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(RESEARCH ARTICLE)

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The influence of work demands and individual characteristics on rotator cuff syndrome severity among palm oil workers

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Abstract

The palm oil industry is a vital sector of Indonesia's economy, yet manual activities such as loading fresh fruit bunches (FFB) onto trucks pose a high risk for Rotator Cuff Syndrome (RCS). This study analyzed the effects of work-related factors and individual characteristics on RCS severity among FFB loading workers. A comparative quantitative approach was employed using the Shoulder Pain and Disability Index (SPADI) questionnaire and non-parametric statistical analysis. Results showed that significant work-related factors included load weight (p=0.000), lifting frequency (p=0.011), and carrying distance (p=0.000), while working duration was not significant (p=0.058). Significant individual characteristics were smoking habits (p=0.010), age (p=0.000), work experience (p=0.000), and history of shoulder injury (p=0.000). In contrast, body mass index (p=0.177) and alcohol consumption (p=0.144) showed no significant effect. These findings highlight the urgent need for ergonomic interventions such as standardized lifting procedures, job rotation, active rest, solar-powered conveyors, and the use of supportive devices. Implementing these measures may reduce musculoskeletal risks and promote worker health in the palm oil industry.

Keywords: Rotator Cuff Syndrome; Occupational Factors; Individual Characteristics; Palm Oil Industry; Musculoskeletal Disorders

1. Introduction

The palm oil plantation industry is one of the most significant contributors to Indonesia's economy, both in terms of exports and employment. According to Statistics Indonesia [1], this sector provides more than four million jobs and contributes approximately 2.3% to the national GDP. Despite its economic importance, palm oil plantation activities are still highly labor-intensive, ranging from land clearing, planting, maintenance, harvesting, to loading and unloading, which are often performed manually. Such activities expose workers to considerable occupational health and safety risks, particularly musculoskeletal disorders (MSDs), which are prevalent among those engaged in heavy manual handling [2]. The manual loading of fresh fruit bunches (FFB) in palm oil plantations using a tojok demands high physical effort, causes rapid fatigue, and increases the risk of injuries. Workers repeatedly lift 15–25 kg bunches and throw them into truck beds up to 2.5 meters high, often in non-ergonomic postures such as bending, shoulder rotation, and one-handed lifting. These conditions elevate the risk of MSDs like back pain, muscle strain, and joint problems, as well as other injuries such as sprains, abrasions, or trauma from failed throws [3, 4].

MSDs are musculoskeletal conditions caused by heavy workloads, non-ergonomic postures, and repetitive movements [5], with a prevalence of 86.2% among palm oil workers: 8.6% mild, 69.0% moderate, and 22.4% severe [6, 7]. The main complaints include shoulder pain (35%), lower back pain (22.9%), neck pain (13.5%), calf pain (11.4%), thigh pain (8.6%), and wrist pain (8.6%) [8]. Repetitive movements, heavy loads, insufficient rest, and non-ergonomic postures have been shown to exacerbate these disorders, as confirmed through OWAS and RULA evaluations [9, 10].

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Rotator cuff syndrome (RCS) is a shoulder disorder caused by excessive muscle use, repetitive movements, or non-ergonomic postures that lead to pain and damage to the muscles and tendons [11]. This condition is commonly experienced by workers engaged in physically demanding tasks and has significant impacts on mobility, work absenteeism, and healthcare costs [12]. The prevalence of RCS is higher in women (7.3%) compared to men (6.1%) [13], with major risk factors including repetitive overhead movements, excessive force, awkward postures, as well as age and a history of shoulder injuries [14, 15]. Previous studies indicate that both physical and psychosocial factors contribute to the incidence of RCS, which is more common among women, workers over 50 years old, and individuals with a history of arm or shoulder problems [16, 12]. RCS can be effectively diagnosed using ultrasonography (USG) [16], and pain-relief injections are considered an effective treatment [17]. Severity is assessed using the Shoulder Pain and Disability Index (SPADI) as low (0–33%), moderate (34–66%), and high (67–100%) [18].

Based on an initial observation of nine fresh fruit bunch (FFB) lifting workers in West Sumatra, Indonesia, 33.3% were found to have low, 44.4% moderate, and 22.3% high RCS severity, indicating a significant risk to shoulder health due to repetitive heavy lifting. Although numerous studies have investigated MSDs in the palm oil industry [4, 6, 7, 19-21] most have focused only on general complaint prevalence. Research specifically analyzing the combined influence of work-related factors and individual characteristics on RCS severity remains limited, even though this information is essential for understanding more specific shoulder injury risks in the palm oil sector.

