuilding sectors, these scores are consistent with tasks classified as ergonomically demanding, highlighting the need for intervention. Proposed interventions are expected to reduce REBA scores by up to 50%, lowering risk levels and enhancing operator safety. Based on these findings, several practical improvement strategies are proposed, including adjustable worktables, ergonomic platforms, and task redesign. Implementing such ergonomic modifications can improve worker well-being, reduce occupational injury risks, and increase productivity and product quality. The results offer valuable guidance for heavy equipment and mechanical manufacturing industries where ergonomic challenges are significant. The integration of ergonomic assessment methods such as REBA into engineering design and workplace planning is essential for sustainable and human-centered production systems.

Keywords: REBA Method, Ergonomic Risk, Work-Related Musculoskeletal Disorders, Occupational Health and Safety

1. Introduction

As the complexity of industrial production processes increases, the health and safety of workers gain greater importance. In this context, it has become a fundamental necessity to utilize the science of ergonomics to design work environments that are conducive to human health, particularly in production areas where workers face job-specific physical demands. Ergonomics aims to adapt work and the work environment to the physical and psychological characteristics of humans, thereby contributing to the protection of worker health, the reduction of workplace accidents and occupational diseases, and the enhancement of productivity.

Especially in production facilities, factors such as repetitive movements, awkward postures, heavy lifting and straining hand movements lead to the emergence of musculoskeletal system disorders (MSDs) in workers. Musculoskeletal disorders (MSDs) in employees, particularly in production facilities, are significantly influenced by factors such as repetitive movements, inappropriate postures, heavy lifting, and forceful hand actions. Research indicates that these disorders arise from a combination of ergonomic and physical risk factors, including awkward postures and high task repetition, which can lead to fatigue and musculoskeletal imbalances over time (Kamijantono et al., 2024). For instance, studies in garment manufacturing reveal that poor trunk and neck postures, along with monotonous tasks, contribute to a high prevalence of MSDs (Subramanya et al., 2021). Additionally, data from various industries show that ergonomic-related injuries account for a substantial portion of workplace compensation costs, highlighting the economic impact of these disorders (Shamsuddin et al., 2014). Interventions such as ergonomic training and adjustments to work environments are essential for mitigating these risks and improving employee health and productivity (Kamijantono et al., 2024; Kahya, 2020). Work-related musculoskeletal disorders (WMSDs) significantly impact individuals' quality of life and contribute to economic burdens through decreased productivity and increased healthcare costs (Lu et al., 2022; Park et al., 2010). These disorders often arise from ergonomic risks such as awkward postures, repetitive movements, and heavy lifting, which are prevalent in various occupations, particularly in healthcare settings (Kim, 2015; Jacquier-Bret & Gorce, 2023; Kamijantono et al., 2024). For instance, healthcare professionals frequently experience high rates of lower back and shoulder disorders due to the nature of their work (Jacquier-Bret & Gorce, 2023). To mitigate these risks, systematic evaluations of work environments are essential, focusing on ergonomic interventions like adjusting workstations, implementing job rotation, and utilizing mechanization (Kamijantono et al., 2024; Park et al., 2010). By addressing these ergonomic factors, organizations can enhance worker health, reduce the incidence of MSDs, and ultimately improve overall productivity (Lu et al., 2022; Kamijantono et al., 2024).

