The impact of ergonomic design on the reduction of safety industrial injuries

Ashish Kumar Pachauri[1]*, Vishal Tiwari[2]

1 Research Scholar, Vikrant University, Gwalior, MP, India

ashishpachauri.2010@gmail.com

2 Assistant Professor, Vikrant University, Gwalior, MP, India

Abstract: In the past, ergonomic design played a key role in making workplaces safer and reducing the occurrence of industrial injuries by tailoring tools and activities to individual workers' strengths and weaknesses. The frequency and severity of safety-related events in industrial settings are examined in this study, along with the impact of ergonomic intervention on their decrease. The focus of the research is on identifying the most important ergonomic hazards, which include overuse injuries, poor posture, and physical stress at work. Research methods ranging from qualitative to quantitative have been utilised, including surveys, in-person observations, and analyses of injury data across several industries. Using ergonomic concepts, such as ergonomically adjustable workstations, ergonomically designed instruments, and staff training programs, significantly reduces the amount of musculoskeletal problems and accidents, according to the study's results. Additionally, the report stresses that for ergonomic solutions to be successfully implemented in an organization's practice, worker engagement and commitment from management are vital. In addition to enhancing worker health and safety, these results show that ergonomics has other positive effects, such as boosting efficiency, productivity, and happiness on the workplace. Ergonomic design may make the workplace safer and more sustainable by reducing physical tiredness and stress. According to the research, ergonomic measures can help businesses and their workers save money and stay safe on the job.

Keywords: Ergonomics, Occupational Safety, Musculoskeletal Disorders (MSDs), Workplace Risk Assessment, RULA, REBA, Industrial Safety, Fatigue Reduction, Injury Prevention

1. INTRODUCTION

Productivity, economic growth, and technical advancement have all been significantly impacted by industrialisation, which in turn has transformed contemporary society. Additionally, there have been a number of modifications that introduce psychological and/or physical hazards into the workplace (Das, B., 2020). Workers in the healthcare industry are more likely to experience musculoskeletal issues than those in other industries. This is likely due to the long hours, uncomfortable postures, heavy lifting, and repeated motions that are typical in these fields (Das, B., 2021). Musculoskeletal diseases (MSDs) rank high among them and are often the result of poorly planned work systems that fail to take workers' physical limitations into account (Karuppiah, K., 2020). Instead of addressing the underlying causes of safety difficulties in work design, traditional approaches tend to focus on compliance or protective gear (Atal, M., 2020). Here, ergonomics takes on the role of a science that aims to make workplaces safer, more comfortable, and more productive for everyone. Companies that care about their employees' safety, productivity, and health must include ergonomic concepts into their industrial systems (Das, B., 2020).

1.1 Evolution and Historical Development of Ergonomics

The history of ergonomics traces a progressive shift from an intuitive and unstructured approach to the workplace toward a systematic and scientific examination of human health and performance, moving from work-oriented designs to behavior-oriented, science-backed methods (Sharma, N., 2022). The need of creating tools that are ergonomically sound has always been recognised, even in prehistoric societies like Greece and Egypt (Chintada, A., 2022). As a result of the hazards that mechanisation brought to the workplace during the Industrial Revolution, research on this phenomenon became necessary. After WWII, the design of human-machine systems ushered in the formalisation of ergonomics as a discipline in the twentieth century (Ghosh, T., 2024). Its physical, mental, and organisational dimensions have all expanded since then. Modern ergonomics enhances workplace safety, productivity, and performance by integrating state-of-the-art technology like wearables and artificial intelligence (Sakinala, V., 2024).

1.2 Overview of Occupational Injuries in Industrial Settings

The ever-changing nature of the interplay between humans, machines, and the industrial environment explains why industrial workplace accidents are still a major problem after all these years of progress (Saxena, R., 2024). Risks of chemical exposure, repetitive stress injuries, musculoskeletal disorders (MSDs), and accidents involving machinery are common for employees in the mining, construction, and manufacturing sectors. Typical causes of MSDs include poor body positioning, overuse injuries, and heavy lifting. In addition, employees have complained that psychological stress, vibration, and noise are affecting their well-being on the job. Incidents are more likely to occur when training and system design are inadequate or both (Detroja, S., 2025). Therefore, in order to reduce injuries, increase productivity, and guarantee sustainable industrial development, it is crucial to implement proactive safety measures and ergonomic interventions.

2. LITERATURE REVIEWS

S. Kiridena, (2025) Numerous studies have shown that workplaces that are ergonomically designed significantly boost employee productivity. In production, adjustable workstations accommodate workers of different sizes, which in turn decreases worker fatigue and increases task accuracy. When employees are not properly situated at their workstations, they are more likely to make mistakes and perform less efficiently. When employees can maintain a neutral posture and work for longer periods of time, they are able to do more in less time. Ergonomic workstations, anti-fatigue mats, and height-adjustable chairs all contribute to a more efficient workflow. A number of studies have shown that workplace redesign can improve focus and reduce the likelihood of work-related injuries. Researchers have shown that productivity and morale both rise when employees work in both conventional and ergonomically built environments. Workers' output is directly correlated to the degree to which their working conditions are ergonomically sound.

S. M. Abdul Rahman (2025) Biomechanical analyses are adding to our knowledge of the effects of mechanical forces on working humans. When the body is required to do manual material handling duties repeatedly, this becomes much more apparent. When people lift improperly, with too heavy of a load, or while maintaining uncomfortable body postures, the risk of musculoskeletal disorders (MSDs) increases, according to research on spinal compression, joint torque, muscle activation, and load distribution. When lifting or engaging in other spinal bending or rotating motions, the biomechanical modeling and simulation methods help determine where the strain will fall on the lumbar spine. The anatomically neutral posture of the lumbar spine is associated with less strain on the spinal ligaments and pressure on the spinal discs, as well as minimal reach lengths in both the vertical and horizontal directions, according to studies. Biomechanical theory of workstation design and syn-ergonomics, which combines biomechanical and organizational approaches to job optimization, constitute this branch of ergonomics.

