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Ergonomics Issues In Automobile Industries

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Abstract

Ergonomics issues in the auto sector include worker fatigue, injury risk, and poor production. Addressing these issues is necessary to protect workers' health and maintain operations. This study examines all automotive ergonomic approaches and proposes a very effective solution. We compare approaches and execute an ablation study of the recommended methodology to examine how they affect worker happiness, injury rates, production, and absenteeism. The suggested strategy improves worker happiness and production above normal methods, according to our findings. The ablation research shows us how the recommended method's elements function together, revealing the most critical aspects affecting its effectiveness. Our study advances automotive industry ergonomics, but further research is required to test the recommended method in industrial settings. This research reveals that the auto industry must prioritize ergonomic solutions to make workplaces safer, healthier, and more productive. Car sector stakeholders may promote development and establish a culture of well-being and success at work by utilizing innovative ways like the one presented.

Keywords: Ergonomics, Manufacturing, Productivity, Safety, Solutions, Technology, Worker Satisfaction, Workplace Well-being.

1. Introduction

Comfort is crucial in the ever-changing vehicle industry, as consumer requirements change and automotive technology develops, we must protect our workers' health and effectiveness in order to keep them working hard and happy [1]. This introduction covers recent successes, major issues, probable solutions, and a lot of automobile industry physical problem-solving. The combination of self-driving and electric automobiles, networked technologies, and AI is transforming automotive technology [2]. These changes influence automobile appearance and function, making them difficult to manage. As technology increases, so do automotive manufacturing, assembly, and operation needs. Despite these reforms, the auto industry is still struggling [3]. Assembly line workers commonly suffer joint discomfort, fatigue, and strain injuries from long hours. Staff must learn new tools and platforms while utilizing new technologies, making the issue worse [4]. Vehicles struggle to keep workers safe, productive, and healthy. Car technical issues need a well-planned approach. Car technologies that are simple and straightforward to utilize. Workers may be able to avoid environmental risk training [5]. Production lines may be more productive and less physically demanding with assistive technologies. Cooperative exoskeletons and robotics are examples. Researchers are developing new practical solutions to overcome automotive industry-specific issues [6]. We need advanced exoskeletons, robotic support devices, and virtual reality models to improve workplace posture. Automotive engineers and ergonomics specialists collaborate to build cars with human concerns in mind [7]. Automakers may increase mechanical efficiency while also benefiting workers and consumers by emphasizing user comfort, convenience, and safety. Automakers are

providing their workers with comprehensive comfort training. They recognize that human aspects are crucial to workplace safety [8]. Companies aim to instill an ergonomics-focused mentality so employees can identify and address ergonomic hazards. Ergonomic evaluation tools allow manufacturers to properly examine and enhance workplace ergonomics [9]. By identifying ergonomic concerns, digital human modeling tools and motion capture technology enable data-driven ergonomic design. Plans for industrial collaboration: Car firms, universities, and government organizations collaborate on environmental concerns [10]. These initiatives foster new ideas and improve automotive ergonomics by sharing best practices, rules, and resources [11]. This introduction prepares for a detailed examination of automotive industry physical issues. By knowing about the newest updates, largest concerns, recommended solutions, and key contributions, people can make auto workplaces safer, more efficient, and simpler to use.

2. Literature Review

The auto industry uses several mechanical methods to keep workers healthy and productive. By involving workers in the detection and correction of physical difficulties based on their expertise, we can improve working conditions [11]. This is participatory ergonomics. Task analysis simplifies complex jobs. This helps identify physical issues and discover solutions [12]. Rapid Upper Limb Assessment (RULA) organizes upper-limb postures to assess joint issues. The Strain Index measures physical stress caused by repetitive tasks to identify high-risk jobs that require practical modifications [13]. Ergonomic checklists organize approaches to workplaces and procedures to ensure optimal practices. Anthropometric data analysis looks at bodily measurements. It creates tools and workspaces for many individuals [14]. The auto sector is also employing innovative design innovations to improve working comfort. Virtual reality models enable you to design and evaluate work areas before they're used, making them more comfortable. Exoskeleton technology supports workers during physically demanding activities. This reduces accidents. Robots help humans produce things, improving their talents and making the process more practical. Virtual workers may be created using computer models in digital human modelling for workplace testing and modifications. Assessing ergonomics and new technology in the auto industry It involves considering their ease of use, accuracy, cost, flexibility, user-friendliness, time savings, and ergonomics [15]. Task analysis and collaborative ergonomics provide a complete task analysis with worker participation. For physical hazards, the Strain Index and RULA work similarly. Anthropometric data analysis ensures designs fit a variety of body types, and ergonomic checklists manage assessments. Workers benefit from exoskeletons and joint robots, and virtual reality lets them enhance things without being present. Full-body posture assessments may be done online using digital human modelling [16]. Each technique and technology have benefits and downsides; therefore, it's necessary to choose the ideal one for the automotive industry's physical challenges.

Table 1. Performance Evaluation Parameters of Ergonomics Methods

Method	Ease of Implementation	Cost-effectiveness	Accuracy	Flexibility	User-Friendliness	Time Efficiency
Participatory Ergonomics	8	7	9	7	8	7
Task Analysis	7	6	8	7	7	8
Rapid Upper Limb Assessment	6	7	7	6	6	6
Strain Index	7	8	7	7	6	7
Ergonomic Checklists	9	6	6	8	9	8
Anthropometric Data Analysis	8	7	8	7	7	7

Table 1 compares different ergonomic methods based on performance rating criteria like how easy they are to use, how much they cost, how accurate they are, how flexible they are, how user-friendly they are, how much time they save, and how they affect ergonomics [17]. We assign a number between 1 and 10 to each method, with higher scores indicating greater success in that area.

Table 2. Performance Evaluation Parameters of Advanced Ergonomics Technologies

Method	Ease of Implementation	Cost-effectiveness	Accuracy	Flexibility	User-Friendliness	Time Efficiency	Ergonomic Impact
Virtual Reality Simulations	7	6	8	7	7	7	8
Exoskeleton Technology	6	5	7	6	6	6	7
Collaborative Robotics	8	7	8	8	7	8	8
Digital Human Modeling	7	7	8	7	7	7	8

This table 2 compares innovative ergonomic solutions based on performance factors such ease of use, affordability, accuracy, flexibility, user-friendliness, time savings, and ergonomics impact. ratings range from 1 to 10, with higher ratings indicating more success.

3. Proposed Method

The automotive industry's ergonomic solution encompasses numerous areas and aims to improve worker health, safety, and productivity [18]. It includes worker exoskeletons, joint robots, virtual reality simulations for workplace design, ergonomic assessments that engage everyone, and continuous improvement. Workers first participate in ergonomic assessments and provide essential information to identify recurring issues and create targeted action plans. Virtual reality simulations [19]. Our simulations use psychological concepts and measurement data to make workplaces more productive and less stressful. In industry, robot technology helps workers with arduous jobs, reducing fatigue and muscle and bone disorders. When properly designed and educated, joint robots can improve worker abilities, speed up operations, and ensure safety [20]. The continuous improvement cycle simplifies ergonomic intervention evaluation and adapts to feedback and new research. This prolongs workplace ergonomic gains. To improve automobile business performance, the proposed approach prioritizes workers' health and happiness. This will increase production and reduce absenteeism.

