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Analysis Of Occupational Safety and Health Risks in Operators in Company X

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ABSTRACT

Grinding activities at PT X have high physical demands and have the potential to cause musculoskeletal disorders (MSDs) in the upper extremities due to repetitive movements, large grip forces, and unergonomic posture. This study aims to measure the risk level of MSDs, identify dominant causative factors, and provide recommendations for ergonomic improvements. The method used is Job Strain Index Data collection was carried out through direct observation, documentation of work posture photos, and measurement of six JSI variables, namely work intensity (IE=6), duration of work (DE=2), effort per minute (EM=0.5), hand-wrist position (HWP=1.5), work speed (SW=1), and daily duration (DD=1). The calculation results showed an SI value of 9 which was included in the high risk category. The main risk factors include strong grip force, non-neutral posture, tool vibration, and long working duration. Recommendations are directed at improving work methods, tool design, and working environment settings to reduce the risk of injury and improve work safety.

Introduction

PT X is a technical implementation unit responsible for the maintenance, repair, and production of steel bridge components. Activities in this work environment face high work challenges, including time pressures, safety risks, and complex technical demands. The job often involves manual physical tasks such as weight lifting, repetitive grips, and unergonomic postures, which give rise to complaints of musculoskeletal disorders (MSDs) in workers, particularly in the upper extremities such as the hands, arms, and shoulders. Various international studies in the last five years have shown that exposure to repetitive movements, high lifting loads, and non-neutral work postures significantly correlates with an increased prevalence of work-related musculoskeletal disorders (WMSDs) in industrial workers (Gupta & Singh, 2024; Kamijantono et al., 2024). In addition, high production demands and working time pressures are known to exacerbate biomechanical exposure, thereby increasing the risk of pain in the shoulder and upper extremities (Frontiers Editorial Team, 2024, 2025). Ergonomics intervention studies also confirm that repeated exposure to physical loads and vibrations of work tools without adequate control can accelerate the occurrence of musculoskeletal disorders in heavy industry sector workers (Crandall et al., 2025).

Musculoskeletal disorders (MSDs) are one of the major occupational health problems in the construction and transportation industry, with symptoms such as muscle pain, inflammation, and functional impairment that can decrease productivity, increase the risk of accidents, and have an impact on the physical and mental health of

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worker. This condition is generally triggered by biomechanical exposure such as high grip intensity, repetitive movements, non-neutral posture, and long working duration. Various international studies in the last five years have shown that these factors are significantly associated with an increase in the prevalence of work-related musculoskeletal disorders (WMSDs) as well as contributing to work absenteeism and the economic burden of companies (Wang et al., 2023; Oakman et al., 2022; Skandfer et al., 2022; Gupta & Singh, 2024). In this study, the *Job Strain Index* (SI) method is a relevant approach to quantitatively identify and measure the level of risk of MSDs in the upper extremities.

The strain index evaluates six main components, namely effort intensity, effort duration, frequency of effort per minute, hand or wrist posture, work speed, and task duration per day, which directly represent the biomechanical exposure that causes WMSDs. Recent studies have shown that *the Strain Index* has good validity and sensitivity in predicting disturbances in the hands, wrists, and arms, especially in jobs with repetitive and stylistic characteristics high grip (Bao et al., 2021; Fan et al., 2022; Roquelaure, 2023). Thus, the integration of MSDs analysis using the SI method can provide an objective picture of the level of risk and be the basis for the formulation of more targeted and evidence-based ergonomic interventions.

Based on the identified problems using the Job Strain Index method, which indicate a high level of exposure to grip forces, static loads, and non-neutral working postures during grinding activities, it is recommended to improve the engineering aspect through redesign or selection of grinding tools that are lighter, have ergonomically appropriate grip diameters, and are equipped with vibration-damping systems to reduce pressure on the upper extremities. In addition, it is necessary to provide a workbench or workplace support with an adjustable height based on workers' anthropometric data, ensuring that the wrist, elbows, and shoulders remain in neutral positions. This intervention is expected to reduce biomechanical load and minimize the risk of musculoskeletal disorders (MSDs).

