Jurnal Serambi Engineering JSE
Volume XI, No.4, Oktober 2026 Hal 21658 - 21664
p-ISSN : 2528-3561
e-ISSN : 2541-1934

Analysis of The Working Postures of Operators Performing Tire Gluing and Cushion Gum Installation Using The Wera Method at CV Rapi Vulkanisir

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Received: November 6, 2026 Approved: November 11, 2026

Abstract
CV Rapi Vulkanisir is a tire recycling company whose production process includes tire gluing and cushion gum installation. This process is still carried out manually using a conventional tire-hanging device, so operators must lift and rotate the tire manually to reach its entire surface. These conditions require operators to work in stooping and squatting postures, which may trigger the risk of musculoskeletal disorders. This study aims to identify the dominant work-posture factors, assess the level of work-posture risk by applying the Workplace Ergonomic Risk Assessment (WERA) method, and develop recommendations for improving the work facilities. The study was conducted on two operators engaged in tire gluing and cushion gum installation. The initial evaluation results showed that the bending and squatting postures were in the medium and high risk category. The proposed improvement was carried out by redesigning the tire-hanging device based on anthropometric data and equipping it with an independent roller system, allowing each tire to be rotated individually without being lifted. The improved WERA score was successfully reduced to the low-risk category, demonstrating that redesigning the tire-hanging device is effective in improving operators' working postures and reducing ergonomic risks.
Keywords: *ergonomics, work posture, wera, msds, cushion gum*

Abstrak
CV Rapi Vulkanisir merupakan perusahaan daur ulang ban yang salah satu proses produksinya meliputi pengeleman ban dan pemasangan *cushion gum*. Proses tersebut masih dilakukan secara manual dengan menggunakan alat gantung konvensional, sehingga operator harus mengangkat dan memutar ban secara manual untuk menjangkau seluruh permukaan. Kondisi ini mengharuskan operator bekerja dengan postur membungkuk dan jongkok yang berpotensi memicu risiko gangguan muskuloskeletal. Penelitian ini bertujuan untuk mengidentifikasi faktor postur kerja yang dominan, menilai tingkat risiko postur kerja dengan menerapkan metode *Workplace Ergonomic Risk Assessment* (WERA), serta menyusun rekomendasi perbaikan terhadap fasilitas kerja. Penelitian dilakukan terhadap dua orang operator pemasangan lem ban dan cushion gum. Hasil evaluasi awal menunjukkan bahwa postur membungkuk dan jongkok berada pada kategori *medium* dan *high*. Usulan perbaikan dilakukan dengan melakukan *redesign* alat gantung ban yang disesuaikan dengan data antropometri serta dilengkapi sistem *roller* independen agar ban dapat diputar secara individual tanpa perlu diangkat. Hasil perbaikan skor WERA berhasil diturunkan menjadi kategori *low*, ini membuktikan bahwa perancangan ulang alat gantung ban efektif dalam memperbaiki postur kerja dan menurunkan risiko ergonomi operator.
Kata Kunci: *ergonomi, postur kerja, wera, msds, cushion gum*

1. Introduction

Human resources play an important role in sustaining production processes in an industry. Therefore, companies need to pay attention to working conditions and workers' body postures to ensure that production activities can be carried out optimally. One aspect that needs to be considered is the application of ergonomics, which is the science that studies the interaction between humans, work, equipment, and the working environment to create safe, comfortable, healthy, and efficient working conditions [1]. The proper application of ergonomics also aims to improve workers' well-being, reduce the risk of injury, and support work productivity [2].

In industrial activities, the workload imposed on workers must be adjusted to their physical and mental capabilities to achieve a balance between job demands and workers' capacities [3]. A workload that is not appropriate for workers' capabilities can cause fatigue and reduce productivity. Research [4]

explain that workload refers to the comparison between workers capabilities and the demands of the tasks they are required to complete. One of the consequences of working conditions that do not comply with ergonomic principles is the occurrence of Musculoskeletal Disorders (MSDs), which are disorders or complaints affecting the musculoskeletal system that can range from mild to severe [5]. These complaints may develop due to prolonged physical loading, excessive muscle use, and repetitive movements [6].

The risk of MSDs can be influenced by several factors, such as age, gender, physical activity, and exposure to inappropriate ergonomic conditions, including awkward body postures, repetitive movements, and excessive force exertion [7]. Symptoms that may occur include pain, fatigue, swelling, limited range of motion, stiffness, tingling, and muscle weakness [8]. One factor closely associated with the occurrence of these complaints is working posture. Working posture refers to the position or alignment of a worker's body while performing work activities. Postures that comply with ergonomic principles can reduce muscle strain and the risk of injury, whereas awkward postures can accelerate fatigue and increase the risk of musculoskeletal disorders [9]. Therefore, working posture assessment is necessary to identify potential risks and determine appropriate corrective actions.