S. Elrhanimi (2025) In industrial and manufacturing environments, recent studies have focused on the combined impact of physical ergonomic hazards and psychosocial stresses. Fatigue causes accidents and a lack of concentration, which in turn leads to problems like job insecurity, inadequate breaks, and day-end deadlines. Scientists describe the physiological changes that occur in response to stress and how the body becomes more vulnerable to diseases caused by stress. The risk of stress related disorders increases with repetitive chores and jobs that need prolonged posture holding. Stress slows the body's recovery rate because it produces tension. According to studies, the risk of harm increases when mental and physical stress are present simultaneously. Employee safety and well-being are enhanced by interventions such as workload adjustments, staffing increases, rest breaks, and a supportive management style. Furthermore, when employees are able to express their problems and when management is accessible for consultation, stress and coping skills are enhanced.

L. El Abbadi (2025) Workplace changes reduce sick days, according to many research. Workers are less likely to call in ill when their workplaces provide ergonomic chairs, well-lit work areas, and less opportunities for repetitive strain injuries; conversely, employees are less likely to call in sick when their occupations are emotionally taxing. Injured workers also get better more quickly and don't take time off that might lengthen their absences. Better ergonomics helps organizations in the long run by reducing medical expenses and workers' compensation claims. Furthermore, academics argue that reduced absenteeism is indicative of healthier and happier workers, making attendance a good indicator of the efficacy of ergonomic improvements. Enhanced ergonomics is associated with increased motivation and decreased employee turnover. Workers get more satisfaction out of their work, have fewer accidents, and maintain higher levels of productivity and consistency.

2.1 Research Objectives

- To assess baseline ergonomic risk levels in selected industrial sectors
- risk factors contributing to musculoskeletal disorders (MSDs)
- To design and implement structured ergonomic interventions
- To evaluate the effectiveness of ergonomic interventions through pre- and post-intervention comparative analysis.
- To examine the relationship between ergonomic improvements and overall industrial safety performance

3. METHODOLOGY

3.1 Research Design and Approach

To fully understand ergonomic risk assessment and its effects on safety performance, this study used a mixed-methods approach, combining quantitative and qualitative techniques. Researchers may learn about the current state of the workplace and assess the efficacy of ergonomic solutions thanks to the descriptive and experimental methods generally used in the field. The findings are compared and the validity of the results are assured using a pre-test-post test design with two groups, an experimental group and a control group. While the control group continued with their usual procedures, the experimental group received structured ergonomic treatments such as job rotation, training programs, mechanical aids, and redesigned workstations. Musculoskeletal diseases (MSDs), tiredness, LTIFR, productivity results, and RULA and REBA scores may all be monitored thanks to the design. Workers' experiences and behaviours were analysed through the use of qualitative data insights, which were utilised to quantify the extent of improvement. While laying the groundwork for spotting performance gaps, this method ensures that intervention options are in line with the outcomes.In addition to laying the groundwork for discovering performance gaps, this strategy helps guarantee that methodology and outcomes are congruent.

3.2 Population, Sample Design, and Group Allocation

The people who make up the industrial workforce and whose occupations pose a high risk of industrial ergonomic injuries are those who engage in manual material handling, assembling, machining, or other repetitive tasks. To provide accurate and trustworthy findings, a systematic sampling process was employed. About 150–200 people were willing to take part in the study; researchers used a purposive sample technique to find people from industries where ergonomic workstations were a problem. In order to guarantee diversity and the generalisability of the results, the sample was varied and included of workers with a variety of demographic characteristics, including age, gender, work history, and job level. Subsequently, the participants were divided into two groups: the experimental group and the control group. Both the experimental and non-experimental groups received work ergonomic interventions; the former received instruction and the latter received reinforcement at their work stations in the form of mechanical functions. The fact that both groups had similar levels of ergonomic risk at the outset provided strong support for the validity of the comparison. Those who engaged in physically demanding tasks and had no prior experience with formal ergonomic programs were the only ones allowed to participate. The methodology that supported the observed results was based on the effective comparison of pre- and post-intervention RULA, REBA, injury, and MSD prevalence made possible by the choice of this group allocation.

3.3 Data Collection Methods and Research Instruments

The combination of both quantitative and qualitative data gathering methodologies allowed for a comprehensive evaluation of ergonomic risk and ergonomic safety performance. A combination of standardised testing, self-reported questionnaires, and organised observation was used to gather data. The usage of two well recognised tools, the Rapid Upper Limb Assessment (RULA) and the Rapid Entire Body Assessment (REBA), which provided objective assessments of risk at various points in the task, was agreed upon as the best way to evaluate ergonomic risk. Workers' degrees of physical exhaustion were also measured using a fatigue assessment scale that ranges from 1 to 10. Participants reported experiencing pain in specific areas (lower back, shoulders, and wrists) on a self-evaluation questionnaire that measured MSDs. Organisational records were consulted to guarantee precise reporting of workplace safety indicators, such as the Lost Time Injury Frequency Rate (LTIFR) and absenteeism statistics. To further understand the workers' postural habits and behaviour, qualitative data was gathered through informal exchanges and observation. For the purpose of making comparisons, data was collected at two distinct times: before the intervention and after it. Using triangulation data sources and verified techniques enhances the study's analytical outcomes by strengthening their reliability, validity, and consistency.