Accordingly, this study contributes to addressing this gap by integrating the Job Strain Index method with a holistic ergonomic intervention approach that incorporates both engineering controls (tool redesign) and anthropometric-based workstation design. This integrated framework not only enables the quantification of risk levels but also delivers actionable and context-specific design recommendations, there providing a more effective strategy for mitigating MSD risks in grinding activities compared to existing approaches.

Literature Review

Work-related musculoskeletal disorders (WMSDs) are among the common occupational health problems experienced by workers in industrial environments. These disorders are associated with physical demands arising from work activities, including repetitive movements, excessive physical exertion, awkward postures, and prolonged exposure to occupational tasks. Industrial workers who perform physically demanding activities are particularly exposed to these risk factors because production processes often require repetitive movements and sustained physical effort. Previous studies have reported that ergonomic conditions in industrial workplaces play an important role in the occurrence of musculoskeletal disorders and that inadequate ergonomic conditions can increase workers' physical burden (Frontiers Editorial Team, 2024; Gupta&Singh,2024;Kamijantonoetal.,2024).

Among the various ergonomic risk factors, repetitive movements and excessive exertion are important contributors to musculoskeletal problems in the upper extremities. Repetitive work requires the same muscles and joints to perform similar movements continuously, which can lead to cumulative physical strain. In addition, high exertion increases the muscular force required to perform a task. When repetitive movements and high exertion occur simultaneously, the physical demands placed on the muscles, tendons, and joints may increase. Bao et al. (2021) emphasized the importance of quantifying exposure to upper-extremity risk factors because the combined exposure to physical demands can contribute to the development of musculoskeletal disorders.

Hand and wrist posture is another important ergonomic factor in upper-extremity risk assessment. Working with the wrist in a non-neutral position, such as excessive flexion, extension, or deviation, can increase the physical demand on the upper extremities. The risk may become greater when an awkward posture is maintained repeatedly or for a prolonged period. In industrial activities involving hand tools, workers may also experience additional physical exposure from vibration generated by the equipment. These conditions are particularly relevant to grinding activities because operators must continuously grip and control the grinding tool while maintaining the required working position. The combination of force, repetition, posture, and

duration can therefore increase the overall biomechanical load experienced by the worker (Bao et al., 2021; Kamijantono et al., 2024).

One method that can be used to assess upper-extremity musculoskeletal risk is the Job Strain Index (JSI), also referred to as the Strain Index. The method evaluates physical demands associated with occupational tasks by considering several factors related to exertion and work exposure. The variables include Intensity of Exertion (IE), Duration of Exertion (DE), Efforts per Minute (EM), Hand/Wrist Posture (HWP), Speed of Work (SW), and Duration per Day (DD). These factors are converted into corresponding multipliers and combined to obtain an overall Strain Index value. The method is useful for identifying tasks that may expose workers to a high risk of musculoskeletal disorders affecting the distal upper extremities. Research by Bao et al. (2021) demonstrated the application of the Strain Index for quantifying exposure to upper-extremity musculoskeletal risk factors, while Caffaro et al. (2021) examined the reliability of the revised Strain Index and its agreement with other observational approaches.

The application of an observational ergonomic assessment is particularly relevant in industrial activities where several physical risk factors occur simultaneously. A task may not involve extremely high repetition or force individually, but the combination of exertion intensity, duration, hand/wrist posture, work speed, and daily exposure may produce a considerable overall risk. Therefore, an assessment method that considers multiple dimensions of occupational exposure can provide a more comprehensive representation of the physical demands experienced by workers. This is relevant to grinding activities, where workers are required to operate a handheld tool while maintaining grip force and controlling the movement of the tool during the work process.