The Rapid Entire Body Assessment (REBA) method is a widely utilized and effective tool for evaluating ergonomic risks in environments where workers are exposed to awkward postures and repetitive tasks, particularly in industries involving manual labor such as cement production, automotive assembly, and welding operations. This method assesses various body regions, including the neck, torso, legs, upper arms, lower arms, and wrists, to determine the level of ergonomic risk and the necessity for intervention. For instance, in the cement industry, workers involved in manual lifting and arranging of heavy sacks were found to have a high REBA score of 10, indicating a significant risk of musculoskeletal disorders (MSDs) and necessitating ergonomic improvements (Rahmawati & Anggraini, 2024). Similarly, in the airport management sector, workers in loading and unloading tasks exhibited high REBA scores, with values ranging from 8 to 11, suggesting a need for posture adjustments and the introduction of assistive devices (Nadila & Suryadi, 2024). The method's utility extends to other industries as well, such as small and medium enterprises, where it has been used to evaluate and improve work postures, thereby reducing the incidence of MSDs (Rizkya et al., 2018). The REBA method's applicability extends to various settings, such as the shoe manufacturing industry, where it helped identify and mitigate risks by improving trunk, upper arm, and wrist movements, reducing the REBA score from 6 to 3 (Jabbar & Suryadi, 2024). In the jewelry-making industry, the REBA assessment revealed that a majority of workers were at medium risk, highlighting the need for ergonomic interventions to prevent MSDs (Raut et al., 2024). In the automotive industry, the REBA method has also been used to identify high-risk postures in various assembly tasks, leading to the implementation of engineering controls that significantly reduced ergonomic risks (Chakravarthya, 2015). Furthermore, in the automotive sector, the REBA method identified high-risk postures during wheel installation tasks, which were subsequently improved by introducing ergonomic tools, reducing the REBA score from 8 to 2 (Sunardi et al., 2024). In welding operations, the REBA method has been applied to assess the postural risks associated with tasks like vertical and overhead welding, where a significant percentage of postures were found to be in the high-risk category, prompting ergonomic interventions to reduce these risks (Syed Mohammed et al., 2022). These examples underscore the REBA method's effectiveness in identifying high-risk postures and guiding ergonomic improvements across diverse industries. The REBA method's comprehensive approach, which includes systematic evaluation of the neck, torso, legs, and arms, makes it a preferred choice for detailed ergonomic risk assessment across diverse work settings (Hignett & McAtamney, 2000). By identifying high-risk postures and suggesting ergonomic improvements, the REBA method helps in designing safer work environments, ultimately enhancing worker productivity and reducing the likelihood of work-related injuries (Karelia et al., 2021; Panjaitan et al., 2024; Yunian et al., 2024; Yohanes et al., 2025).

In light of the growing importance of ergonomic interventions across various industries, this study aims to evaluate the ergonomic risks present in the production area of a manufacturing company operating across five main product lines. Eight different workstations, where operations such as welding, grinding, foot roofing, vertical boom roofing, cylinder assembly, cylinder testing, radial drilling, and turning are carried out, were systematically assessed using the REBA method. The primary objective is to identify high-risk postures that may contribute to the development of musculoskeletal disorders and to propose targeted improvements to reduce these risks.

This study was conducted out of a necessity to ensure safer and healthier working conditions, particularly in sectors involving intensive manual labor. By focusing on real-world production tasks and quantifying ergonomic risks through a validated assessment tool, this research contributes to both academic understanding and practical applications of ergonomic risk mitigation. The findings aim not only to protect workers' health but also to improve overall productivity and product quality by promoting sustainable and human-centered workplace design. This study uniquely contributes by presenting a comprehensive REBA-based ergonomic risk mapping for eight stations in crane production, providing practical intervention proposals validated with real-world observations. The methodological rigor applied through multi-operator and shift-spanning observations enhances its applicability in similar heavy industry settings. In the following sections, the methodology, results, and recommendations for improvement are presented in detail.

2. Method

The Rapid Entire Body Assessment (REBA) method was developed by Sue Hignett and Lynn McAtamney in 2000 at Nottingham Hospital (UK) as a result of collaborative work by ergonomists, physiotherapists, and nurses who analyzed approximately 600 working postures. The REBA method provides a systematic approach to evaluating postures involving the upper extremities (arm, forearm, wrist), trunk, neck and lower extremities to be analysed together. It also considers muscle activity, the type of grip used during the task, and the level of force applied. The method classifies ergonomic risk into five levels ranging from negligible to very high and is widely applied in various industries to assess the risk of work-related musculoskeletal disorders (WMSDs).

In this study, ergonomic risks to which workers were exposed during assembly operations in a crane manufacturing facility were assessed using the REBA method. The study was conducted in a medium-sized crane manufacturing plant operating in Turkey. The evaluation process consisted of three main stages.