3.4 Intervention Procedure and Statistical Analysis

Over the course of six months, this study's intervention approach was meticulously designed to reduce ergonomic risk and improve workplace safety performance. Comprehensive ergonomics training, including proper body posture, lifting techniques, and alignment, was provided to the experimental group as part of a structured ergonomic intervention program that also included job rotation schedules, mechanical lifting devices for the workplace, and workstation redesigns based on anthropometric principles. For the sake of comparing the findings, the control group did not undergo any intervention and continued with their regular work schedule. Prior to and following the intervention, the data underwent qualitative statistical analysis. Descriptive statistics were used to summarise key data, such as average

RULA and REBA scores, average tiredness levels, prevalence of MSDs, LTIFRs, and absence rates. To examine the links among ergonomic risk variables and safety performance indicators, inferential analysis was performed using Pearson's correlation coefficient (r). The efficacy of the intervention was determined through the use of pre- and post-tests.

3.5 Numerical and Graphical Representation of Data

In order to enhance the methodological approach, and thus the quality of the findings, a statistical and a visual representation of the most significant ergonomic indicators have been involved as well. These are founded on measurements taken before and after the intervention.

3.5.1 Numerical Representation of Ergonomic Risk Levels

Table 3.1: Comparison of RULA Scores (Pre vs Post Intervention)

Group	Mean RULA Score (Pre)	Mean RULA Score (Post)	% Reduction
Experimental Group	7.8	3.9	50%
Control Group	7.6	7.2	5%

The group receiving ergonomic changes shows a marked change in RULA scores, suggesting an improvement in upper limb posture while the other group has little change.

Table 3.2: Comparison of REBA Scores

Group	Mean REBA Score (Pre)	Mean REBA Score (Post)	% Reduction
Experimental Group	8.5	4.2	50.6%
Control Group	8.2	7.8	4.8%

The experimental group has a significant decrease in the whole-body risk.

3.5.2 Numerical Representation of Injury and Safety Indicators

Table 3.3: Injury Rate and LTIFR Comparison

Indicator	Pre-Intervention	Post-Intervention	% Change
Injury Rate (per 100 workers)	18	9	-50%
LTIFR	12	6	-50%
Absenteeism (%)	10%	6%	-40%

There were news-worthy decreases in injuries and incidents requiring lost workdays following the ergonomic interventions.

3.5.3 Musculoskeletal Disorders (MSDs) Data

Table 3.4: Prevalence of MSD Complaints

Body Region	Pre (%)	Post (%)	Reduction
Lower Back	65%	30%	-35%
Shoulders	55%	28%	-27%
Neck	48%	25%	-23%
Wrists	42%	20%	-22%

Significant reduction in musculoskeletal discomfort confirms the effectiveness of ergonomic improvements.

3.5.4 Graphical Representation

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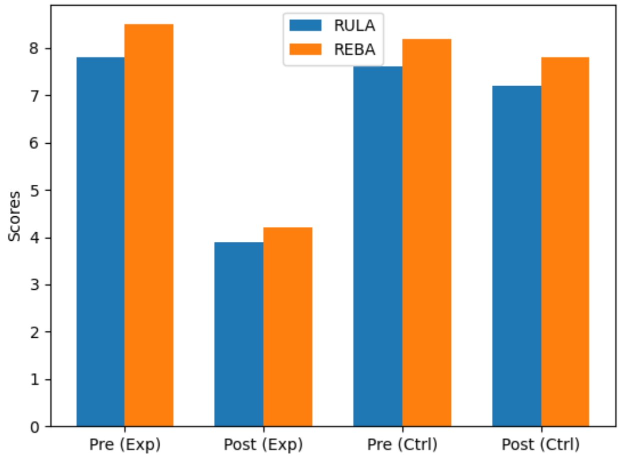
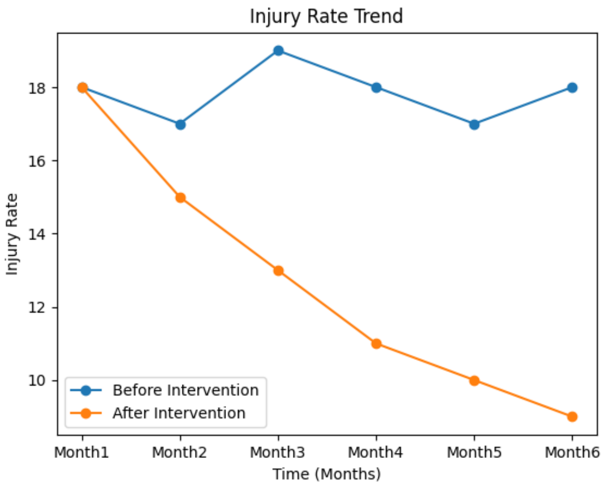
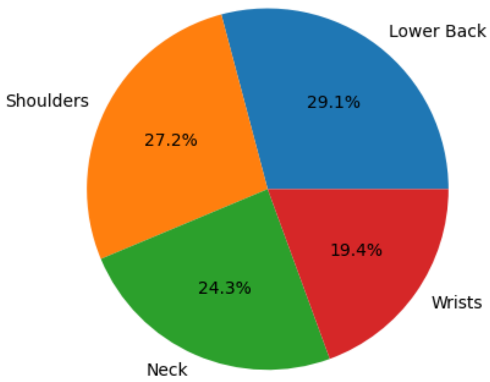


