

Musculoskeletal symptom survey and ergonomic assessments associated with maintenance tasks in the Indonesian railway industry

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ABSTRACT

Introduction: Suboptimal work design of maintenance tasks in railway industries often leads to adverse health effects for workers. This study aimed to determine the ergonomic risk levels and assess the extent of musculoskeletal symptoms associated with train maintenance tasks in the Indonesian railway industry.

Methods: The study involved 34 workers responsible for daily handling of locomotive components within a railway maintenance workshop in Indonesia. A musculoskeletal symptom survey was conducted using the Indonesian version of the Nordic Musculoskeletal Questionnaire to determine the prevalence and severity of such adverse health effects. Ergonomics assessments were conducted using the Rapid Entire Body Assessment (REBA) to evaluate the risk level and contributing risk factors associated with the investigated maintained tasks.

Results: Participants predominantly experienced musculoskeletal symptoms in the lower back (100%), followed by shoulders (91%), and knees (88%), while the highest severity were also observed in these regions. The ergonomics assessments revealed that over 50% of the maintenance tasks were categorized as either high or very high risk, with higher REBA section scores noted in the neck, leg, and trunk compared to those of the lower arm, wrist, and upper arm.

Conclusion: Workers performing train maintenance tasks experience a high prevalence and moderate severity of musculoskeletal symptoms. Additionally, most maintenance tasks performed were considered risky. Prompt interventions are necessary to address these findings.

Keywords: ergonomics assessment; maintenance tasks; musculoskeletal symptoms survey; train

Introduction

Railway industries have to ensure smooth operations to maintain factors that lead to customer satisfaction, such as minimizing delays.^{1,2} Additionally, operators need to prioritize passenger safety due to the substantial capacity for human transportation.³ This necessitates regular maintenance of all components, including trains and rail tracks. Regular maintenance reduces downtime, enhances system reliability,⁴ and decreases unexpected breakdowns that could result in

accidents.^{5,6}

Despite the crucial role of maintenance activities in ensuring smooth operations and passenger safety, the work design of maintenance facilities in rail industries is sometimes suboptimal.^{7,8} This leads to various ergonomic challenges, including physically strenuous tasks characterized by awkward postures, forceful exertions, and exposures to vibration and noise.⁹⁻¹² Consequently, maintenance tasks associated with rail transport industries are prone to causing

musculoskeletal problems, particularly in the lower back region.¹³⁻¹⁵ If not managed properly, these adverse health effects could impact workers' productivity, thereby affecting company performance.¹⁶⁻¹⁸

To the best of the author's knowledge, there is a dearth of comprehensive ergonomic studies that have investigated the prevalence of adverse health effects such as musculoskeletal symptoms, caused by maintenance tasks in Indonesian railway industries. Additionally, there is a scarcity of studies assessing the ergonomic risk levels associated with these tasks. This study aims to assess ergonomic risks and to determine the prevalence of musculoskeletal symptoms associated with maintenance tasks commonly found in trains operated by Indonesian railway industries. By addressing these gaps, this study aims to lay the groundwork for future research aimed at developing interventions to minimize adverse health effects associated with maintenance tasks in Indonesian railway industries.

Methods

This observational study utilized a cross-sectional study design, with data collection conducted over a 2-month period (April to June 2023).¹⁹ All 34 employees working at a train maintenance workshop in Yogyakarta, Indonesia were included in the study. The participants specialized in maintaining 16 upper body components of the train's locomotive (Table 1). All participants were male and met the inclusion criteria, which required being permanent employees with a minimum of six months' experience in the upper body components maintenance group, and currently not experiencing any injuries. Participants' ages ranged from 24 to 55, with a mean±SD of 35.2±7.8. Prior to participating in the study, all participants provided their consent. The study protocols were approved by the IRB committees of the Universitas Gadjah Mada (No. KE/UGM/012/EC/2023).