2.1. Observation and Data Collection

Eight different workstations in the production area were examined through direct observation and video recording. At each workstation, three employees were observed individually during a full 8-hour day shift, covering all operational tasks and breaks. This allowed for the comprehensive identification of physically demanding or awkward movements, which were documented for further REBA analysis.

2.2. REBA Analysis (Figure 1)

The Rapid Entire Body Assessment (REBA) method offers a structured approach to evaluating whole-body postural risks associated with work-related musculoskeletal disorders. The method divides the body into two main analysis groups: Group A, which includes the neck, trunk, and legs, and Group B, which includes the upper arms, lower arms, and wrists. Each group's postures are assessed based on their angles and deviations from neutral positions. In Group A, there are 60 possible posture combinations, which are further modified by the application of a Load/Force score that reflects the physical effort required in the task. Group B contains 36 posture combinations, which are similarly adjusted by a Coupling score that evaluates the quality of the hand grip or tool handling involved in the activity. After scoring both groups, these two group scores are integrated—the A and B scores are then combined in Table C to produce a total of 144 possible combinations. In other words the values are combined using a predefined matrix (Table C) to obtain a single composite score. To this, an Activity Score is added, which accounts for factors such as task repetition, static loading, and duration of the posture. The final REBA score, ranging from 1 (negligible risk) to 15 (very high risk), reflects the urgency of intervention required. This scoring system enables a comprehensive assessment of biomechanical risks, guiding necessary ergonomic improvements in workplace design and practices (Hignett & McAtamney, 2000).