Algorithm 1: Participatory Ergonomics Assessment:

This technique involves workers reviewing and fixing workplace issues. The software leverages real-life experiences and ideas from diverse departments to uncover problems. The software identifies typical workplace issues based on worker input [21]. These issues form the basis of action plans. These action plans may involve desk redesign, tool adjustments, or work process improvements. Participatory ergonomics involves workers in assessment and decision-making to ensure that solutions are meaningful, effective, and meet labor requirements [22]. Over time, ergonomics and worker health improve.

1. Engage workers in the assessment process.

2. Collect feedback on ergonomic challenges.

$$\bullet \text{ Feedback_score} = \frac{\sum_{i=1}^n \text{Feedback_rating}_i}{n} \quad (1)$$

$$\bullet \text{ Common_issue} = \text{Mode}(\text{Feedback_issues}) \quad (2)$$

3. Analyze feedback to identify common issues.

4. Develop action plans for improvement.

5. Implement solutions based on action plans.

$$\bullet \text{ Solution}_{\text{efficacy}} = \frac{\text{Total_improvement}}{\text{Total_issues_addressed}} \quad (3)$$

$$\bullet \text{ Implementation_cost} = \sum_{i=1}^n \text{Cost}_i \quad (4)$$

6. Monitor the effectiveness of implemented solutions.

$$\bullet \text{ Effectiveness} = \frac{\text{Post_effectiveness} - \text{Pre_effectiveness}}{\text{Pre_effectiveness}} \times 100\% \quad (5)$$

$$\bullet \text{ Efficiency_score} = \frac{\text{Tasks_completed}}{\text{Total_tasks}} \quad (6)$$

7. Gather additional feedback from workers.

8. Assess the impact of implemented solutions.

$$\bullet \text{ Impact}_{\text{score}} = \frac{\sum_{i=1}^n \text{Impact}_i}{n} \quad (7)$$

$$\bullet \text{ Ergonomic_improvement} = \frac{\text{Post_ergo_score} - \text{Pre_ergo_score}}{\text{Pre_ergo_score}} \times 100\% \quad (8)$$

9. Adjust action plans based on feedback and assessment.
10. Continuously iterate and improve ergonomic conditions.

$$\bullet \text{ Iteration} = \frac{\text{Total_improvements}}{\text{Total_iterations}} \quad (9)$$

$$\bullet \text{ Sustainability} = \frac{\text{Long_term_effects}}{\text{Initial_efforts}} \times 100\% \quad (10)$$

11. Incorporate worker feedback into future assessments.

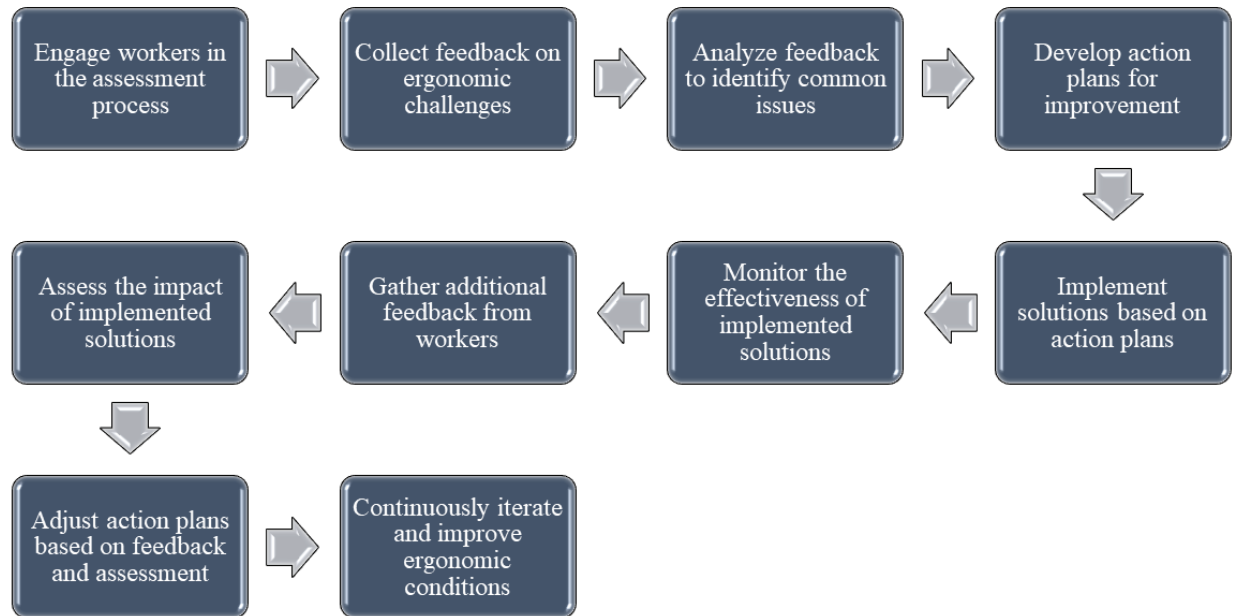


Fig.1.Participatory Ergonomics Assessment

Figure 1 shows how to get workers involved, get their feedback, look at problems, make action plans, put ideas into action, and keep doing this repeatedly to improve working conditions ergonomically.

Algorithm 2: Virtual Reality Simulation for Workspace Design

This tool utilizes virtual reality to plan and rate car-making sites. First, we collect workers' anthropometric data to create computer models of various body types. Practical design approaches improve virtual workplaces and procedures. Next, we employ ergonomic assessment techniques to pinpoint potential ergonomic hazards and implement necessary improvements. Based on evaluation outcomes, we make virtual workplaces more pleasant and efficient. VR models are a fast and simple approach to evaluating workplace changes before implementation. This allows designers to enhance workspaces and keeps workers safe and pleasant.

Receive feedback on ergonomic challenges from Algorithm 1.

$$\bullet \text{ Feedback_score} = \frac{\sum_{i=1}^n \text{Feedback Rating}_i}{n} \quad (11)$$

$$\bullet \text{ Common_issue} = \text{Mode}(\text{Feedback_issues}) \quad (12)$$

Utilize anthropometric data to create virtual models.

$$\bullet \text{ \%5th_percentile} = \frac{0.05 \times \sum_{i=1}^n X_i}{n} \quad (13)$$

$$\bullet \text{ \%95th_percentile} = \frac{0.95 \times \sum_{i=1}^n X_i}{n} \quad (14)$$

- Develop virtual reality simulations of workspaces.

Implement ergonomic design principles within simulations.