One method that can be used to assess ergonomic risks is the Workplace Ergonomic Risk Assessment (WERA) method. WERA is an ergonomic risk assessment method used to identify exposure to physical risk factors that may contribute to the occurrence of MSDs among workers [10]. WERA assessment covers nine factors, namely shoulder, wrist, back, neck, leg, force, vibration, contact stress, and task duration. The assessment results are classified into three risk categories: low, medium, and high. These categories can be used as a basis for determining the need for improvements in work activities [11]. The use of this method is expected to help identify body parts and work-related factors that contribute most significantly to ergonomic risks.

Working posture problems have also been identified at CV Rapi Vulkanisir, a company engaged in the recycling of used tires. One of its production processes involves tire gluing and cushion gum installation, which are carried out manually using a conventional tire hanging rack. The equipment is not yet equipped with a roller system that allows each tire to be rotated independently. Consequently, operators must manually lift and rotate the tires to reach their entire surface. These activities require operators to work in bent and squatting positions, particularly when reaching the lower part of the tire. In addition, operators must maintain certain body positions while holding a brush and a can of adhesive throughout the work process. These conditions have the potential to increase the physical load on the back, shoulders, wrists, and legs, thereby increasing the risk of musculoskeletal disorders (MSDs). Based on preliminary interviews, tire gluing and cushion gum installation are activities associated with relatively high levels of MSDs complaints; therefore, an evaluation of the operators' working postures is necessary.

Previous research conducted by [12] showed that the WERA method can be used to identify ergonomic risks and serve as a basis for designing more ergonomic work facilities. Improvements to work facilities in that study successfully reduced the risk level from medium to low. Research by [5] also showed that work activities involving less ergonomic postures can lead to MSDs risks, making corrective actions necessary. Furthermore, [13] found that bent postures, repetitive movements, excessive force exertion, and long working durations are factors that contribute to workers' ergonomic risks. Based on these studies, working posture assessment using WERA and improvements to work facilities are approaches that can be applied to reduce ergonomic risks in production activities.

Efforts to improve work facilities need to consider workers' body dimensions to ensure that the resulting design meets users' needs. Anthropometry is the science that studies the measurement of human body dimensions and physical characteristics, which are used as a basis for designing products and work facilities [14]. The use of anthropometric data aims to produce designs that correspond to workers' body dimensions, thereby improving comfort and safety during work [15]. In its application, percentile selection must be adjusted to the function and dimensions of the designed facility so that it can properly accommodate users' body sizes.

Based on these problems, this study was conducted to analyze the working postures of two operators performing tire gluing and cushion gum installation activities at CV Rapi Vulkanisir using the WERA method. This study aims to identify the most dominant ergonomic factor contributing to MSDs risks, determine the level of risk associated with the operators' working postures, and propose improvements to work facilities based on ergonomic assessment results and workers' anthropometric data. The proposed improvement involves redesigning the tire hanging rack by adding an independent roller system so that each tire can be rotated individually without having to be lifted manually. Through this improvement, operators' working postures are expected to become more ergonomic, thereby minimizing the risk of MSDs.

2. Materials and Methods

This study employed a quantitative descriptive approach with a cross-sectional design to assess ergonomic risks among workers at CV Rapi Vulkanisir, particularly operators involved in tire gluing and cushion gum installation. This approach also aimed to identify musculoskeletal disorders and various ergonomic risk factors arising from mismatches between workers and work facilities. These factors included work methods, body posture, the use of work equipment, and lifting activities during the production process.

2.1 Research Location and Object

This research was conducted at CV Rapi Vulkanisir, located in Cot Sereuni, Krueng Mane, Muara Batu District, North Aceh. The company operates in the field of used-tire recycling, with a production process that still involves manual work, particularly in the activities of applying tire adhesive and installing cushion gum. The research object focused on two operators who carried out this process, especially the bent, squatting, and standing work postures, as well as the activities of lifting and rotating tires manually. This research was conducted to analyze ergonomic risks using the Workplace Ergonomic Risk Assessment (WERA) method and to formulate recommendations for improving work assistance equipment based on the results of posture assessment and anthropometric measurements.

2.2 Research Method

This study used the WERA method to analyze the work postures of workers in the tire adhesive application and cushion gum installation section at CV Rapi Vulkanisir, and then proposed a design improvement for work facilities based on the workers' anthropometric data.

2.3 Data Sources

The data used consisted of primary and secondary data. The primary data in this study included workers' personal data, documentation of workers' activities, and interviews with parties relevant to the research at CV Rapi Vulkanisir. The secondary data in this study consisted of the company profile, books, and journals.