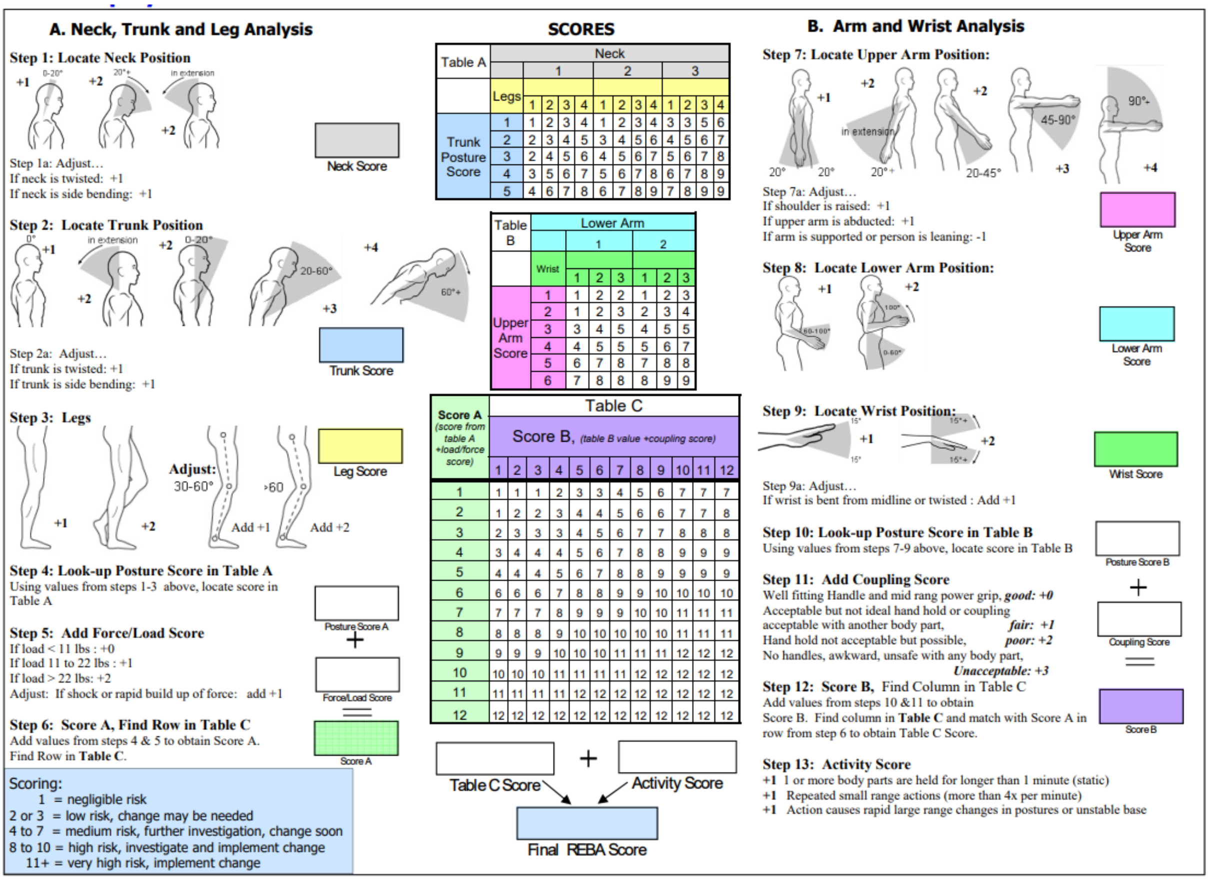

Figure 1. REBA Employee Assessment Worksheet

(The figure provided by Practical Ergonomics based on Technical note: Rapid Entire Body Assessment (REBA), Hignett, McAtamney, Applied Ergonomics 31 (2000) 201-205.)

Postural angles were estimated through frame-by-frame video analysis. A motion analysis approach commonly used in ergonomic assessments (e.g., via software such as Kinovea®) supports accurate 2D joint angle evaluation. All observations were conducted with the informed consent of the employees, and the REBA assessments were carried out independently by trained evaluators to ensure accuracy and reliability. The final scores were used to classify each posture into one of five risk categories, ranging from negligible to very high, guiding the prioritization of necessary ergonomic interventions. REBA was selected over methods such as RULA or OWAS due to its suitability for analyzing entire body postures in dynamic and standing-heavy tasks. Unlike RULA, which emphasizes upper limbs, REBA provides a more comprehensive evaluation in environments such as crane assembly, where lower limb strain is also significant.

2.3. Improvement Suggestions

Based on the REBA scores obtained, ergonomic improvement recommendations were developed for postures identified as high-risk. These suggestions focused on equipment design, workstation layout, and modifications to work procedures to reduce ergonomic risks and improve working conditions.

3. Results

In this study, eight different workstations located in the production area of a manufacturing company producing in five main product lines were evaluated from an ergonomic perspective. Welding, grinding, foot frame assembly/welding, vertical boom assembly/welding, hydraulic cylinder assembly, hydraulic cylinder testing, drilling with radial drill press and turning (Lathe) operations are carried out at these workstations and the postures exhibited by the employees during these operations were analyzed using the REBA method.

Welding is one of the most fundamental processes used to join crane components. Steel parts such as chassis, booms, and linkage arms are joined using methods like MIG, MAG, or arc welding. Due to high heat, smoke, and awkward working positions, this process involves high ergonomic risks. Grinding is performed after welding to smooth surfaces and remove burrs or make dimensional corrections. It is generally done with handheld grinders, causing stress on the wrist, arm, and shoulders due to prolonged use. Foot frame assembly/welding involves assembling or welding the base frame on which the crane is mounted or stabilized. This process may include lifting and securing heavy parts, requiring attention to both occupational safety and ergonomics. Vertical boom assembly/welding involves the assembly or welding of the crane's main vertical lifting boom. The parts are large and heavy, requiring lifting, alignment, and welding. It often includes awkward postures and poses high ergonomic risks. Hydraulic cylinder assembly includes the installation of hydraulic cylinders onto the boom or other moving components. The process involves both mechanical connections and hydraulic hose assembly and requires precision and physical effort. The hydraulic cylinder testing process tests the functionality of the mounted cylinders under pressure and checks for leakage. Operators must work with control panels and observe pressure gauges, requiring focused attention and controlled movements. Drilling with radial drill press used to drill precise holes into large and heavy metal components. Proper positioning and clamping of the workpiece are essential. Typically performed standing and may lead to back and arm strain. Turning (lathe operations) used for machining cylindrical parts such as shafts and pins. CNC or manual lathes are used. The task requires maintaining a fixed posture and performing repetitive motions, involving fine motor skills. These processes form the backbone of mechanical manufacturing and are critical points for ergonomic risk assessments. Proper workstation design, tool selection, and safety precautions should be considered for each.