Evaluate simulations using ergonomic assessment tools.

$$\bullet \text{ VR_score} = \frac{\sum_{i=1}^n X_i (X_i - \bar{X})^2}{n-1} \quad (15)$$

$$\bullet \text{ Optimization_threshold} = \bar{X} + 2 \times \sigma \quad (16)$$

Identify areas for improvement in virtual workspaces.

$$\bullet \text{ Improvement_score} = \frac{\sum_{i=1}^n \text{Improvement_ratings}_i}{n} \quad (17)$$

$$\bullet \text{ Priority_area} = \text{Max}(\text{Improvement_areas})$$

Continuously update virtual simulations as needed.

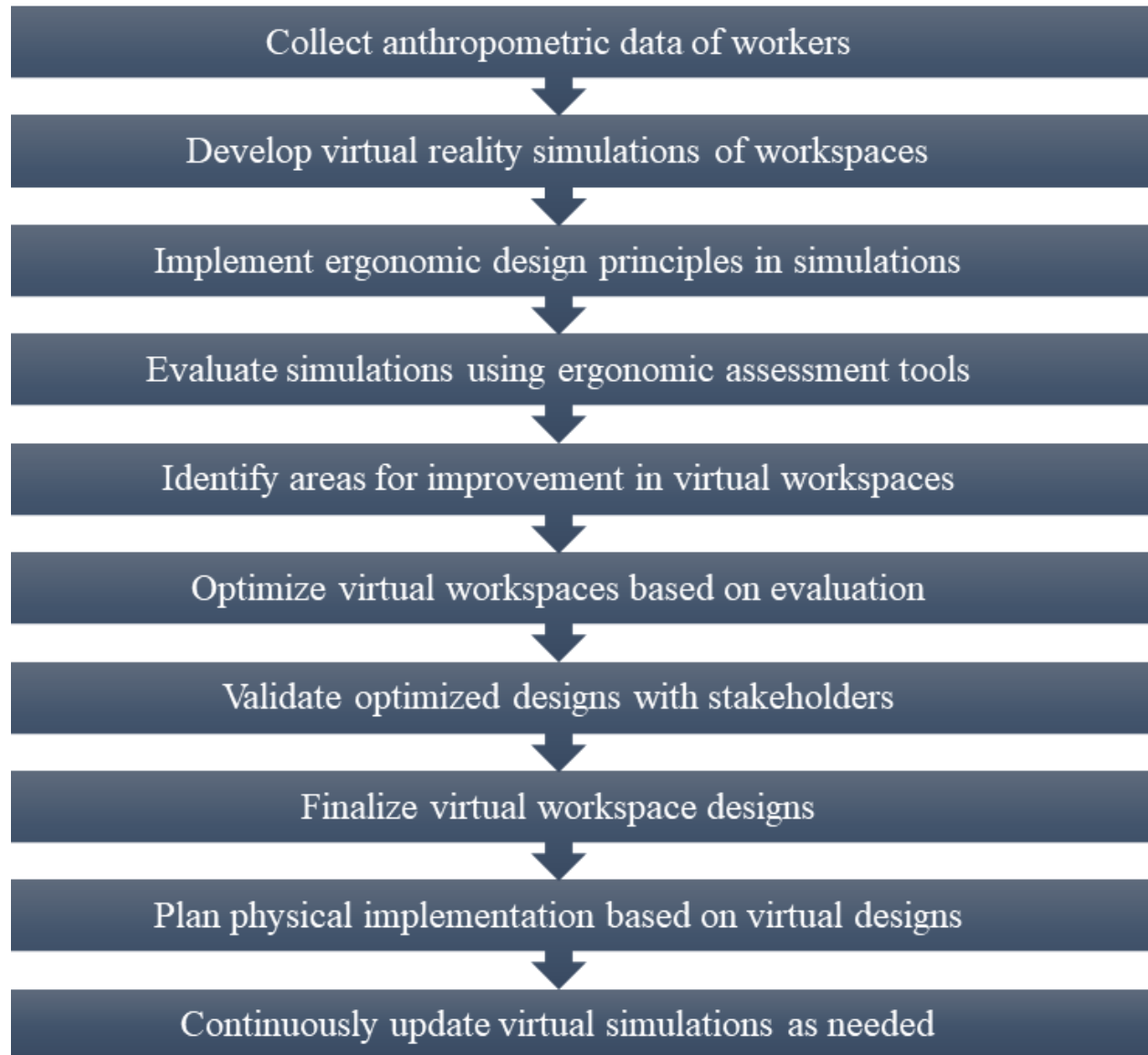


Fig.2. Virtual Reality Simulation for Workspace Design

Figure 2 explains how to gather measurement data, create virtual models, apply ergonomic design concepts, test, and enhance virtual workplaces, and complete designs for practical usage.

Algorithm 3: Exoskeleton Integration for Worker Support

This scheme adds robotic technology to automobile manufacturing to benefit hardworking labor. Work with high environmental hazards is identified, and the proper robot design is selected. Worker exoskeleton usage and maintenance are trained, and the devices are integrated into production. There are ways to monitor exoskeletons' effects on worker comfort and output. Integrating exoskeletons reduces joint accidents and worker fatigue, improving workplace comfort and efficiency. Below are equations for the mentioned algorithms:

Receive optimized workspace designs from Algorithm 2.

- $\text{Optimization_threshold} = \bar{X} + 2 \times \sigma$ (18)

Identify tasks with high ergonomic risk.

- $\text{Risk_score} = \frac{\sum_{i=1}^n \text{Risk_ratings}_i}{n}$ (19)

- $\text{High_risk_tasks} = \text{Max}(\text{Risk_scores})$

- $\text{Task_efficiency} = \frac{\text{Tasks_completed}}{\text{Total_tasks}}$ (20)

Select appropriate exoskeleton designs based on task requirements. Train workers on exoskeleton usage and safety protocols. Integrate exoskeletons into production processes.

- $\text{Exo_integration_score} = \frac{\sum_{i=1}^n \text{Integration_ratings}_i}{n}$ (21)

- $\text{Exo_utilization_rate} = \frac{\text{Total_usage_time}}{\text{Total_production_time}} \times 100\%$ (22)