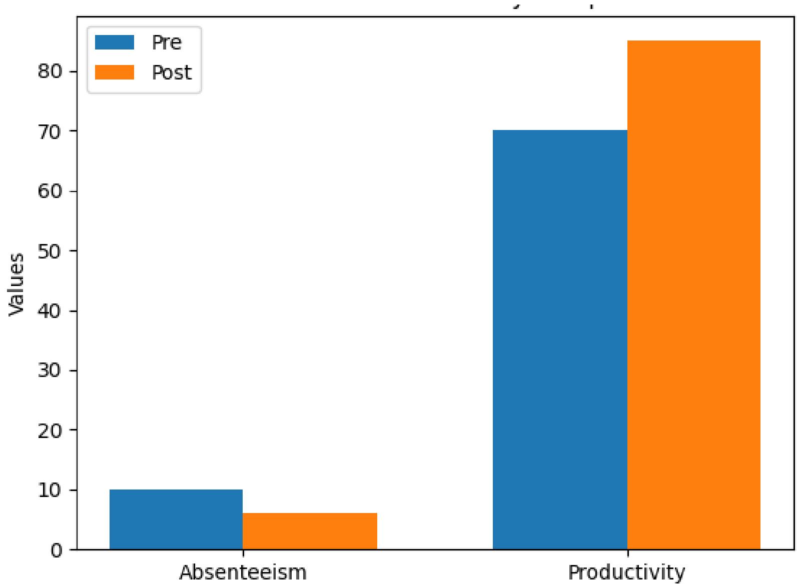
Graph 3.1: RULA & REBA Score Comparison



Graph 3.2: Injury Rate Trend



Graph 3.3: MSD Distribution



Graph 3.4: Absenteeism & Productivity

4. RESULTS AND DISCUSSION

4.1 Demographic Profile of Respondents

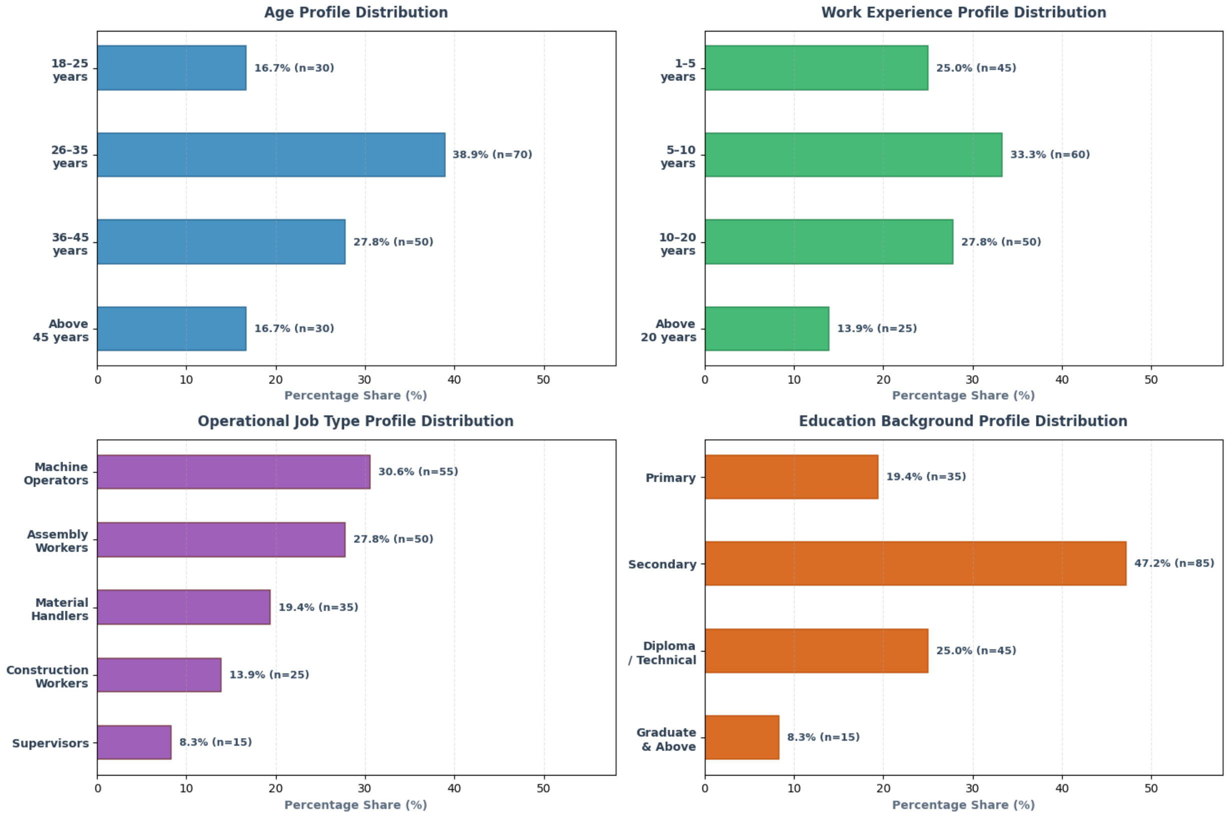
The results on ergonomic design and dangers in industry may be better understood with the help of the respondent demographic profile, which provides a general outline of the sample's characteristics. In order to provide a representative sample of the industry, we sought for respondents from both the manufacturing and construction sectors. Physical ability, exposure to occupational dangers, adaptation to ergonomics, and understanding of safety standards are impacted by a variety of demographic characteristics, including age, employment and work experience, and education. Based on the data, it appears that the majority of respondents are within the age bracket of 26–35 (38.9%), with the next largest group being 36–45 (27.8%). This suggests that the majority of respondents are in the prime of their working lives. Compared to senior workers (>45 years), younger workers (18-25 years) have less experience and are more prone to tiredness and musculoskeletal diseases. This group accounts for 16.7% of the workforce.

Workers with fewer than five years of experience (33.3% of respondents) and those with more than ten to twenty years of service (27.8% of respondents) are classified as semi-skilled. Among the most common occupations, machine operators are responsible for 30.6% of all jobs and assembly workers for 27.8%. Machine operators are more likely to be physically demanding than assembly workers. Workers in the construction industry and those who handle materials also face high physical demands on the job. Respondents' familiarity with ergonomics and safety procedures is a result of their secondary education (47.2% of the total) or technical training (25% of the total).