Ergonomic risk levels were identified using REBA, and improvement suggestions were developed. Welding and foot frame assembly postures were analyzed in detail to illustrate high-risk areas and required interventions. The proposed measures aim to enhance both worker health and operational efficiency.

3.1. REBA Evaluation – Postural Analysis of Welding Task (Figure 2)

To determine the ergonomic risk level of the welding process (as seen in Figure 2) with the REBA method, first the A score was calculated. The A score is calculated by substituting the neck, trunk and leg scores in the A table and adding the load/force score to the obtained value. Since the neck bending angle is more than 20° and a sideways rotation movement is observed in the neck, the neck is scored as 3 points. Since the body bending angle is more than 60° and there is bending and sideways rotation in the body, the trunk score is scored as 5. The weight is on one leg and is in an unbalanced position. Since there is no flexion in the legs, the legs are scored as 2 points. The neck, trunk and leg scores are substituted in Table A (Figure 1) and the A group score of 8 is obtained. Since there is no factor requiring the addition of any force/load score to the A group score, the final A group score is found as 8. As a second step, the upper arm, lower arm and wrist scores are determined, and the B score is calculated. In the analysis, it was evaluated that the upper arm made an angle of approximately 45°-90° with the body and since the arm was pulled out, the upper arm score was scored as 4. Since the angle of the lower arm with the upper arm was between 60°-100°, it scored as 1. Since the angle of the wrists was between 0°-15°, it scored as 1. There was no rotation in the wrist. The upper arm, lower arm and wrist scores were combined in Table B (Figure 1) and the B group score obtained was obtained as 4. In the final stage, the A and B group scores were combined in Table C (Figure 1) and the C group score was obtained. The C group score of the welding process was 9 and since it was not a work type that required adding an activity intensity score, the final REBA risk score was calculated as 9.

Figure 2. Working Posture during Welding Task

As a result, it was evaluated that the risk level was high as a result of the analysis conducted with the REBA method and that improvement was needed in a short time. The REBA evaluation process is briefly summarized in Table 1.

Table 1. REBA Evaluation – Postural Analysis of Welding Task

A Score (Trunk Region Assessment)		
Body Part	**Observed Posture**	**Score**
Neck	Flexed >20°, with lateral bending	3
Trunk	Flexed >60°, twisted laterally	5
Legs	Weight on one leg, unstable stance	2
A Score: 8		
Load/Force Adjustment: +0		
Final A Score: 8		
B Score (Upper Limb Assessment)		
Body Part	**Observed Posture**	**Score**
Upper Arm	Raised between 45°–90°, abducted	4
Lower Arm	Angle between 60°–100°	1
Wrist	Neutral (0°–15°), no twisting	1
Wrist Twist	None	0
B Score: 4		
C Score (Overall REBA Score)		
A Score	**B Score**	**C Score**
8	4	9
Activity Score Adjustment: +0		
Final REBA Score: 9		
Risk Level: High Risk→ Immediate intervention required		