A survey was conducted to assess the prevalence and severity of musculoskeletal symptoms across

nine regions of the body (neck, shoulders, upper back, elbows, lower back, wrists/hands, hips/thighs, knees, ankles/feet) among participants. The survey utilized the Indonesian-adapted version of the Nordic Musculoskeletal Questionnaire.²⁰ The prevalence of musculoskeletal symptoms was determined by asking participants to indicate the presence of symptoms such as aches, pain, and discomfort experienced over the last 12 months. Meanwhile, the severity of musculoskeletal symptoms was gauged by asking participants to rate the intensity of their symptoms on a scale from 0 to 10.





Ergonomic assessments were carried out to determine the risk levels associated with maintenance tasks for each train component performed by the participants. Given the nature of the investigated tasks, which involve full-body movements, assessments were conducted using the Rapid Entire Body Assessment (REBA) method.²¹ For each investigated train component, the assessments were conducted for a minimum of four selected postures associated with the maintenance tasks. These posture selections were determined based on the most physically straining postures identified through focus group discussions with the participants. Table 1 provides illustrations of the maintenance tasks associated with 16 train components performed by the participants.

The prevalence of musculoskeletal symptoms in the nine regions of the body was determined by calculating the percentage of participants who experienced them. The severity of the musculoskeletal symptoms across participants in each body region was averaged. Additionally, the risk level of each maintenance task was assessed based on the overall REBA scores, with 1 indicating negligible risk, 2-3 representing low risk, 4-7 indicating medium risk, 8-10 denoting high risk, and 11+ representing very high risk.²¹ To identify the contributing risk factors to the overall REBA scores, the two sections of REBA scores—comprising neck, trunk, and leg, as well as lower arm, wrist, and upper arm—were normalized to the maximum scores. This was followed by

conducting statistical tests, such as Mann-Whitney tests, to determine if any differences existed among the scores of the two sections.

Table 1. Names of locomotive components and illustrations of postures associated with each Maintenance Task

Component names	Codes	Illustration of the selected postures	Component names	Codes	Illustration of the selected postures
Locomotive Body	A		Auxiliary Generator	I	
Diesel Engine and Generator	B		Exciter Generator	J	
Radiator Fan	C		Blower TM	K	
Lube Oil Cooler	D		Blower Exhauster	L	
Compressor	E		Gear Box	M	
Blower Rectifier	F		Main Generator	N	

Component names	Codes	Illustration of the selected postures	Component names	Codes	Illustration of the selected postures
Long Axle	G		Intercooler	O	
Dynamic Brake	H		Boffer and Draftgear	P	

Results

Musculoskeletal symptoms survey results

Figure 1 illustrates the prevalence of musculoskeletal symptoms in nine regions of the body. As depicted by the figure, the highest prevalence of musculoskeletal symptoms was observed in the lower back (100%), followed by shoulders (91%), and knees (88%). Conversely, the lowest prevalence of musculoskeletal symptoms was observed in the neck; nevertheless, its

prevalence remained higher than 50%.

Figure 2 illustrates the mean severity of musculoskeletal symptoms across nine regions of the body. As depicted, the highest intensity was observed in the lower back with a mean±SD of 5.2±2.0, followed by the shoulders, with a mean±SD of 4.1±2.0 and the knees, with a mean±SD of 4.0±2.5. Conversely, the lowest intensity of musculoskeletal symptoms was observed in the neck, with a mean±SD of 2.7±2.1.