Lifting FFB onto trucks involves heavy and repetitive physical activities, such as handling 15–25 kg FFB and throwing them onto trucks 2–2.5 meters high, often with non-ergonomic postures, including bending, shoulder rotation, and one-handed handling. These conditions increase the risk of shoulder injuries and exacerbate RCS severity. This study is expected to provide a foundation for more effective prevention and intervention strategies, while also assisting the palm oil industry in designing better ergonomic policies to improve worker well-being and reduce injury risks, particularly in West Sumatra, Indonesia.

The introduction should be typed in Cambria with font size 10. Author can select Normal style setting from Styles of this template. The simplest way is to replace (copy-paste) the content with your own material. In this section highlight the importance of topic, making general statements about the topic and presenting an overview on current research on the subject. Your introduction should clearly identify the subject area of interest.

2. Material and methods (Heading 1, WJS heading level 1)

2.1. Research Design

This study employed a quantitative comparative design with a cross-sectional approach, conducted among oil palm workers involved in loading FFB onto trucks in West Sumatra, Indonesia. The cross-sectional design was selected to analyze the relationship between occupational factors and individual characteristics with the severity of RCS.

2.2. Population and Sample

The study population consisted of workers directly involved in loading FFB onto trucks in the palm oil industry. Samples were selected using a purposive sampling technique with the inclusion criterion of having at least one year of work experience, while the exclusion criterion was workers with a history of shoulder injury. The sample size was determined using the Lem show formula with a 10% margin of error, resulting in a minimum requirement of 96 respondents.

2.3. Research Variables

The dependent variable in this study was the method selection in this study encompassed measurement instruments, statistical analysis techniques, and mitigation strategies. The severity of RCS was assessed using the SPADI questionnaire, which consists of two subscales: pain (5 items) and disability (8 items). This instrument was chosen due to its validity and reliability in evaluating shoulder pain and functional limitations. Data analysis was performed using the Chi-Square test to examine the relationship between occupational factors and RCS severity, while individual characteristics were analyzed using the Chi-Square test and Spearman correlation. The results served as the basis for developing RCS prevention strategies, which were designed according to the hierarchy of risk controls: elimination, substitution, engineering controls, administrative controls, and the use of personal protective equipment (PPE).

2.4. Data Collection

The research data were collected using three main techniques: (1) direct observation of workers' activities while loading FFB onto trucks, (2) structured interviews to obtain information on occupational factors and individual characteristics, and (3) completion of the SPADI questionnaire to assess the severity of RCS.

2.5. Data Analysis

Data were analyzed using IBM SPSS version 22. The Chi-Square test was applied to assess the relationship between occupational factors and the severity of RCS. The Chi-Square test and Spearman correlation were also used to examine the association between individual characteristics and RCS severity. The results of these analyses were then used as the basis for developing RCS prevention strategies, which were formulated according to the hierarchy of risk controls.

3. Result

3.1. Characteristics of Respondents

The study involved 100 workers who manually lifted FFB in five palm oil–producing districts in West Sumatra. The respondents' ages ranged from 19 to 57 years, with an average of 31.85 years. The average height was 167.99 cm, the average body weight was 61.24 kg, and the average body mass index (BMI) was 21.70. Their work experience ranged from 1 to 21 years, with an average of 7.11 years. These data indicate that the sample consisted of individuals in the productive age group with a wide variation in work experience.

3.2. Severity of Rotator Cuff Syndrome (RCS)

The severity of RCS was assessed using SPADI questionnaire. The results showed that 17% of respondents were classified in the mild category, 54% in the moderate category, and 29% in the severe category. These findings indicate that the majority of workers had already experienced musculoskeletal disorders with moderate to severe levels of severity.

3.3. Relationship Between Work Factors and Severity of RCS

The Chi-Square test was conducted to examine the relationship between lifting load, work duration, lifting frequency, and carrying distance with the severity of RCS among workers handling FFB. The cross-tabulation results are presented in Table 1.