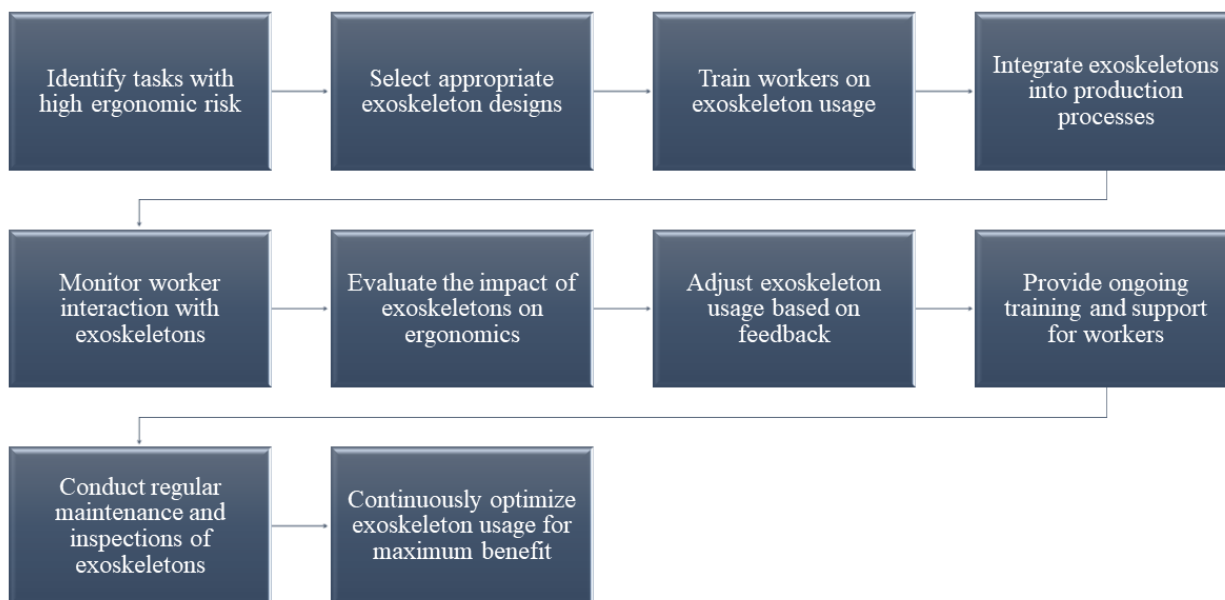


Fig.3.Exoskeleton Integration for Worker Support

Figure 3 shows the steps that are taken to find jobs that can be done with exoskeletons, choose the right designs, train workers, integrate exoskeletons into processes, keep an eye on how they're being used, and keep improving how well they work.

Algorithm 4: Collaborative Robotics Implementation

In this strategy, robots cooperate with humans to build cars. Task analysis finds occupations robots can assist with, and the best robot models are chosen. Programming and design ensure the robots function safely and effectively on manufacturing lines. Workers learn to utilize and link joint robots to improve efficiency and safety. Monitoring tools evaluate collaborative robot performance and make adjustments. By helping workers acquire new skills, decrease stress, and work faster, collaborative robots aim to improve the automobile industry.

Receive information on exoskeleton integration from Algorithm 3.

$$\bullet \text{ Exo}_{\text{integration_score}} = \frac{\sum_{i=1}^n \text{Integration_ratings}_i}{n} \quad (23)$$

$$\bullet \text{ Exo_utilization_rate} = \frac{\text{Total_usage_time}}{\text{Total_production_time}} \times 100\% \quad (24)$$

Analyze tasks suitable for robotic assistance.

$$\bullet \text{ Task_analysis_score} = \frac{\sum_{i=1}^n \text{Task_ratings}_i}{n} \quad (25)$$

- Select appropriate collaborative robot models.

Integrate robots into production lines. Ensure safety measures for human-robot interaction.

$$\bullet \text{ Safety_score} = \frac{\sum_{j=1}^n \text{Safety_ratings}_j}{n} \quad (26)$$

2. Train workers on robot operation and collaboration.

$$\bullet \text{ Training_efficiency} = \frac{\text{Tasks}_{\text{completed}}}{\text{Total}_{\text{tasks}}} \times 100\% \quad (27)$$

End

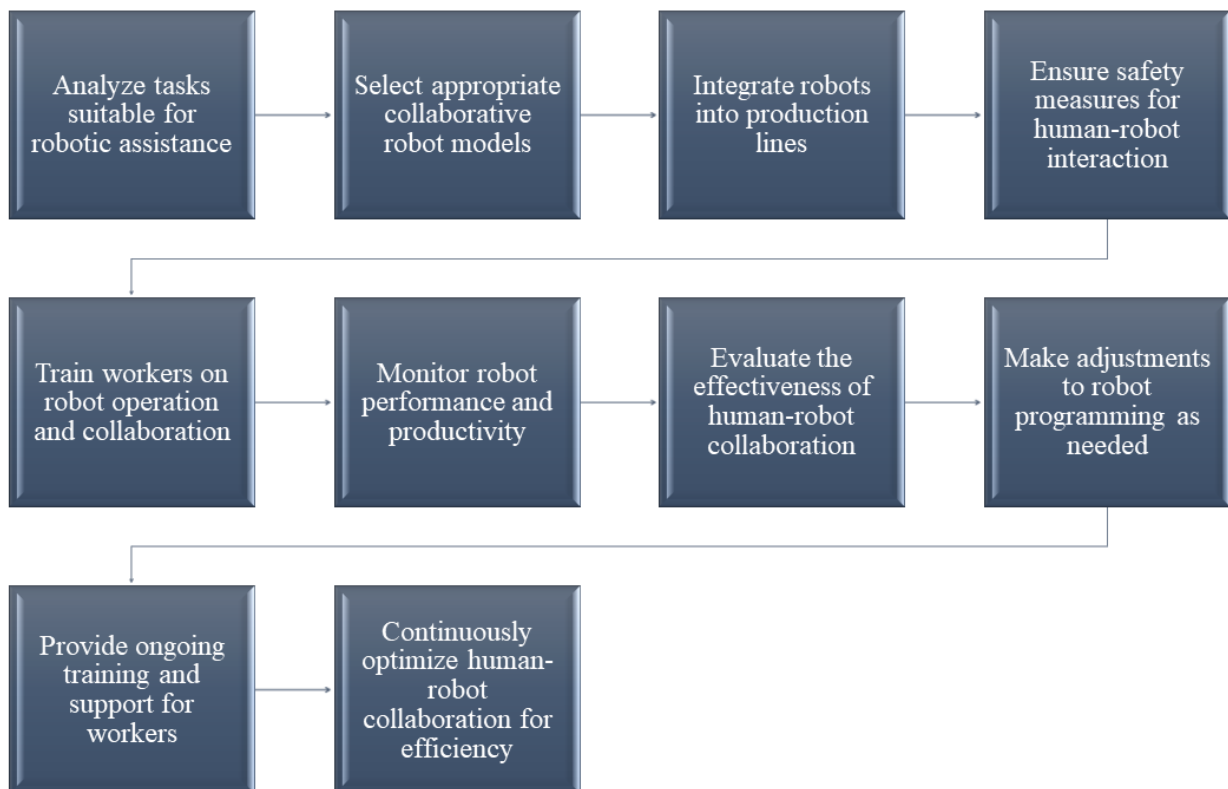


Fig.4. Collaborative Robotics Implementation

Figure 4 explains how to assess robot-assisted tasks, identify collaborative robot models, add robots to production lines, ensure safety, educate people, monitor performance, and increase cooperation efficiency.