Welding, a fundamental process in metal fabrication, poses significant ergonomic risks due to the high heat, smoke, and awkward working positions involved, which can lead to musculoskeletal disorders (MSDs) among workers. The Rapid Entire Body Assessment (REBA) method is a valuable tool for evaluating these risks by analyzing the postures and loads on various body regions such as the neck, torso, and limbs during welding tasks. Studies have shown that welders frequently experience MSDs in areas like the neck, back, shoulders, and knees due to awkward postures such as bending, twisting, and working overhead, which are common in welding operations (Anwar et al., 2019; Liu et al., 2019; Syed Mohammed et al., 2022; Nedohe et al., 2022; Hasanuddin et al., 2023). For instance, in a study involving 66 welding operators, REBA results indicated that 57% of postures were in the high-risk category, with 7% in very high risk, highlighting the need for ergonomic interventions (Syed Mohammed et al., 2022). Similarly, another study found that 78% of welders reported neck discomfort due to prolonged tilting during welding, and 67% experienced general discomfort and pain, underscoring the negative impact of poor ergonomic conditions (Nedohe et al., 2022). The prevalence of MSDs is notably high among welders, with ergonomic loads contributing significantly to these disorders, as evidenced by the high exposure levels in specific body regions like the lower back and neck (Liu et al., 2019). Ergonomic assessments using tools like REBA and Quick Exposure Checklist (QEC) have consistently identified high-risk levels in welding activities, prompting calls for immediate ergonomic improvements (Putra & Khatamy, 2024). For instance, ergonomic workstations and tools designed with worker safety in mind have been shown to reduce the risk of MSDs and improve productivity (Hamizatun et al., 2023). In the context of crane assembly, the welding process itself can be optimized to enhance safety and efficiency, such as by regulating the sequence of welding operations to prevent structural weaknesses and improve the quality of the assembly. Furthermore, the integration of ergonomic principles into the design of assembly tools and workstations can significantly reduce the physical strain on workers, thereby decreasing the incidence of MSDs (Aziz et al., 2017; Hamizatun et al., 2023). Proposed solutions include redesigning workstations to better suit the physical conditions of workers, which has been shown to significantly reduce MSD risks, as evidenced by a decrease in REBA scores from 8 to 3 following ergonomic interventions (Muharam & Puspasari, 2024). Additionally, the use of AI technology for posture detection and risk assessment has been suggested as a cost-effective and accurate method to enhance worker safety by providing real-time feedback and warnings for posture adjustments (Ruengdech et al., 2024). Despite these advancements, the adoption of personal protective equipment (PPE) remains low, with less than 12% usage for items like masks and gloves, except for eye protection, which is more commonly used (Hasanuddin et al., 2023). Overall, the integration of ergonomic interventions, safety training, and the use of advanced technologies are crucial for mitigating the ergonomic risks associated with welding and improving the occupational well-being of welders (Aswalekar & Tungikar, 2017; Liu et al., 2019; Pandit et al., 2023). This study presents improvement suggestions for welding processes based on the REBA ergonomic risk assessment, as shown in Table 2.

Table 2. Ergonomic Improvement Recommendations for Welding Task

Problem Area	**Recommendation**	**Explanation**
Excessive Trunk Bending	Use adjustable-height welding tables	Reduces need to bend forward by elevating the workpiece
Neck and Head Posture	Implement seated welding stations	Minimizes neck and back strain through seated posture
Leg Instability	Provide anti-fatigue or height-adjustable platform	Ensures even weight distribution and balance
Arm Support	Use elbow support or counterbalance arms	Reduces fatigue caused by extended arm elevation
Workpiece Positioning	Integrate rotating tables or jigs	Allows the part to be moved instead of the worker
Work Organization	Plan for micro-breaks during tasks	Prevents musculoskeletal fatigue from static postures

3.2. REBA Evaluation – Postural Analysis of Foot Frame Assembly/Welding Operation (Figure 3)

To determine the ergonomic risk level of the foot frame assembly/welding operation (as seen in Figure 3) using the REBA method, the A score was first calculated. Since the neck flexion angle was observed to be more than 20°, the neck score was scored 2 points. No twisting or lateral bending of the neck was observed. The trunk flexion angle was between 20° and 60°, so the trunk was scored 3 points. There was no twisting or lateral bending of the trunk. As the weight was supported on one leg in an unstable position and with a flexion angle of 30°–60°, the legs were scored 3 points. Neck, trunk, and leg scores were entered into Table A (Figure 1), resulting in an A group score of 6. Since there was no additional force/load requiring adjustment, the final A score remained 6. In the second step, the upper arm was assessed to be at an angle between 20° and 45° relative to the trunk, and it was scored 2 points. There was no shoulder elevation or rotation in the upper arm. The lower arm formed an angle between 60° and 100° with the upper arm and was scored 1 point. The wrist angle was between 0° and 15°, and since wrist twisting was present, it was scored 2 points. Upper arm, lower arm, and wrist scores were combined using Table B (Figure 1), yielding a B group score of 2. In the final step, A and B group scores were combined using Table C (Figure 1) to obtain the C score. The C score for the welding operation was 6. Since the nature of the task did not require adding an activity score, the final REBA risk score was calculated as 6. As a result of the REBA analysis, the ergonomic risk level of the operation is assessed as medium, indicating that corrective action is required. The REBA evaluation process is briefly summarized in Table 3.