Table 1 Relationship Between Work Factors and Severity of RCS (n = 100)

Variable	Category	Mild RCS	Moderate RCS	Severe RCS	Total	Statistical Test	p-value	Remark
Lifting Load	<2 tons	17	10	1	28	Chi-Square	0.000	Significant
	2–3.5 tons	0	32	9	41			
	>3.5 tons	0	12	19	31			
Total		17	54	29	100			
Work Duration	<6 hours	8	9	6	23	Chi-Square	0.058	Not significant
	6–8 hours	8	28	13	49			
	>8 hours	1	17	10	28			
Total		17	54	29	100			
Lifting Frequency	<100 times/day	10	20	3	33	Chi-Square	0.011	Significant
	100–200 times	5	23	15	43			
	>200 times	2	11	11	24			

Total		17	54	29	100			
Carrying Distance	<2 meters	12	10	2	24	Chi-Square	0.000	Significant
	2–3 meters	5	20	8	33			
	>3 meters	0	24	19	43			
Total		17	54	29	100			

Based on Table 1, the analysis revealed that the severity of RCS among workers is strongly influenced by mechanical factors in their tasks. Heavier lifting loads (>3.5 tons), higher lifting frequency (>200 times/day), and longer carrying distances (>3 meters) were significantly associated with severe RCS ($p < 0.05$). In contrast, daily work duration did not show a significant effect on RCS severity ($p=0.058$). These findings highlight that the intensity and physical characteristics of lifting activities are key determinants of shoulder injury risk, suggesting that preventive interventions should focus on reducing load, frequency, and carrying distance to mitigate the severity of RCS.

3.4. Relationship Between Individual Characteristics and RCS Severity

The relationship between individual characteristics and the severity of RCS was analyzed using appropriate statistical tests. Categorical variables, including smoking habit, injury history, and alcohol consumption, were analyzed using the Chi-Square test, while continuous variables, including BMI, age, and work experience, were analyzed using Spearman's rank correlation. The results are presented in Table 2.

Table 2 Relationship Between Individual Characteristics and RCS Severity (n = 100)

Variable	**Category**	**Mild RCS**	**Moderate RCS**	**Severe RCS**	**Total**	**Statistical Test**	**p-value**	**Remark**
Smoking Habit	Non-smoker	3	5	1	9	Chi-Square	0.010	Significant
	<1 pack/day	12	28	8	48			
	1–3 packs/day	2	17	14	33			
	>3 packs/day	0	4	6	10			
Total		17	54	29	100			
BMI	(continuous)	-	-	-	-	Spearman	0.177	Not significant
Age	(continuous)	-	-	-	-	Spearman	0.000	Significant
Work Experience	(continuous)	-	-	-	-	Spearman	0.000	Significant
History of Injury	No	16	16	1	33	Chi-Square	0.000	Significant
	Yes	1	38	28	67			
Total		17	54	29	100			
Alcohol Use	No	17	46	23	86	Chi-Square	0.144	Not significant
	Yes	0	8	6	14			
Total		17	54	29	100			

Based on Table 2, several individual characteristics were significantly associated with the severity of RCS. Smoking habits, age, work experience, and history of injury demonstrated a significant impact on RCS severity ($p<0.05$). Specifically, higher daily cigarette consumption, older age, longer work experience, and previous injuries were correlated with increased RCS severity. In contrast, BMI and alcohol consumption did not show a significant association with RCS severity ($p>0.05$). These findings highlight the importance of individual factors particularly age, work experience, smoking habits, and prior injury history in the prevention and management of RCS among workers.

3.5. Designing a Prevention Strategy for Rotator Cuff Syndrome in Fresh Fruit Bunch (FFB) Lifting Activities in the Palm Oil Industry

ata analysis of 100 workers involved in FFB lifting activities revealed that 34% experienced mild RCS, 45% moderate, and 21% severe, indicating a high prevalence of shoulder musculoskeletal disorders associated with repetitive lifting tasks. Occupational factors significantly related to RCS severity included lifting load (p=0.000), lifting frequency (p=0.011), and carrying distance (p=0.000), whereas work duration was not statistically significant (p = 0.058). These findings indicate that higher loads, increased lifting frequency, and longer carrying distances contribute to greater RCS severity. Individual factors influencing RCS severity included smoking habits (p=0.004), age (p=0.000), work experience (p=0.000), and history of injury (p=0.000), while BMI and alcohol consumption were not significantly associated. Workers with prior shoulder injuries exhibited higher RCS severity, highlighting the cumulative effect of repetitive strain and previous musculoskeletal trauma.