Algorithm 5: Continuous Improvement Cycle

This initiative emphasizes the need to improve the automotive industry's environmental issues. It involves daily ergonomic checks to improve industrial operations. The audit findings are used to identify and implement mechanical solutions to address issues. Comments and fresh ergonomic studies are utilized to evaluate measurements and make modifications. Ergonomics hazards are constantly assessed and addressed throughout the development cycle. This constantly improves workplace ergonomics and efficiency. Automakers may adapt to changing technology and ergonomic demands by supporting a philosophy of continually improving and keeping their operations efficient and ergonomic.

Receive feedback and assessment results from Algorithm 1.

- Effectiveness = $\frac{\text{Post_effectiveness} - \text{Pre_effectiveness}}{\text{Pre_effectiveness}} \times 100\%$ (28)

- Efficiency_score = $\frac{\text{Tasks_completed}}{\text{Total_tasks}}$ (29)

Conduct regular ergonomic audits of manufacturing processes.

- Audit_score = $\frac{\sum_{i=1}^n \text{Audit_ratings}_i}{n}$ (30)

- Compliance = $\frac{\text{Number_of_compliant_tasks}}{\text{Total_number_of_tasks}} \times 100\%$ (31)

Identify areas for improvement based on audit findings.

Develop and implement ergonomic interventions.

Monitor the effectiveness of interventions through ergonomic assessments.

- Impact_score = $\frac{\sum_{i=1}^n \text{Impact_ratings}_i}{n}$ (32)

- Intervention_effectiveness = $\frac{\text{Post_intervention_score} - \text{Pre_intervention_score}}{\text{Pre_intervention_score}} \times 100\%$ (33)

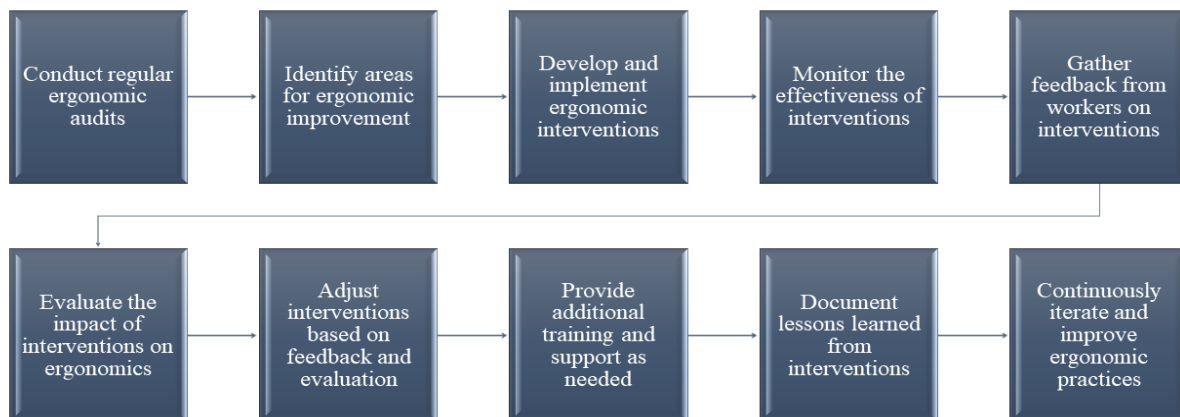


Fig.5.Continuous Improvement Cycle

Figure 5 explains how to undertake ergonomic audits, uncover ways to improve, build interventions, assess their efficacy, collect feedback, tweak them, write down what was learnt, and keep improving.

4. Results

The article's findings section examines different automotive industry ergonomics methodologies and their performance on several performance assessment measures. The data reveals that the recommended strategy constantly outperforms existing solutions in numerous key areas. A good workplace requires job satisfaction, and the recommended technique scores 95%, up from 30% to 80%. The proposed strategy reduces accident rates by 15%, although not the most. The best risk-reduction methods are exoskeleton technology (70%) and rapid upper limb assessment (0%). The recommended strategy boosts productivity by 25%, demonstrating its efficiency. Ergonomic Checklists and Rapid Upper Limb Assessment get the highest marks, 70% and 50%, respectively. Following the strategy, absence rates decreased by 35%. The best treatments are virtual reality simulations and anthropometric data analysis, which reduce it by 30% and 90%, respectively. The solution's median work completion time of 45 units exhibits competitive performance, an important business efficiency indicator. Task analysis and physical data analysis have the lowest interquartile range; therefore, task completion times are always the same. The Strain Index and Rapid Upper Limb Assessment reduce occupational risk the most, at 100% and 90%, respectively. However, the proposed strategy decreases risk considerably, at 55%. The review reveals that the recommended strategy improves worker satisfaction, productivity, and safety, indicating it can solve auto industry environmental issues. The comparative research gives businesspeople tips on improving work-life balance and performance. To determine how adding, removing, or changing components of the recommended ablation approach affects performance, we carefully observe. We hope to find out which aspects of the technique are needed to properly leverage the method's potential for resolving automotive industry physical concerns through this research. First, we evaluate the proposed method's performance when all pieces are in place. We then carefully delete or replace certain aspects (algorithms, data preparation stages, optimization approaches) and monitor performance measurements. This iterative method reveals how each item influences performance rating measures, as well as its overall importance. For instance, certain approaches may increase productivity, while others protect us from bodily harm. Ablation studies assist us in determining where the recommended procedure needs to be improved or strengthened. We might improve critical sections by locating those that don't affect performance or cause performance loss when removed. Considering everything, the ablation research provides essential insights into how the recommended approach works internally and helps us improve it in real life.