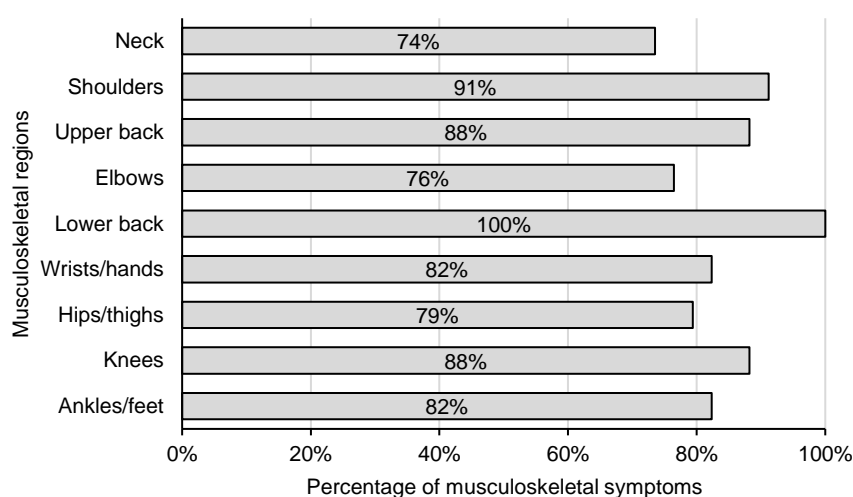


Figure 1. The prevalence of musculoskeletal symptoms in nine regions of the body

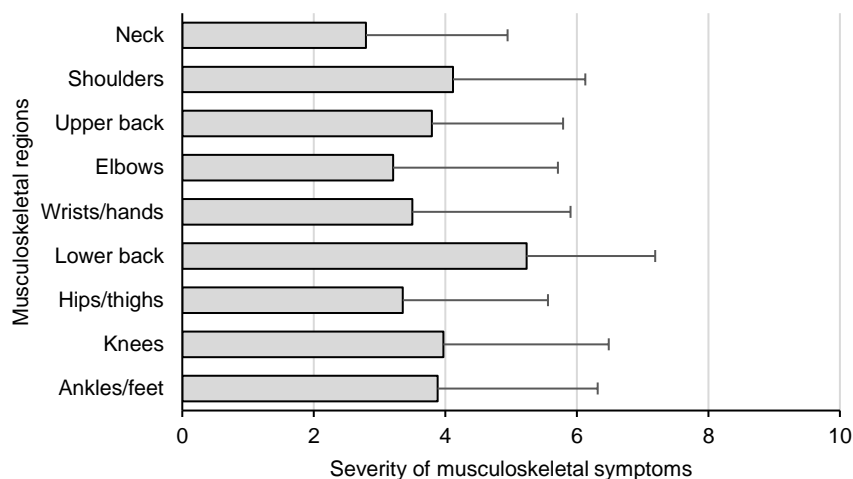


Figure 2. The mean severity of musculoskeletal symptoms across nine body regions

Ergonomic assessment results

Figure 3 presents the risk levels determined based on the overall REBA scores associated with maintenance tasks for each investigated train component. As indicated in the figure, more than 50% were categorized as either high or very high risk. Only 5% of the tasks were classified as less than or equal to low risk. Furthermore, maintenance tasks associated with component A appear to have the highest risk level, followed by components C and B. Meanwhile, maintenance

activities associated with components G and D appear to have the lowest risk level.

Figure 4 displays the mean values of the normalized REBA scores for the neck, leg, and trunk, as well as for the lower arm, wrist, and upper arm groups. As indicated by the figure, the mean of the normalized neck, leg, and trunk REBA scores were approximately 70%. Meanwhile, those of the lower arm, wrist, and upper arm were about 45%, which significantly lower than those of neck, leg, trunk ($p < 0.001$).