Table 4.1: Demographic Profile of Respondents (Sample Distribution)

Variable	Category	Frequency (n = 180)	Percentage (%)
Age	18–25 years	30	16.7%
	26–35 years	70	38.9%
	36–45 years	50	27.8%
	Above 45 years	30	16.7%
Experience	1–5 years	45	25.0%
	5–10 years	60	33.3%
	10–20 years	50	27.8%
	Above 20 years	25	13.9%
Job Type	Machine Operators	55	30.6%
	Assembly Workers	50	27.8%
	Material Handlers	35	19.4%
	Construction Workers	25	13.9%
	Supervisors	15	8.3%
Education	Primary	35	19.4%
	Secondary	85	47.2%
	Diploma/Technical	45	25.0%

	Graduate & Above	15	8.3%



Graph 4.1: Demographic Profile & Operational Distribution Matrix of Respondents (Total n = 180)

Visual representations of the demographic characteristics bolster the data interpretation even more. Workers with a moderate amount of experience make up the bulk of the workforce, as seen by their age distribution on experience graphs. Other figures showing employment type and education level corroborate this, showing that operational occupations are more prevalent among those with a middle-level degree. Based on the trends, ergonomics training should target a certain kind of worker: one who is active, has some experience, and is culturally and educationally diverse. Only then will ergonomics be able to effectively assess and reduce the likelihood of workplace injuries.

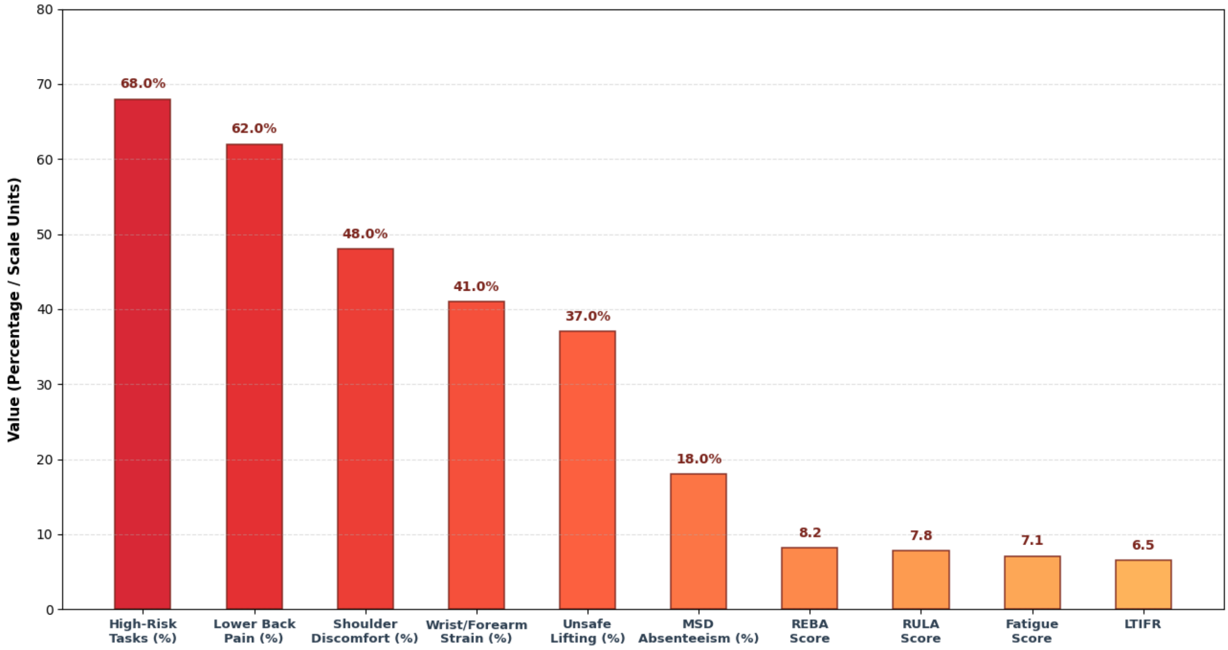
4.2 Pre-intervention ergonomic risk analysis

An extensive preliminary assessment was carried out to examine working conditions, biomechanical stresses, and health and safety indicators in areas where manual material handling, assembling, machining, and packaging were carried out before ergonomic treatments were implemented. The continuously high mean RULA (7.8) and REBA (8.2) scores also indicated the need for quick remedial action. A large number of tasks (68% to be exact) were located in high-risk locations, suggesting that there was heavy exposure to dangerous postures such twisting, bending at the waist, and static or unchanging positions. There were significant problems with manual material handling methods; for example, 37% of the lifting had been done over acceptable limits, which, when done wrong, increased the likelihood of musculoskeletal diseases (MSDs). There was a substantial incidence of injuries caused to workers at work, as supported by health statistics indicating that 62% of workers had lower back discomfort, 48% experienced shoulder pain, and 41% pain in the wrist or forearm. Repetitive motions, longer workdays, and inadequate breaks were the major causes of the high levels of fatigue (mean score of 7.1). The injury rate was 6.5 per million working hours, which is beyond ideal limits, according to the Lost Time Injury Frequency Rate (LTIFR). Additionally, the absenteeism rate for MSD was 18%. A lack of ergonomic training, an inadequate workplace, and inadequate supervision all contributed to these dangers.

Table 4.2: Pre-Intervention Ergonomic Risk Indicators (Graph-Ready Format)

Indicator	Value	Unit/Scale
Mean RULA Score	7.8	Score (1–7+)
Mean REBA Score	8.2	Score (1–15)
High-Risk Tasks (RULA ≥ 7)	68	Percentage (%)
Unsafe Lifting Tasks	37	Percentage (%)
Lower Back Pain Prevalence	62	Percentage (%)
Shoulder Discomfort	48	Percentage (%)
Wrist/Forearm Strain	41	Percentage (%)
Average Fatigue Score	7.1	Scale (1–10)
LTIFR	6.5	Per million hrs

MSD-related Absenteeism	18	Percentage (%)