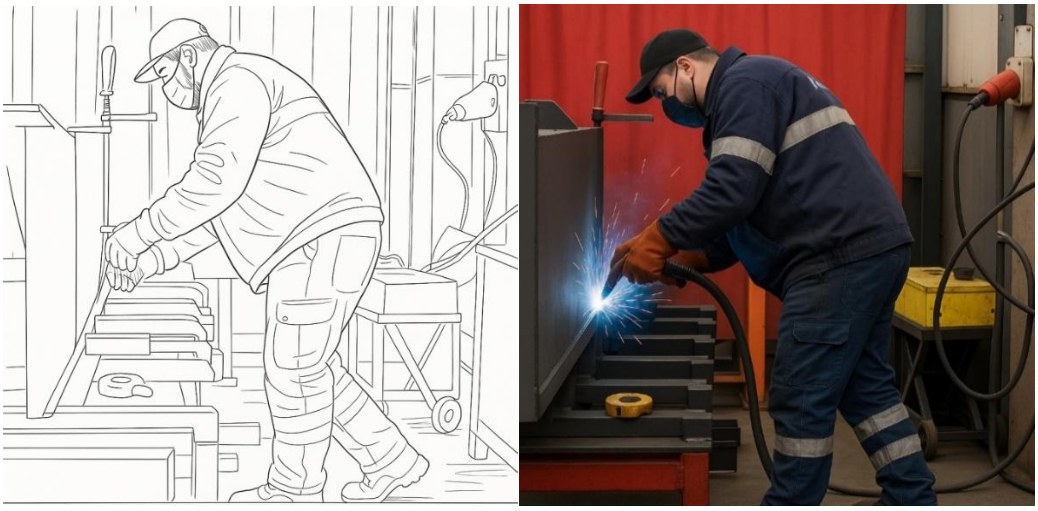

Figure 3. Working Posture during Foot Frame Assembly/Welding Operation

Foot frame assembly/welding can lead to potential musculoskeletal disorders (MSDs) due to high task repetition, forceful exertion, and awkward postures involved in lifting and securing heavy parts. The risk factors include sustained awkward postures, heavy loads, and contact stress, which can exacerbate physical disorders. By identifying and ranking the difficult tasks and affected body parts, organizations can design ergonomic solutions and implement policies to enhance occupational safety and reduce the likelihood of MSDs among workers (Satapathy, 2018).

Table 3. REBA Evaluation – Postural Analysis of Foot Frame Assembly/Welding Operation

A Score (Trunk Region Assessment)		
Body Part	**Observed Posture**	**Score**
Neck	Flexed >20°	2
Trunk	Flexed 20°-60°	3
Legs	Weight on one leg, unstable stance, 30°-60° flexion	3
A Score: 6		
Load/Force Adjustment: +0		
Final A Score: 6		
B Score (Upper Limb Assessment)		
Body Part	**Observed Posture**	**Score**
Upper Arm	Raised between 20°-45°	2
Lower Arm	Angle between 60°-100°	1
Wrist	Neutral (0°-15°), twisting	1
Wrist Twist	Twisting	+1
B Score: 2		
C Score (Overall REBA Score)		
A Score	**B Score**	**C Score**
6	2	6
Activity Score Adjustment: +0		
Final REBA Score: 6		
Risk Level: Medium Risk→ Intervention required		