3.6. Risk mitigation strategies were designed according to the hierarchy of controls

3.6.1. Substitution

Heavy manual lifting tools were replaced with ergonomically designed, lighter equipment featuring cushioned handles and adjustable lengths, reducing repetitive shoulder load, particularly for older and experienced workers. Figure 4.1 illustrates the updated ergonomic design of the tojok developed to enhance worker comfort and safety. The tojok is made from seamless material with a thickness of 2.5 mm, featuring a 20 cm pointed tip and an 80 cm shaft, resulting in a total length of 100 cm. It has a diameter of 25 mm and a soft 14 cm handle grip. Weighing only 1 kg, the tojok can be customized according to the worker's height upon request. Its ergonomic design and lightweight structure help reduce lifting loads and minimize the risk of shoulder muscle injuries during Fresh Fruit Bunch (FFB) lifting activities, thereby supporting optimal work efficiency and safety.

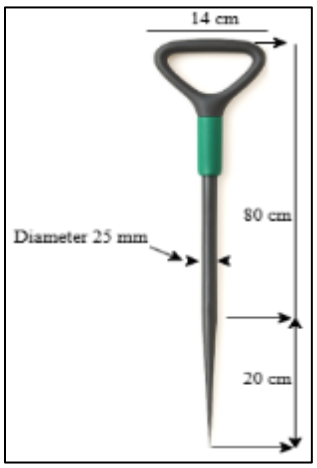

Figure 1 Ergonomic Design of the Took

3.7. Engineering Controls

A solar-powered conveyor system was implemented to transport FFB from collection points to trucks as an engineering control to reduce repetitive manual lifting. The system decreases manual lifting, minimizes lifting distance and frequency, maintains neutral postures, and improves operational efficiency. Workers only need to place FFB on a low, ergonomically designed conveyor equipped with side guards and automatic sensors, adjustable to their height to ensure safe postures, thereby reducing the risk of RCS. The system is efficient, environmentally friendly, and can operate independently of electricity or diesel, making it suitable for remote locations while also reducing costs and supporting sustainable industrial practices. The design of the conveyor is shown in Figures 1.

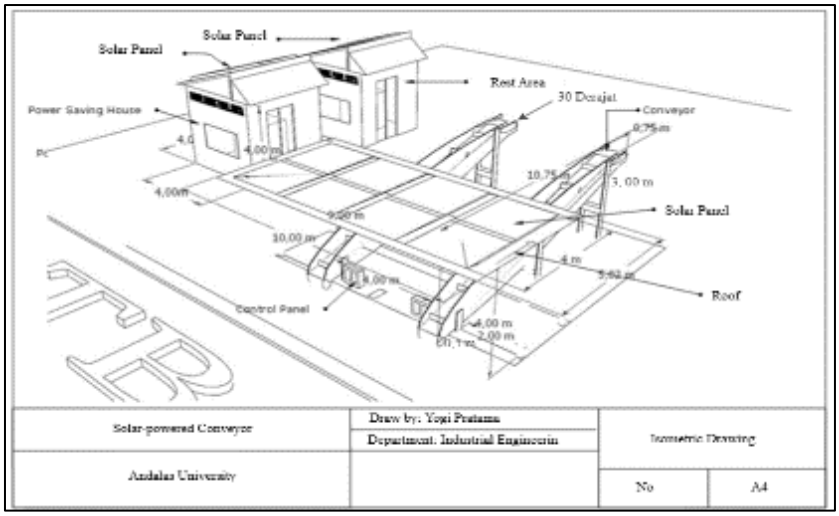

Figure 2 Design of Solar-Powered Conveyor

3.8. Administrative Controls

Standard Operating Procedures (SOPs) and safe lifting training were implemented. Job rotation every one hours, periodic active rest breaks every 1–2 hours, and adjusted assignments for workers with prior shoulder injuries were applied. Smoking cessation guidance was also provided to support muscle recovery.

3.9. Personal Protective Equipment (PPE)

Shoulder braces were recommended to stabilize the shoulder joint, reduce load on rotator cuff muscles, limit extreme shoulder movements, and prevent severe RCS. Light stretching exercises were advised to maintain flexibility and strength

4. Discussion

4.1. Analysis of the Relationship between Occupational Factors and the Severity of RCS in FFB Loading Activities

Load weight was significantly associated with the severity of RCS (p=0.000). Repeated lifting of FFB weighing 15–25 kg to a height of approximately 2 meters places substantial stress on the supraspinatus muscle and shoulder tendons. This finding is consistent with Meyers et al [14], who reported that high mechanical loads reduce shoulder integrity, and Smith et al [22], who found that repetitive lifting of more than 20 kg increases the risk of shoulder injuries.