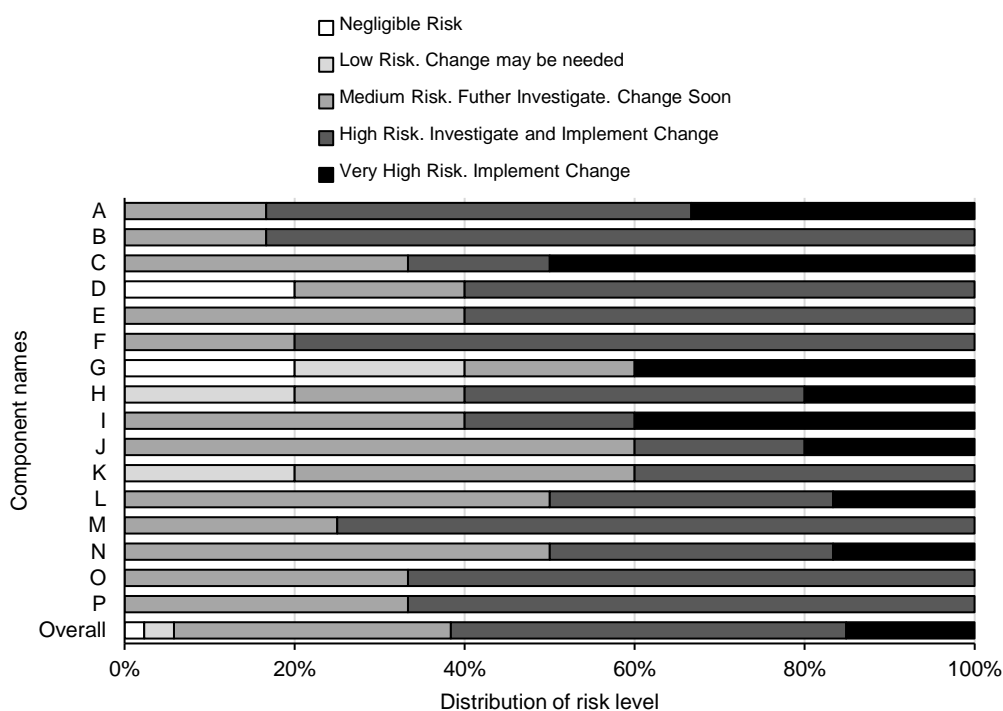


Figure 3. Distribution of risk levels among investigated train components

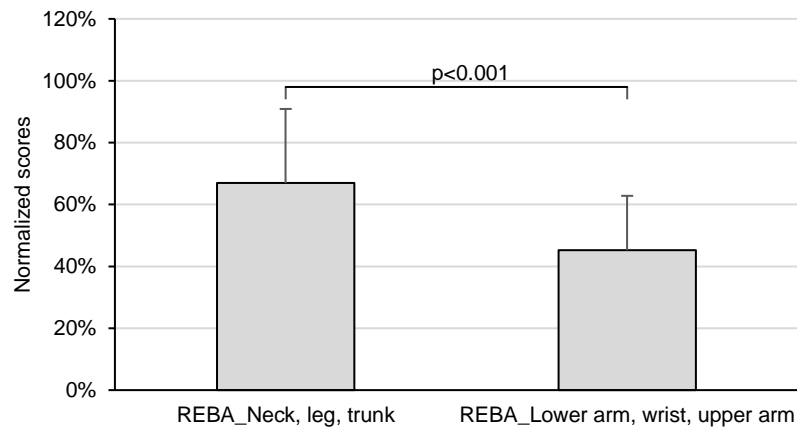


Figure 4. The mean values of the REBA section scores

Discussion

This study revealed the dominance of locomotive maintenance tasks with a high degree of ergonomic risks. Furthermore, participants who performed the maintenance tasks also reported a high prevalence of musculoskeletal symptoms. The REBA scores in the sections also indicate that the neck, leg, and trunk scores were higher than those of the arms, suggesting that maintenance tasks were dominated by awkward postures in those body regions. Hence, ergonomic interventions need to be proposed to ensure a safe and healthy workplace.

The ergonomic assessments revealed that locomotive maintenance activities investigated in the study were dominated (>50%) by tasks with a high degree of ergonomic risk. The symptom survey results also indicated that more than 70% of participants reported experiencing musculoskeletal symptoms in the last 12 months, with the low back being the region with the highest prevalence. This finding is consistent with the results of Sebtı et al.,²² where it was observed that most train maintenance tasks in a Tunisian railway company expose workers exposed to either high or very high degrees of ergonomic risks. Asadi et al.²³ also observed a high percentage of high-risk tasks in airline maintenance activities, with an average REBA score of about 8, indicating high risk. The high prevalence of musculoskeletal symptoms, exceeding 70%, was also observed on that study, particularly among associates who involved in

maintenance activities including cabin repair, engine change, and logistics. Similarly, other musculoskeletal symptom surveys among rail track maintenance workers and airline maintenance associates also reported that the low back was the part of the body with the highest number of musculoskeletal symptoms.^{9,24,25} Due to the nature of risky jobs and the evidence of a high prevalence of musculoskeletal symptoms, the work design of maintenance tasks for large vehicles such as trains and airplanes should receive serious attention. This could be managed up by providing effective ergonomic interventions aimed at creating a healthier and safer workplace for workers who perform the maintenance tasks on a daily basis.