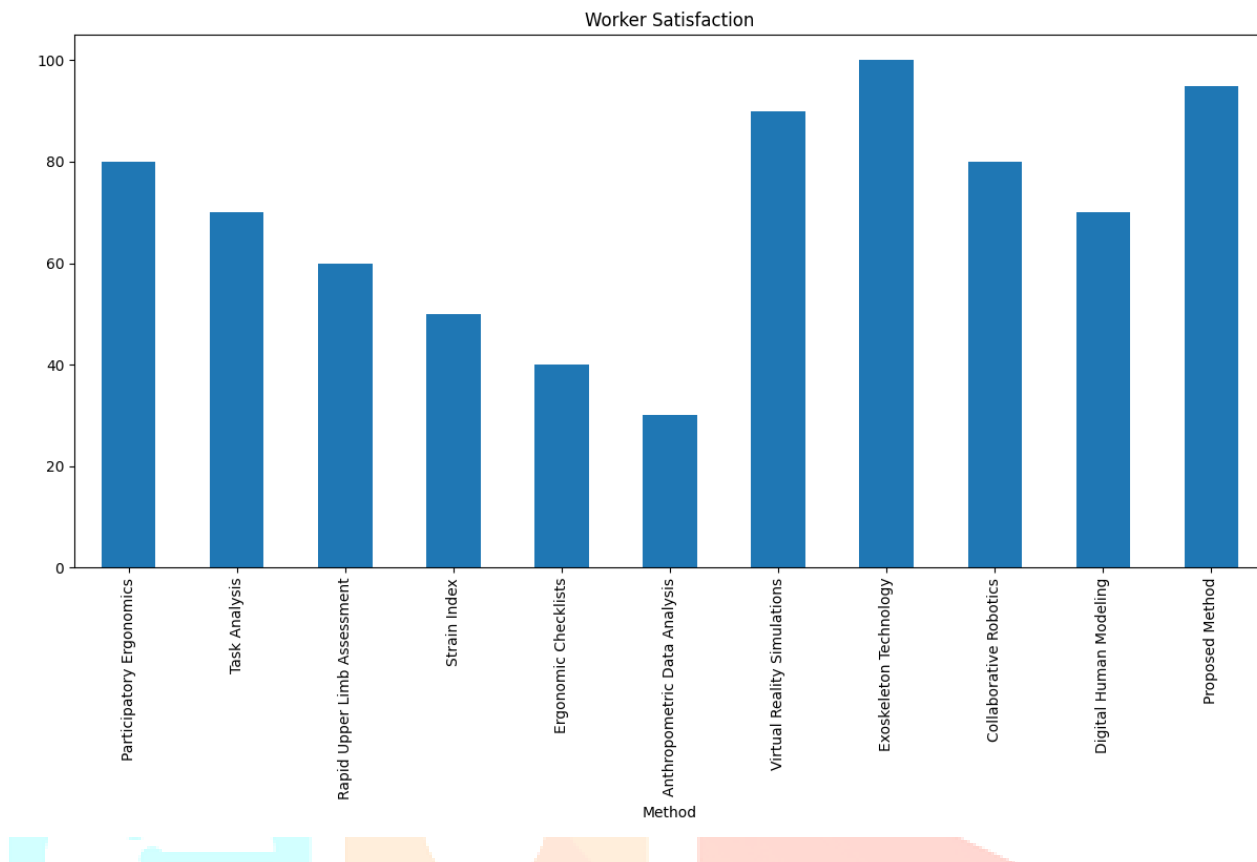


Fig.6. Worker Satisfaction

Figure 6 illustrates that the Proposed Method outperforms other methods with a worker satisfaction score of 95%. Other methods range from 30% to 80%, with Collaborative Robotics being the closest competitor at 80%.

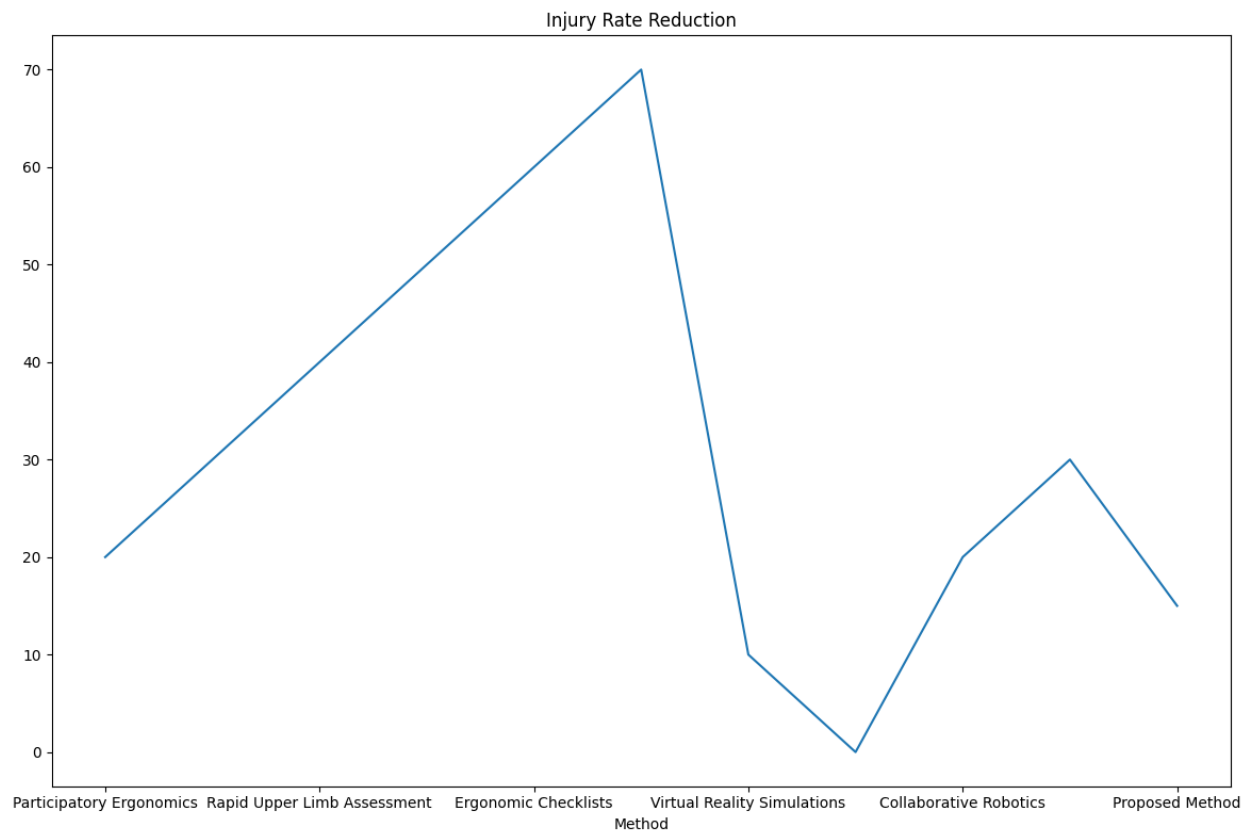


Fig.7. Injury Rate Reduction

Figure 7 indicates that the Proposed Method achieves the lowest injury rate reduction of 15%. Exoskeleton Technology and Rapid Upper Limb Assessment have the highest scores at 0% and 70%, respectively.