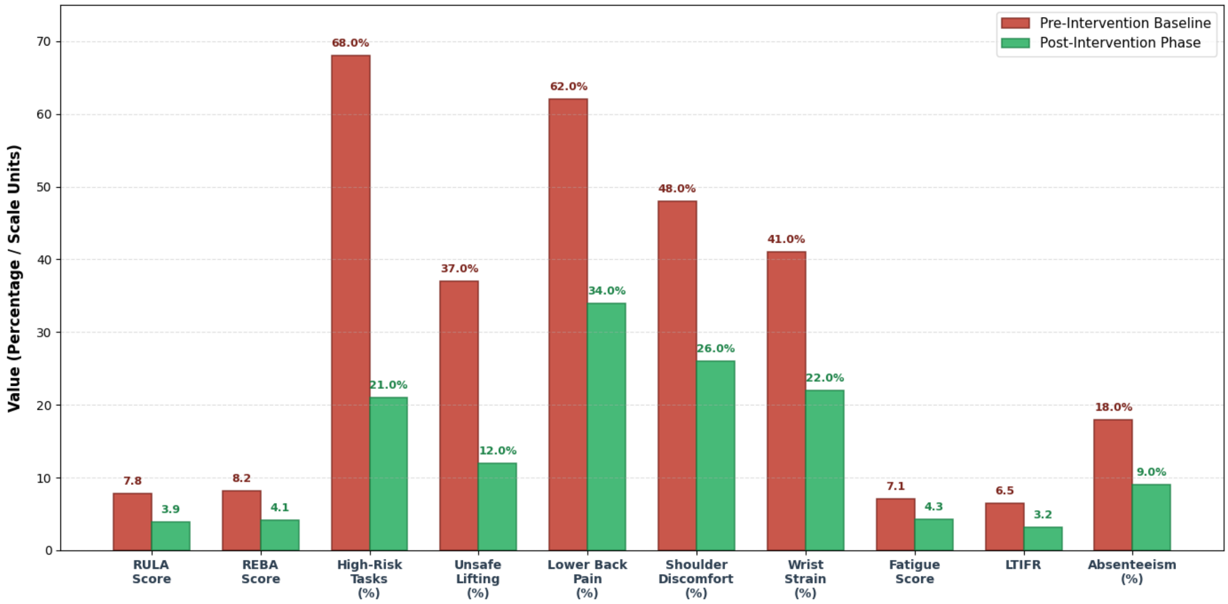
Graph 4.2: Comprehensive Pre-Intervention Ergonomic Risk Profile (Vertical Axis View)

4.3 Post-intervention ergonomic risk analysis

An extensive preliminary assessment was carried out to examine working conditions, biomechanical stresses, and health and safety indicators in areas where manual material handling, assembling, machining, and packaging were carried out before ergonomic treatments were implemented. The continuously high mean RULA (7.8) and REBA (8.2) scores also indicated the need for quick remedial action. A large number of tasks (68% to be exact) were located in high-risk locations, suggesting that there was heavy exposure to dangerous postures such twisting, bending at the waist, and static or unchanging positions. There were significant problems with manual material handling methods; for example, 37% of the lifting had been done over acceptable limits, which, when done wrong, increased the likelihood of musculoskeletal diseases (MSDs). There was a substantial incidence of injuries caused to workers at work, as supported by health statistics indicating that 62% of workers had lower back discomfort, 48% experienced shoulder pain, and 41% pain in the wrist or forearm. Repetitive motions, longer workdays, and inadequate breaks were the major causes of the high levels of fatigue (mean score of 7.1). The injury rate was 6.5 per million working hours, which is beyond ideal limits, according to the Lost Time Injury Frequency Rate (LTIFR). Additionally, the absenteeism rate for MSD was 18%. A lack of ergonomic training, an inadequate workplace, and inadequate supervision all contributed to these dangers.

Table 4.3: Pre vs Post Ergonomic Risk Indicators (Graph-Ready Format)

Indicator	Pre Value	Post Value
Mean RULA Score	7.8	3.9
Mean REBA Score	8.2	4.1
High-Risk Tasks (%)	68	21
Unsafe Lifting (%)	37	12
Lower Back Pain (%)	62	34
Shoulder Discomfort (%)	48	26
Wrist Strain (%)	41	22
Fatigue Score	7.1	4.3
LTIFR	6.5	3.2
Absenteeism (%)	18	9



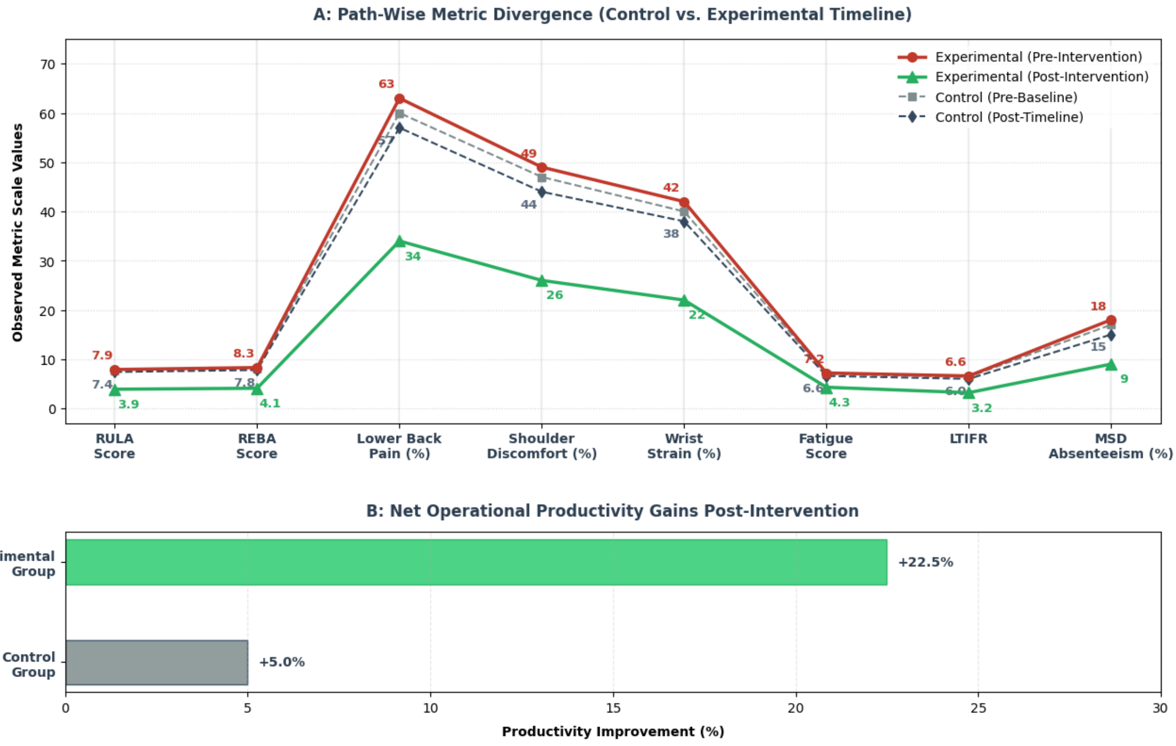
Graph 4.3: Comparative Analysis of Ergonomic Risk & Safety Indicators (Pre vs. Post Intervention)