2.4 Data Collection and Analysis Techniques

Data collection in this study was carried out using several techniques, namely observation, interviews, documentation, questionnaire administration, and literature study. The operational variables examined in this study included working posture, force, vibration, *contact stress*, and task duration. Data analysis in this study was conducted using the WERA method to assess ergonomic risks among two operators performing tasks in standing, stooping, and squatting postures. The assessment was based on body posture, repetitive movements, force, vibration, contact stress, and task duration. In addition, anthropometric measurements were taken for the following body dimensions: body height (TB), standing shoulder height (TH), hand reach (JT), and standing elbow height (TS), which served as the basis for designing the work facility.

3. Results and Discussion

3.1 Recapitulation of the WERA Assessment

The production flow at CV Rapi Vulkanisir consists of tire inspection, buffing, gluing and cushion gum installation, tread liner installation, enveloping, and vulcanization followed by finishing. Because most of these stages rely on manual handling, the gluing stage poses the greatest physical demand: operators must bend or squat while holding a brush and an adhesive can, and must repeatedly lift each tire to bring its lower section upward. This repeated lifting adds force exertion on top of the postural load, particularly on the back, wrists, and legs. Based on observations at CV Rapi Vulkanisir, the tire hanging rack used in the tire gluing and *cushion gum* installation processes still employs a conventional structure without an independent roller system. Consequently, operators must manually lift the tires to change their positions so that the entire tire surface can be reached. This condition makes the work process less efficient and potentially leads to non-ergonomic working postures. The actual condition of the tire hanging rack before redesign is shown in **Figure 1**.



Fig. 1: Tire Hanging Rack Before Redesign

The ergonomic risk assessment was conducted using the WERA method by evaluating nine ergonomic risk factors, namely the shoulder, wrist, back, neck, legs, force, vibration, contact stress, and duration of work. Work posture observations were carried out on two operators during the activities of applying tire adhesive and installing cushion gum at CV Rapi Vulkanisir. The observations included the standing, bending, and squatting work postures performed by the operators throughout the work process. Documentation of the actual work postures of both operators is presented in the figure below.



Fig. 2: (a) Standing Work Posture of Operator 1, (b) Bent Working Posture of Operator 1, (c) Squatting Working Posture of Operator 1, (d) Standing Work Posture of Operator 2, (e) Bent Working Posture of Operator 2, (f) Squatting Working Posture of Operator 2

The results of the data processing for the tire gluing and cushion gum installation activities performed by operators at CV Rapi Vulkanisir using the WERA method are presented in **Table 1**.

Table 1. WERA Assessment Summary

Operator	Working Posture	Score
1	Standing	23
	Stooping	45
	Squatting	43
2	Standing	23
	Stooping	46
	Squatting	45

Based on the WERA assessment, the tire gluing and cushion gum installation activities were classified as having a *medium* risk level in the stooped and squatting postures, while the standing posture was classified as *low* risk. The risk of MSDs was primarily associated with the wrist, back, legs, and *contact stress*, each of which had a score of > 4 due to non-ergonomic working postures, such as bending, squatting, and lifting heavy loads. Therefore, improvements to the work facilities are necessary to reduce these risks.

3.2 Anthropometric Analysis

Anthropometric measurements were conducted to determine the dimensions of an ergonomic work facility based on four body measurements, namely body height, standing shoulder height, arm reach, and standing elbow height. The collected data were analyzed using data uniformity tests, data adequacy tests, and percentile calculations. The results showed that all data met the statistical criteria and were suitable for use as the basis for designing the proposed workstation. Anthropometric data were collected from five tire retreading workers. The uniformity test using upper and lower control limits showed that the measurements fell within the limits, and the data sufficiency test produced N′ values smaller than the number of observations (N = 5) for all dimensions. The 95th percentile ($\bar{x}$ + 1.645 SD) was then applied so that the facility could accommodate the larger operators. For example, standing elbow height had a mean of 114 cm and a standard deviation of 2.55 cm, which gives a 95th percentile of 118.1 cm.

Based on the anthropometric calculations of tire retreading workers, a tire hanging rack design was obtained with a height of 118 cm and a length of 326 cm. The height dimension was determined based on the workers' standing elbow height anthropometric data.

Table 2. Summary of Anthropometric Data

Anthropometric Data	95th Percentile
Body Height	173,7
Standing Shoulder Height	147,4
Arm Reach	79,3
Standing Elbow Height	118,1

3.3 Proposed Work Facility Design

Based on the working posture analysis using the WERA method, the tire gluing and *cushion gum* installation activities require improvements to the work facilities to reduce the risk of musculoskeletal complaints. The existing tire hanging rack is not equipped with rollers, requiring operators to manually lift the tires to reach their entire surface. This condition results in excessive force exertion and uncomfortable working postures. Therefore, the tire hanging rack needs to be redesigned by adding an independent roller system and adjusting its dimensions based on workers' anthropometric data. This design is expected to improve work comfort, safety, and efficiency while reducing the risk of musculoskeletal complaints. The proposed design of the tire hanging rack, which has been adjusted to workers' anthropometric data, is presented in **Figure 3**.