In addition to identifying ergonomic risks, previous research emphasizes the importance of implementing interventions to reduce workers' exposure to musculoskeletal risk factors. Ergonomic interventions may include improvements to work methods, workstation design, tools, working posture, and work organization. Crandall et al. (2025) highlighted the importance of workplace interventions in reducing work-related musculoskeletal disorders among industrial workers. Improvements in tool design, appropriate handle dimensions, reduction of vibration exposure, and management of working duration can be considered as potential approaches for reducing physical workload. Therefore, the results of ergonomic risk assessment should not only be used to classify the level of risk but also serve as a basis for developing appropriate interventions.

Based on previous studies, ergonomic risk assessment has been widely used to identify physical factors associated with musculoskeletal disorders among industrial workers. However, grinding activities involve a combination of several risk factors, including exertion intensity, repetitive movements, hand and wrist posture, prolonged work duration, and exposure to tool vibration. These factors may interact and produce a cumulative physical burden on the upper extremities. Therefore, the present study applies the Job Strain Index to evaluate the level of upper-extremity musculoskeletal risk in grinding activities and to identify the ergonomic factors that contribute to the observed risk. The results are subsequently used as a basis for developing ergonomic improvement recommendations for the grinding work process.

Methodology

This study was conducted at PT X, focusing on operators performing steel plate grinding activities. Data collection was carried out through direct field observation, photo documentation of work postures, and physical measurement during active work cycles. To evaluate the ergonomic risk level associated with upper extremity musculoskeletal disorders (MSDs), this study employed the Job Strain Index (JSI) method proposed by Garg and Moore (1995). The assessment involves six biomechanical parameters:

1. Intensity of Exertion (IE): Evaluated based on the Borg scale and maximum strength percentage required to control tool vibrations and apply grinding pressure.
2. Duration of Exertion (DE): Measured as the percentage of active exertion time relative to the total observation cycle time ($DE = \frac{\text{exertion time}}{\text{total observation time}} \times 100\%$).
3. Efforts per Minute (EM): Calculated from the frequency of exertion cycles per minute.
4. Hand/Wrist Posture (HWP): Assessed through direct posture angle measurements (flexion, extension, and ulnar deviation) recorded via photo documentation.
5. Speed of Work (SW): Evaluated by comparing the observed working pace against the MTM-1 standard pace.

6. Duration of Task per Day (DD): Quantified based on total cumulative daily grinding duration.

Each parameter is assigned a multiplier score derived from standard JSI rating tables. The final Strain Index (SI) score is calculated using the following equation:

$$SI = IE \times DE \times EM \times HWP \times SW \times DD$$

The resulting SI score is categorized into four risk severity levels: safe (≤ 3), not recommended ($3 - 5$), potential injury risk ($5 - 7$), and hazardous / very dangerous level (> 7). The identified risk factors and multiplier values serve as the basis for designing targeted ergonomic interventions, including tool redesign, posture adjustment, and workstation optimization.

Result and Discussion

Workstation Observation and Task Identification

The study began with direct field observation of the grinding workstation at PT X. The grinding process involves manual physcal tasks where operators are required to continuous hold and maneuver the grinding tool against steel plates. As shown in Figure 1, the work posture involves a stooped position, prolonged static muscle loading, high grip forces to control tool vibration, and unergonomic postures. These physical exposures indicate potential biomechanical strain, particularly on the upper extremities including the hands, wrists, and arms.



Figure 1. Grinding Activities
Source : Author (2026)

Job Strain Index (JSI) Variables Evaluation To quantitatively evaluate the risk of upper extremity musculoskeletal disorders (MSDs), six JSI parameters were analyzed based on field measurements and direct observation:

a. Intensity of Exertion (IE) : The grinding activity requires substantial physical force to stabilize the grinding unit against high vibrations and to apply sufficient surface pressure. The effort intensity falls within 30%–49% of maximum strength with a Borg scale rating of 4–5. Referring to the JSI criteria, this exertion is classified as "Heavy," yielding a multiplier value of IE = 6.
b. Duration of Exertion (DE) : Observation showed an active exertion duration of 120 seconds per 2400-second cycle. The calculated exertion duration ratio is:

$$DE = \frac{120}{2400} \times 100\% = 5\%$$

Since the duration is less than 10% of the cycle time, it corresponds to level 1 with a multiplier value of DE = 2
c. Efforts per Minute (EM) : Grinding is performed 12 times per 480-minute shift, with a cycle time of 140 seconds. This frequency corresponds to less than 4 exertions per minute, resulting in an EM multiplier value of EM = 0.5.
d. Hand/ Wrist Posture (HWP) : Postural analysis (Figure 2) reveals non-neutral wrist alignments during tool operation, with measured flexion at 30° and extension at 40°. This position deviates from the neutral axis and is categorized as "Fair" (normal deviation), assigning a multiplier value of HWP = 1.5.



Figure 2. Hand and Wrist Posture
Source : Author (2026)

e. Speed of Works (SW) : Workers maintain a steady and controlled working pace aligned with Standard Operating Procedures (SOP). Comparison with MTM-1 standards places the working speed in the 91%–100% range ("Normal"), giving a multiplier value of SW = 1
f. Duration of Task per Day (DD) : he grinding operation is performed across 12 cycles per day at 40 minutes per cycle, totaling 480 minutes (8 hours per day). Falling within the 4–8 hours category, the daily duration multiplier is DD = 1.

Strain Index Score and Risk Level Assessment The final Strain Index (SI) score is calculated by multiplying the six individual variable multipliers:

$$SI = IE \times DE \times EM \times HWP \times SW \times DD = 6 \times 2 \times 0.5 \times 1.5 \times 1 \times 1 = 9$$

Table 1. Recapitulasi of Job Strain Inddex (JSI) score and risk level

Stations	**IE**	**DE**	**EM**	**HWP**	**SW**	**DD**	**JSI Score**	**Risk Level**
Grinding	6	2	0.5	1.5	1	1	9	Height

Source : Author's Calculation (2026)

Based on the standart JSI risk classification (≤ 3: Safe; $3-5$: Not Recommended; $5-7$: Injury Risk; > 7: Hazardous/Very Dangerous), the obtained SI score of 9 places the grinding operation in the High Risk category. The high Strain Index score ($SI = 9$) indicates a significant risk of upper extremity musculoskeletal disorders (MSDs) for grinding operators at PT X. This risk is primarily driven by three critical parameters: high exertion intensity ($IE = 6$), exertion duration ($DE = 2$), and non-neutral hand/wrist postures ($HWP = 1.5$). Continuous force required to resist tool vibration, combined with wrist flexion (30°) and extension (40°) over an 8-hour shift, generates severe mechanical strain on joint structures. These findings align with prior research showing that sustained force, vibration, and non-neutral postures significantly elevate WMSD risks in industrial environments (Gupta & Singh, 2024; Bao et al., 2021).

Conclusion

The results of the research that have been carried out on the grinding activities in the production division at PT X. Based on the results of the analysis using the Job Strain Index (JSI) method, grinding activities in the production division at PT X are classified as high-risk work with a Strain Index (SI) value of 9. This indicates a significant potential for musculoskeletal disorders (MSDs), particularly in the upper extremities. The high risk is mainly influenced by several dominant factors, including high exertion intensity, non-neutral hand and wrist posture, and duration per day repetitive movements combined with continuous exposure to tool vibration and static muscle contractions further increase biomechanical load on workers. Although the effort frequency is relatively low, the cumulative effect of these factors results in a substantial risk level. To mitigate these risks, it is necessary to implement comprehensive ergonomic interventions. These include improving working posture to maintain more neutral positions, reducing excessive force during tool operation, and managing working time through scheduled breaks or job rotation. Additionally, redesigning or selecting more ergonomic grinding tools such as those with appropriate handle dimensions and vibration-reduction features should be considered. Overall, the implementation of these improvements is expected to reduce biomechanical load, enhance worker safety, and minimize the risk of musculoskeletal disorders in grinding operations.

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