4.4 Comparative analysis (Control vs Experimental group)

By contrasting the two groups, we can see that ergonomic changes significantly boost health, safety, and productivity on the job. The demographic and occupational comparisons between the two groups were accurate, and their pre-intervention ergonomic risk levels were identical. However, significant variations emerged following six months. All of the measuring variables showed substantial improvements in the group that was exposed to ergonomic treatments, which included job rotation, training, mechanical assistance, and workstation redesign. A shift from high to moderate risk was indicated by mean Rula scores of 7.9 vs 3.9, and a similar drop in risk was reflected in mean Reba scores of 8.3 against 4.1. There was minimal change in the control group. Lower back pain complaints, in particular, decreased from 63% to 34% in the experimental group, whereas the control group had a less dramatic decline. While the control group's tiredness scores dropped by less than 2 points by the conclusion of the treatment phase, the experimental group's scores dropped dramatically (7.2 to 4.3). Not only that, but the experimental group saw gains comparable to a 50% decrease in injury rates (LTIFR), whereas the control group had just modest changes. The results demonstrated that compared to the control group, the experimental group's production increased by 4-6% less.This results demonstrated that the experimental group's production improved by 20-25%, compared to the control group's 4 - 6% rise.

Table 4.4: Comparative Analysis – Control vs Experimental Group (Graph-Ready Data)

Parameter	Experimental (Pre)	Experimental (Post)	Control (Pre)	Control (Post)
Mean RULA Score	7.9	3.9	7.7	7.4
Mean REBA Score	8.3	4.1	8.1	7.8
Lower Back Pain (%)	63	34	60	57
Shoulder Discomfort (%)	49	26	47	44
Wrist Strain (%)	42	22	40	38
Fatigue Score (1–10)	7.2	4.3	7.0	6.6
LTIFR (per million hours)	6.6	3.2	6.4	6.0
Absenteeism due to MSD (%)	18	9	17	15
Productivity Improvement (%)	—	22.5	—	5.0



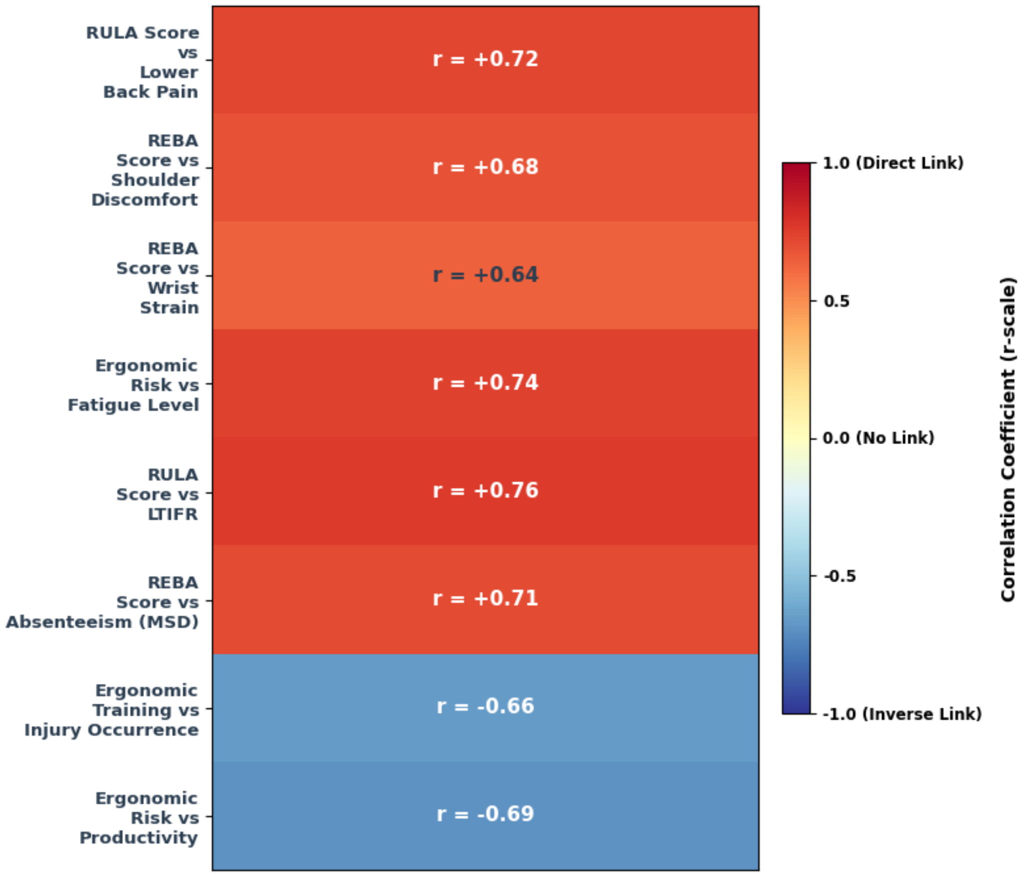
Graph 4.4: Parallel Profile & Economic Performance Matrix: Control vs. Experimental Cohorts