The results of the ergonomic assessments, as indicated in the section scores, underscore that the neck, leg, and trunk REBA scores were relatively higher than those of the arms, indicating less favorable postures in these body regions. Almost half of the maintenance tasks performed by the participants involved unfavorable back postures, such as bending and twisting. Çınar-Medeni et al.²⁵ and Hoy et al.²⁶ found that risky low back postures are strongly associated with higher prevalence of musculoskeletal symptoms in the lower back. Besides the risky trunk postures adopted by some participants, the elevated neck, leg, and trunk REBA scores could also be attributed to unbalanced and non-neutral leg postures, including kneeling and squatting, which were necessary for certain maintenance tasks

performed by the participants. Furthermore, in addition to the high REBA scores in the lower extremity regions, a significantly high prevalence of musculoskeletal symptoms was also observed in that body region, particularly when compared to the prevalence in a manufacturing setting where workers typically perform relatively mono-task jobs.²⁷

Given that locomotive maintenance tasks often require participants to adopt awkward postures, such as back bending and kneeling, it is essential to implement interventions in the workplace to alleviate the physical strain on workers while performing these tasks. One effective engineering control method to minimize awkward postures is the installation of an adjustable elevated work platform.²⁸ This intervention not only reduces unfavorable postures but also helps by placing workers in their power zone.²⁹ Additionally, administrative controls in the form of task or job rotation should be considered. Proper task or job rotation allows workers to utilize varied muscle groups, distributing the load more evenly across their bodies.³⁰⁻³³ When tasks involve heavy lifting, pulling, or pushing, implementing a team lifting approach can also distribute the load across workers.³⁴ However, regardless of the intervention level, whether it involves engineering controls or administrative measures, prioritizing workers' involvement in the development program is crucial. This ensures the sustainability of the ergonomic program.^{35,36}

While the study yielded important findings, it is important to acknowledge several limitations, especially related to the chosen methodological approach. The ergonomic assessments in this study exclusively relied on the REBA, primarily designed for capturing risk factors associated with awkward postures.³⁷ Given the multifaceted nature of maintenance tasks, which involve manual material handling, future research could benefit from incorporating additional observational-based methods, such as the NIOSH Lifting Equation allowing for more detailed

assessments of risk factors associated with forceful exertions.³⁸ Moreover, should any intervention be proposed, biomechanical studies focusing on kinetics or kinematics, akin to those conducted by Draicchio et al.,³⁹ could also be undertaken to assess the efficacy of such interventions in minimizing risks for workers.

Conclusions

This study revealed a significant prevalence and moderate severity of musculoskeletal symptoms across all examined body regions among participants who underwent the train maintenance tasks. The highest prevalence was observed in the lower back, followed by shoulders, and knees. Similarly, the highest severity of musculoskeletal symptoms was noted in same areas: the lower back, shoulders, and knees. Moreover, ergonomic assessments revealed that more than half of the train maintenance tasks investigated in the study were categorized as either high risk or very high risk. The normalized Rapid Entire Body Assessment (REBA) scores for the neck, leg and trunk were significantly higher than those for the arms. This suggests that the tasks often required participants to adopt unfavorable postures, such as bending and kneeling, which could contribute to musculoskeletal issues. To help workers performing train maintenance tasks alleviate the high physical strain that can lead to adverse health effects, interventions particularly aimed at reducing awkward postures such as back bending and kneeling need to be introduced promptly. Echoing the trends observed in other ergonomic assessments and surveys of musculoskeletal symptoms, our findings highlight the global nature of ergonomic challenges in maintenance work. Therefore, there is a widespread need for targeted ergonomic improvements to safeguard workers' health more broadly.

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