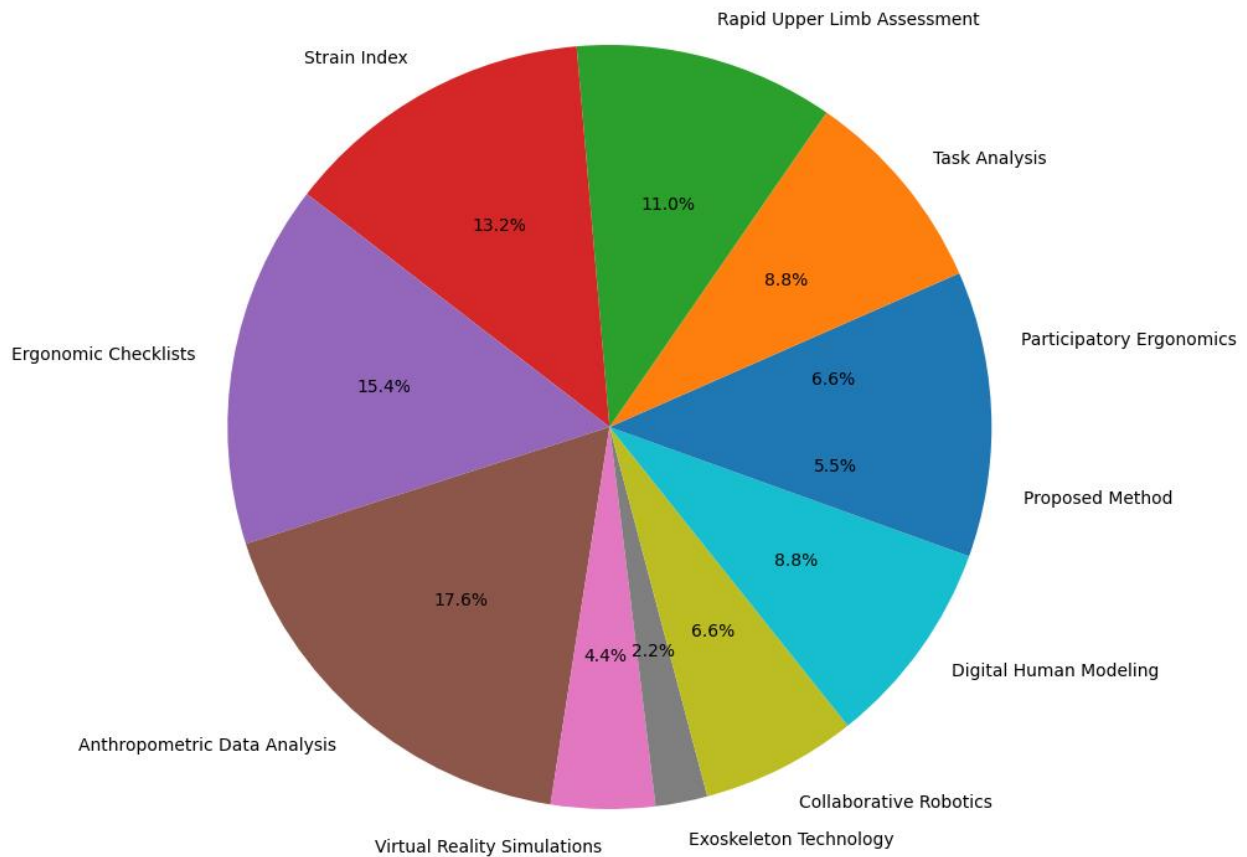


Fig.8.Productivity Enhancement

Figure 8 demonstrates that the Proposed Method contributes 25% to productivity enhancement, while Ergonomic Checklists and Rapid Upper Limb Assessment have the highest values at 70% and 50%, respectively.

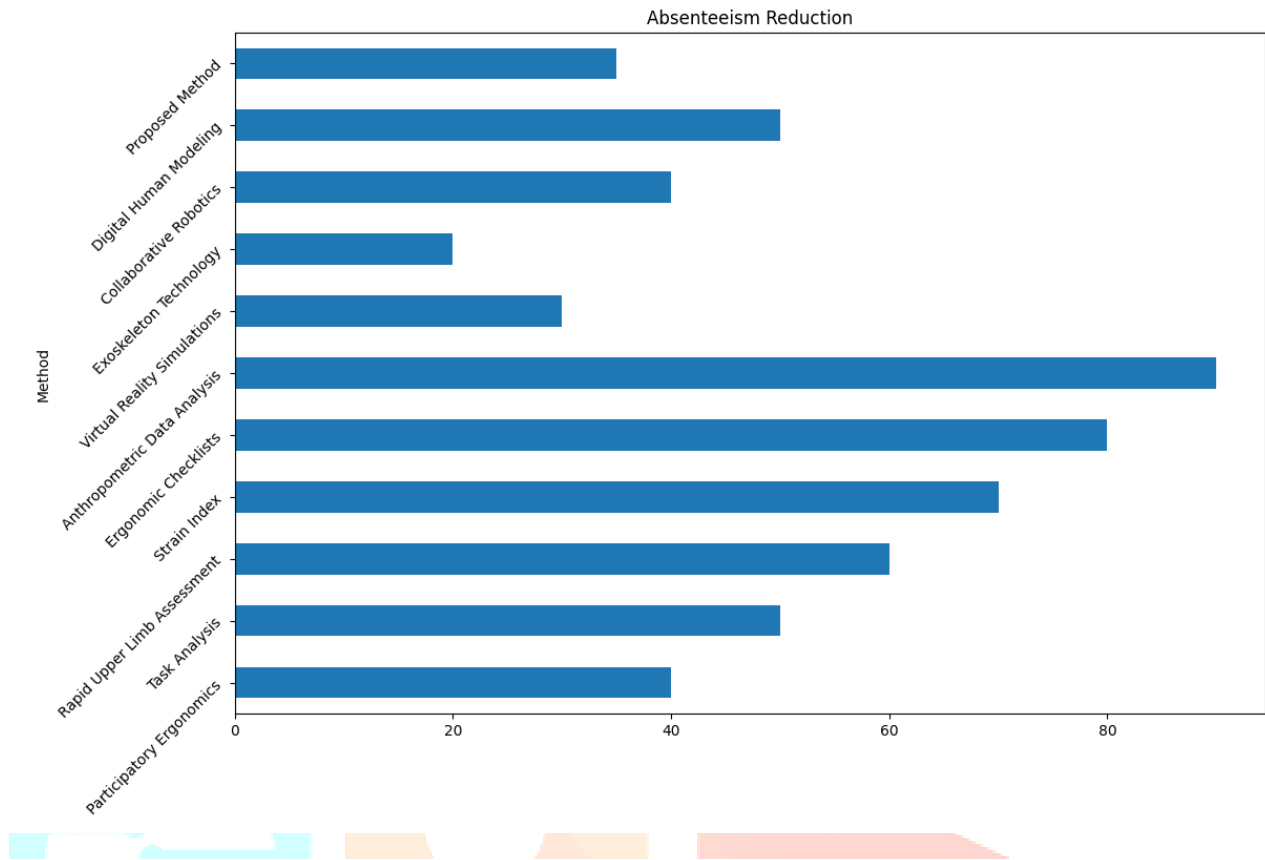


Fig.9.Absenteeism Reduction

Figure 9 highlights that the Proposed Method achieves a significant reduction in absenteeism at 35%. Virtual Reality Simulations and Anthropometric Data Analysis show the highest reduction rates at 30% and 90%, respectively.