To improve ergonomics in foot frame assembly and welding operations, several strategies can be implemented based on insights from the provided studies. Firstly, embedding ergonomic principles in the design of welding assembly tools can significantly enhance worker safety and productivity. For instance, the introduction of hand supports in welding assembly tools has been shown to reduce the Rapid Upper Limb Assessment (RULA) scores from high to medium risk, indicating a substantial improvement in ergonomic conditions for automotive assembly workers (Hamizatun et al., 2023). Similarly, the development and implementation of ergonomic welding tables, as demonstrated in educational settings, have been effective in reducing musculoskeletal disorder (MSD) complaints by lowering Nordic Body Map (NBM), REBA, and RULA scores (Estriyanto et al., 2024). Additionally, optimizing workstation design—by lowering holder levels and adjusting the height and angle of work surfaces—can alleviate physical strain associated with prolonged static postures (Yunian et al., 2024). Moreover, ergonomic workstations tailored to specific tasks, such as those proposed for catwalk welding, can mitigate musculoskeletal risks and enhance workplace safety and productivity (Putra & Khatamy, 2024). The use of virtual assembly simulations, such as those conducted with DELMIA software, allows for ergonomic process modeling and can lead to significant improvements in operator ergonomics by optimizing workstation height and layout (Usman et al., 2015). Additionally, the design of multifunctional welding frames and positioners can facilitate the handling and positioning of components, thereby improving welding efficiency and precision. Participatory ergonomics, combined with lean manufacturing principles, can further enhance ergonomic solutions by involving employees in the design process, ensuring that workstations are suitable for diverse worker populations and reducing unnecessary activities (Miguez et al., 2017).

Overall, these studies underscore the importance of integrating ergonomic considerations into the design and operation of welding and assembly processes to improve worker well-being and operational efficiency. Addressing the ergonomic challenges in crane foot frame assembly and welding is crucial for enhancing occupational safety and reducing the prevalence of MSDs among workers in this field (Satapathy, 2018; Kobak & Krasnova, 2024). In this study, as a result of the ergonomic risk assessment using the REBA method, suggestions for improvement in foot frame assembly/welding operations are presented as shown in Table 4.

Table 4. Ergonomic Improvement Recommendations for Foot Frame Assembly/Welding Operation

Improvement Area	**Suggestion**
Neck Position and Movement	Adjust the working height: The workbench or assembly area should be arranged to prevent neck strain and reduce the need for bending. Encourage posture changes: Create regular intervals for workers to rest their necks and promote posture changes to prevent continuous neck bending.
Trunk Flexion	Ergonomic work platforms: Adjust the height of work platforms to allow workers to work comfortably without bending their trunks. Provide back support and protective clothing: Equip workers with back support garments or protective equipment.
Leg Position	Change leg positions: Encourage workers to move their legs at regular intervals to improve blood circulation. Arrange workstations for both sitting and standing: Design workbenches and machines to be suitable for both sitting and standing work.
Upper and Lower Arm Position	Arm support devices: Provide armrests to help workers maintain a comfortable arm position. Improve arm angles: Adjust the height and position of the work area to ensure ergonomic arm angles.

4. **Conclusion**

In this study, key production processes such as welding, grinding, turning, assembly, and drilling were ergonomically evaluated in a labor-intensive manufacturing facility using the REBA (Rapid Entire Body Assessment) method. The findings revealed that workers frequently adopt improper postures, leading to significant physical strain on the musculoskeletal system. The design and layout of the machinery often require employees to work in bent or unstable positions, thereby increasing the risk of ergonomic-related health problems.

According to the REBA analysis, tasks such as foot frame assembly and welding pose significant ergonomic risks, indicating an urgent need for improvements in workstations and operational conditions. The absence of adequate leg support, frequent trunk rotation, and reliance on manual handling in various processes were identified as critical factors contributing to elevated ergonomic risk levels. Implementing ergonomic interventions in the workplace will not only safeguard worker health but also enhance productivity and product quality. It is recommended that mechanical lifting aids be introduced, machinery be reconfigured in accordance with anthropometric standards, supportive equipment be utilized, and ergonomics training be provided to increase awareness among employees.

After applying the proposed ergonomic interventions, an expected reduction of REBA scores by 30-50% is projected, potentially bringing welding from high to medium risk and improving operator comfort and safety. In conclusion, ergonomics-based improvements play a crucial role in preventing occupational accidents and diseases, while also contributing to the long-term sustainability and competitiveness of the organization. Such interventions will improve employee well-being and strengthen overall corporate performance.

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