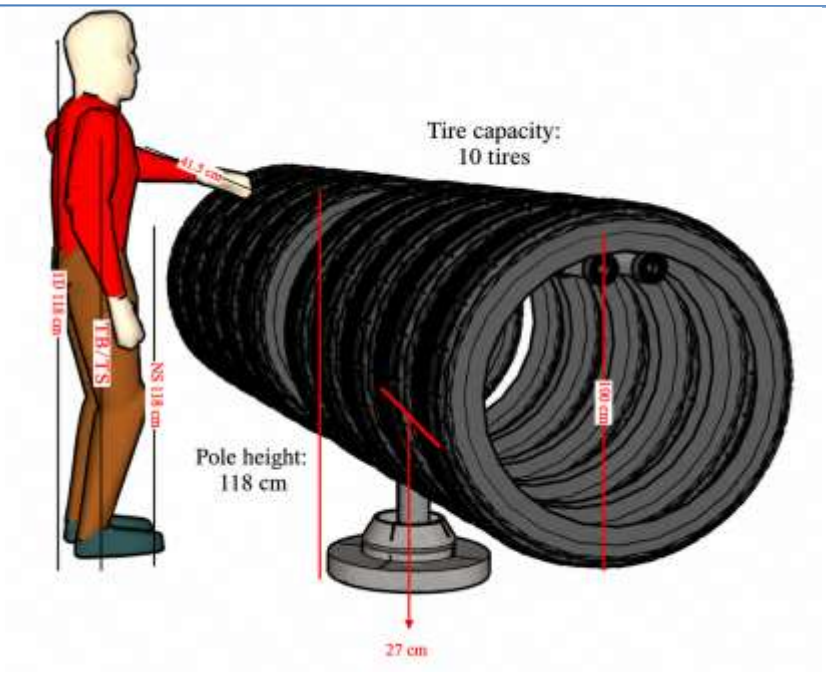


Fig. 3: Proposed Design of the Tire Hanging Rack

3.4 Evaluation of the Proposed Design

The effectiveness of the proposed tire hanging rack was evaluated by reassessing the workers' postures using the WERA method after implementing the proposed design. The evaluation results showed that the WERA score decreased from 43–46 to 23 (*low*). A comparison of the WERA scores before and after the proposed improvement is presented in **Table 3**.

Table 3. Comparison of WERA Scores

Before Improvement			
Operator	**Working Posture**	***Final Score***	**Risk Category**
1	Standing	23	*Low*
	Stooping	45	*High*
	Squatting	43	*Medium*
2	Standing	23	*Low*
	Stooping	46	*High*
	Squatting	45	*High*
After Improvement			
Operator	**Postur**	***Final Score***	**Risk Category**
1	Standing	23	*Low*
2	Standing	23	*Low*

4. Conclusion

Based on the working posture assessment using the WERA method, the most dominant ergonomic risk factor contributing to the risk of MSDs in tire gluing and cushion gum installation activities was the working posture of the back. This was indicated by a back score of 6 for both operators when performing stooping and squatting postures, which was the highest score among the other physical indicators. This condition occurred because operators had to bend their bodies to reach the tire surface, particularly the lower section, thereby increasing the load on the back and the WERA risk score.

The WERA assessment results showed that Operator 1 obtained a score of 23 (*low* risk) in the standing posture, 45 (*high* risk) in the stooping posture, and 43 (*medium* risk) in the squatting posture. Meanwhile, Operator 2 obtained a score of 23 (*low* risk) in the standing posture, 46 (*high* risk) in the stooping posture, and 45 (*high* risk) in the squatting posture. These results indicate that stooping and squatting postures have higher risk levels than the standing posture.

The proposed ergonomic improvement involved redesigning the tire hanging rack based on the operators' anthropometric data by incorporating an independent roller mechanism. This design allows tire gluing and cushion gum installation activities to be performed in a standing position without requiring operators to bend or squat. In addition, each tire can be rotated individually with a gentle push, without

the need for manual lifting or affecting the rotation of other tires. This improvement is expected to reduce the load on the back and legs, facilitate hand and wrist movements, and reduce repetitive tire-lifting activities.

5. Acknowledgment

The authors would like to express their sincere gratitude to Universitas Malikussaleh for the academic support provided throughout this research. The authors would also like to thank CV Rapi Vulkanisir for granting permission and providing the opportunity to conduct this research, as well as the workers who participated and provided the necessary data. Special appreciation is extended to the supervisors for their valuable guidance, advice, and support throughout the research process. Finally, the authors would like to thank all parties who contributed to the completion of this research.

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