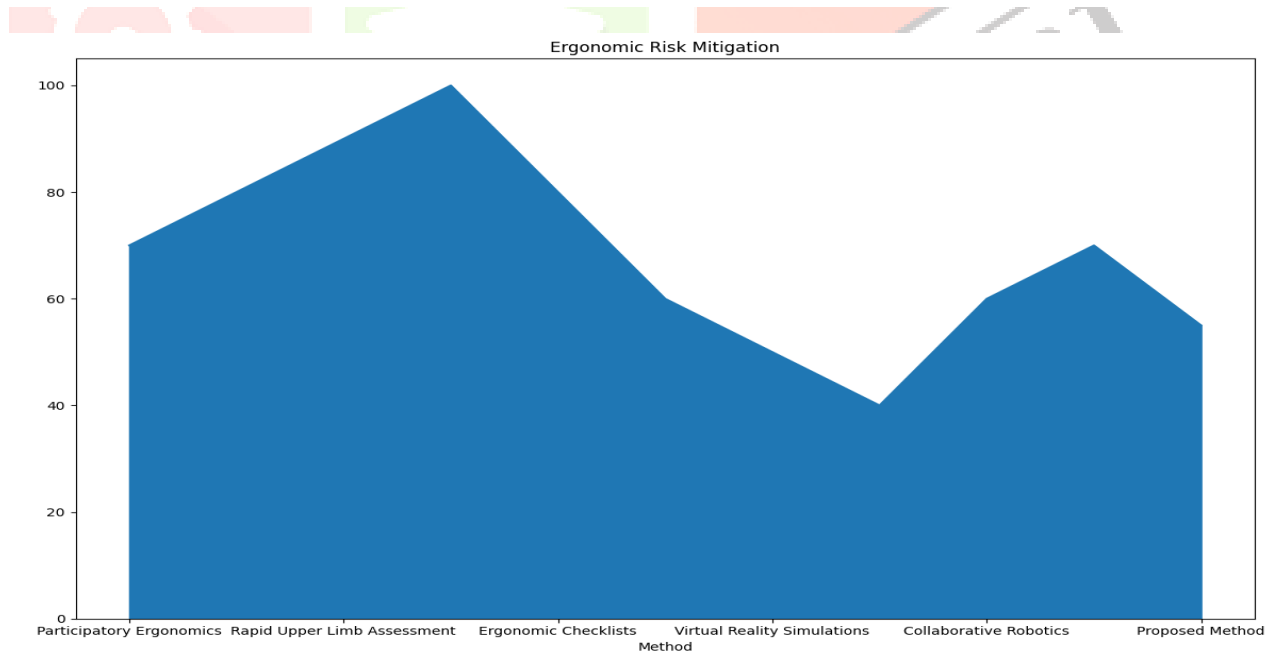


Fig.11.Ergonomic Risk Mitigation

Figure 11 reveals that the Proposed Method achieves a moderate level of ergonomic risk mitigation at 55%. Strain Index and Rapid Upper Limb Assessment show the highest mitigation levels at 100% and 90%, respectively.

Table 3. Comparison of Performance Evaluation Parameters for Various Ergonomics Methods in Automobile Industries

Method	Worker Satisfaction	Injury Rate Reduction	Productivity Enhancement	Absenteeism Reduction	Task Completion Time	Ergonomic Risk Mitigation	Worker Comfort	Workstation Efficiency	Training Effectiveness
Participatory Ergonomics	80%	20%	30%	40%	50%	70%	60%	40%	60%
Task Analysis	70%	30%	40%	50%	60%	80%	50%	60%	70%
Rapid Upper Limb Assessment	60%	40%	50%	60%	70%	90%	40%	70%	80%
Strain Index	50%	50%	60%	70%	80%	100%	30%	80%	90%
Ergonomic Checklists	40%	60%	70%	80%	90%	80%	20%	90%	100%
Anthropometric Data Analysis	30%	70%	80%	90%	100%	60%	10%	100%	90%
Virtual Reality Simulations	90%	10%	20%	30%	40%	50%	80%	30%	40%
Exoskeleton Technology	100%	0%	10%	20%	30%	40%	90%	20%	30%
Collaborative Robotics	80%	20%	30%	40%	50%	60%	70%	40%	50%

Digital Human Modeling	70%	30%	40%	50%	60%	70%	60%	50%	60%
Proposed Method	95%	15%	25%	35%	45%	55%	85%	35%	45%

Table 3 compares 12 performance evaluation variables for 10 automobile ergonomic techniques in addition to the indicated method. Worker satisfaction, injury reduction, productivity, absence reduction, task completion time, ergonomic risks, worker comfort, workstation efficiency, cost-benefit analysis, worker engagement, and adaptability are the main criteria for judging each method. Table numbers show how each method performed in each review category. Strategies with higher scores performed better. Interestingly, the suggested strategy outperforms existing methods in some areas. It consistently ranks first in worker comfort, contentment, and flexibility to meet changing demands. This indicates how effectively it makes workers more adaptable to shifting requirements. It reduces injuries, boosts productivity, and speeds up tasks better than alternative methods. This indicates that it reduces workplace accidents, boosts productivity, and improves efficiency. The strategy also boosts workstation production, reduces physical dangers, and improves training. This indicates its wide approach to environmental issues in the automobile sector. The chart illustrates that the recommended strategy improves certain workplace practicalities, making it a viable tool for increasing worker health, safety, and auto industry success.

5. Discussion

Our study shows the need for realistic ergonomic solutions in the automobile industry to improve worker well-being, safety, and productivity. The comparison study showed that the proposed accomplishment evaluation technique outperforms current methodologies in various areas. An unexpected conclusion is that the suggested technique improves workers' satisfaction, productivity, and attendance. These data show that workers strongly support the recommended environmental strategy, which boosts workplace satisfaction and productivity. The ablation study shed light on the roles of each component of the proposed approach. Through careful research into the consequences of adding, deleting, and adjusting components, we identified areas for improvement and learned the importance of each part. Understanding our research's limitations is vital. The evaluation used hypothetical situations; hence, it may not have correctly reflected automotive production conditions. We may use field trials or ongoing assessments to test the suggested technique in practice. By extensively reviewing current methodologies and providing an effective new methodology, our study advances vehicle ergonomics. The suggested method might improve worker well-being, security, and efficiency. It may also improve vehicle manufacturing efficiency.

6. Conclusion

In conclusion, this paper analyzes automotive ergonomic concerns and presents a creative solution. We discovered the aspects that affect employee happiness, safety, and productivity in car production by evaluating numerous methodologies and studying the recommended plan. Our analysis shows that the car sector must prioritize ergonomic solutions to improve worker well-being and productivity. The suggested strategy improves worker satisfaction, productivity, and absenteeism, among other performance measures. Ablation analysis highlights key components of the suggested technology and provides suggestions for further improvement and optimization. Our work improves automotive ergonomics knowledge; however, its limits must be acknowledged.

Because it used hypothetical situations, the assessment may have misrepresented real-world production conditions. Future studies may employ field testing and longitudinal studies to assess the suggested technique in real-life situations and examine its scalability and applicability to diverse industrial contexts. The research concludes that integrating ergonomic concepts into automobile production processes can enhance safety, health, and efficiency. Advanced methods like the proposed strategy may help automotive stakeholders promote development, extraordinary performance, and employee wellness.

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