Work duration was not significant (p=0.058), which contrasts with Perdana et al [23] and Saputri et al [19], who reported that longer work duration increases the risk of musculoskeletal complaints. This difference may be due to rest periods, task distribution, and individual physical variations. Nevertheless, Fadhillah et al [6] noted that prolonged working hours remain associated with musculoskeletal complaints among palm oil workers.

Lifting frequency was significant (p=0.011). The more frequently lifting is performed, the greater the cumulative load on the shoulders, which may lead to tissue inflammation. This result is in line with Wicaksono et al [3] and Bodin et al [13], who reported that high lifting frequency, particularly overhead, increases the risk of RCS by up to 3.3 times.

Carrying distance was significant (p=0.000). Carrying FFB while walking increases biomechanical stress on the shoulders and upper body. This finding is consistent with Khairunnisa et al [24], who identified carrying distance as a key predictor of musculoskeletal injuries, as well as Nurhadi et al [20] and Lina et al [25], who reported that non-ergonomic work environments contribute to increased shoulder pain complaints.

4.2. Analysis of the Relationship between Individual Characteristics and the Severity of RCS

Smoking habits were significant (p=0.004). Nicotine reduces the supply of oxygen and nutrients to the tendons, thereby increasing the risk of inflammation and muscle damage.

BMI was not significant (p=0.177). This result is consistent with Rika and Dwiyanti [26], who also found that BMI does not significantly affect shoulder complaints, although excess body weight may still impose additional pressure on the joints.

Age was significant (p=0.000). The older the worker, the higher the risk of RCS due to decreased muscle strength and flexibility. This finding is in line with Svendsen et al [27], who reported that workers over 45 years of age are more prone to shoulder disorders.

Work experience was significant (p=0.000). Long-term exposure to repetitive lifting activities increases biomechanical stress and the risk of injury. This result supports study by Giraudo et al [28], who found that workers with more than 10 years of experience are more susceptible to shoulder complaints.

History of injury was significant (p=0.000). Workers with a prior shoulder injury are more likely to experience tendon damage recurrence. This finding is consistent with Gopinath et al [29], Similarly, shoulder pain prevalence is higher among actively working individuals with prior injuries or heavy physical workloads, increasing the risk of tendon tears during the productive working age [30].

Alcohol consumption was not significant (p=0.144). Although Passaretti, et al [31] found that heavy alcohol consumption is associated with rotator cuff ruptures, its impact was not evident among field workers, possibly due to variations in drinking patterns.

4.3. Analysis of Preventive Measures

Substitution of heavy metal harvesting tools with lighter ergonomic tools can reduce shoulder load Wickson et al [3] and Mohamad an et al [32] demonstrated that ergonomic design decreases awkward postures and improves work comfort. Engineering controls such as solar-powered conveyors reduce manual lifting frequency and are environmentally friendly. Although costly, this method is effective in reducing physical workload and supporting energy sustainability. Administrative controls such as SOP, job rotation, and active rest breaks are inexpensive to implement and help prevent the accumulation of repetitive strain. Padula, et al [33] emphasized that active breaks are essential in reducing musculoskeletal complaints. Use of PPE such as a shoulder brace provides shoulder stability and additional protection, even though it does not eliminate the primary source of load. Shalihah and Munawaroh [34] reported that such interventions help prevent muscle strain.

5. Conclusion

The severity of Rotator Cuff Syndrome (RCS) in palm oil fresh fruit bunch loading workers is significantly associated with load weight, lifting frequency, carrying distance, smoking habits, age, work experience, and prior shoulder injury, while work duration, body mass index, and alcohol consumption show no significant effect. These findings underscore the importance of preventive strategies, including the adoption of ergonomic tools such as solar-powered conveyors, standardized lifting procedures, job rotation, active rest breaks, and supportive devices, to mitigate ergonomic risks and protect workers' shoulder health.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors affirm that this study was conducted independently and objectively, without any commercial or financial involvement that could influence the findings or be interpreted as a potential conflict of interest.

Statement of ethical approval

All respondents voluntarily participated in this study and provided written informed consent. Ethical clearance was not formally obtained because the study was conducted as part of an academic research project; however, the research adhered to ethical principles in accordance with the Declaration of Helsinki.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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