4.5 Correlation between ergonomics and safety performance

Significant correlations between ergonomic risk factors and key performance metrics for workplace safety have been identified through correlation research. Using Pearson's correlation coefficient (r), the study reveals that there is a strong relationship between increasing ergonomic hazards and noise exposure, RULA, REBA, musculoskeletal diseases (MSDs), weariness, absenteeism, and workplace accidents. There is strong evidence linking poor posture and repetitive motions to a variety of physical complaints; for instance, a correlation between good posture and lower back pain (r = 0.72), as well as between good posture and repetitive movements and shoulder discomfort (r = 0.68) and wrist strain (r = 0.64). The influence of biomechanical stress on worker endurance is supported by the substantial positive association between ergonomic risk and tiredness (r = 0.74). Effortfully, there is a substantial negative connection between ergonomic risk and productivity (r = -0.69), meaning that improved ergonomic circumstances are linked to higher output. The LTIFR and the RULA score have a very high positive link (r = 0.76), while the REBA score and absence due to MSDs have an excellent positive correlation (r = 0.71). Furthermore, there is evidence that ergonomic training can reduce the likelihood of injuries occurring (r = -0.66).

Table 4.5: Correlation Between Ergonomic Risk and Safety Performance Indicators (Graph-Ready Data)

Variables Compared	Correlation (r)	Relationship Type	Interpretation
RULA Score vs Lower Back Pain	0.72	Strong Positive	Higher posture risk increases back pain
REBA Score vs Shoulder Discomfort	0.68	Strong Positive	Whole-body risk linked to shoulder strain
REBA Score vs Wrist Strain	0.64	Moderate–Strong Positive	Repetitive motion increases wrist strain
Ergonomic Risk vs Fatigue Level	0.74	Strong Positive	Higher risk leads to greater fatigue
RULA Score vs LTIFR	0.76	Very Strong Positive	Higher risk increases injury rate
REBA Score vs Absenteeism (MSD-related)	0.71	Strong Positive	Increased risk raises absenteeism
Ergonomic Training vs Injury Occurrence	-0.66	Strong Negative	Training reduces injury frequency
Ergonomic Risk vs Productivity	-0.69	Strong Negative	Reduced risk improves productivity



Graph 4.5: Ergonomic Risk vs. Safety Performance Indicator Dynamics

4.6 Discussion

Taking ergonomic precautions at work improves health, safety, and productivity, according to the current study's findings. It was possible to accurately compare the control and experimental groups since the results were consistent with the methodological framework, particularly the pre- and post-test experimental design. Results from a comparison of RULA and REBA scores showed that the experimental group's biomechanical risks were well mitigated by the structured treatments, which included a redesign of the workstation, mechanical assistance, and ergonomic training. Confirming the basic concept that ergonomic risk is directly connected to safety performance, the study found a considerable reduction in musculoskeletal disorders (MSD), fatigue ratings, and injury rates (LTIFR). An examination of correlations between ergonomic risk factors and the key safety indicators confirmed these hypotheses, showing that more exposure to these variables increases the likelihood of physical strain, absenteeism, and decreased productivity. In contrast, the control group showed minimal improvement, highlighting the need for methodical ergonomic implementation as opposed to just doing it. An additional demonstration of the complementary nature of ergonomics—its positive effects on both worker health and organisational efficiency—is the fact that the experimental group saw a rise in output at the same time.

5. CONCLUSION

The study validated a strong association of high ergonomic risk scores with reduced safety performance, musculoskeletal disorders (MSDs) and fatigue in industrial tasks. Pre-intervention results revealed that RULA and REBA scores were higher than usual, indicating critical issues, whilst post-intervention results revealed there were significant improvements. Structured ergonomic interventions were effective in managing the level of risk, injury and fatigue. The comparative analysis confirms the highly important role ergonomics has in the improvement of a worker's well-being and overall industrial safety.

6. FUTURE SCOPE

- **Assessment of Baseline Ergonomic Risk Levels:** Further studies could be conducted in other industrial jobs, like construction, agricultural, healthcare, and service jobs, to increase the generalizability of the results. Multi-site and large scale studies can contribute to the development of ergonomic benchmarks and standards to create safer workplaces across the industry.

- **Identification of Risk Factors for Musculoskeletal Disorders (MSDs):** To accurately and further identify ergonomic risk factors, advanced technologies can be used such as: wearable sensors, motion tracking systems, posture monitoring devices and AI-based ergonomic assessment tools. These can help prevent and early detect the onset of musculoskeletal disorders in workers.

- **Design and Implementation of Ergonomic Interventions**: Future studies can be directed towards the development of industry-specific ergonomic interventions combined with Industry 4.0, robotics and automation technologies. The inclusion of participatory ergonomics, which involves active involvement of employees in the design and implementation of interventions, can also improve the effectiveness and sustainability of ergonomic interventions.

- **Evaluation of Ergonomic Interventions through Comparative Analysis**: Long-term effectiveness and sustainability of ergonomic interventions can be assessed in different workplaces and organizational settings with longitudinal and comparative studies. Further research could also explore the transferability and adaptability of ergonomic enhancements to different industries and work environments.

Relationship between Ergonomic Improvements and Industrial Safety Performance: Further research is warranted to examine how other aspects of ergonomic enhancements affect industrial safety-related outcomes like injury frequency, employee attendance, productivity, employee health, and organizational results. Future studies on the economic impacts and return on investment (ROI) of ergonomic programs could reinforce the business case for implementing ergonomics in the workplace safety management system.

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