



Repetitive Motion: Is A Risk Factor For Musculoskeletal Disorders Among Warehouse Workers?

Nima Eka Nur Rahmania^{1*}, Ellyza Setya Maryiantari², Achmat Kuncoro³, Riza Irianingtyas⁴, Ratih Damayanti⁵

^{1,2,3,4}Program Studi Keselamatan dan Kesehatan Kerja, Politeknik Kesehatan Kerta Cendekia, Sidoarjo, Indonesia

⁵Program Studi Keselamatan dan Kesehatan Kerja, Universitas Airlangga, Surabaya, Indonesia

Corresponding Author: Nima Eka Nur Rahmania, ne.rahmania@gmail.com

ABSTRAK

Pendahuluan: *Musculoskeletal Disorders* (MSDs) sering terjadi pada pekerja gudang akibat aktivitas *manual handling* dan beban kerja fisik selama proses kerja. **Tujuan:** Penelitian ini bertujuan menganalisis hubungan gerakan berulang, beban kerja fisik, Indeks Massa Tubuh (IMT), dan MSDs pada pekerja gudang di Sidoarjo. **Metode:** Penelitian menggunakan desain observasional analitik dengan pendekatan *cross-sectional* terhadap 40 pekerja gudang pakan ternak menggunakan teknik total sampling. Gerakan berulang dinilai menggunakan metode *Threshold Limit Value* (TLV) dari *American Conference of Governmental Industrial Hygienists* (ACGIH), beban kerja fisik diukur menggunakan metode *Cardiovascular Load* (%CVL), dan keluhan muskuloskeletal diukur menggunakan kuesioner *Nordic Body Map*. Analisis data dilakukan menggunakan uji *Chi-square* atau *Fisher's Exact*, korelasi *Spearman*, dan regresi logistik biner. **Hasil:** Hasil penelitian menunjukkan bahwa gerakan berulang ($p=0,01$) dan beban kerja fisik ($p=0,04$) berhubungan signifikan dengan MSDs. Gerakan berulang merupakan faktor paling dominan yang berhubungan dengan MSDs ($OR=2,8$; 95% $CI=1,21-6,42$; $p=0,02$). IMT menunjukkan hubungan *borderline* dengan MSDs ($p=0,05$), sedangkan usia, masa kerja, dan kebiasaan olahraga tidak berhubungan signifikan. **Kesimpulan:** Gerakan berulang dan beban kerja fisik berhubungan signifikan dengan MSDs.

ABSTRACT

Introduction: *Musculoskeletal Disorders* (MSDs) are frequently found among warehouse workers due to manual handling activities and physical workloads during work processes. **Objective:** This study aimed to analyze the relationship between repetitive motion, physical workload, Body Mass Index (BMI), and MSDs among warehouse workers in Sidoarjo. **Methods:** An observational analytic study with a cross-sectional design was conducted on 40 animal feed warehouse workers using a total sampling technique. Repetitive motion were assessed using the *Threshold Limit Value* method from the *American Conference of Governmental Industrial Hygienists* (ACGIH), physical workload was measured using the *Cardiovascular Load* method, and musculoskeletal complaints were measured using the *Nordic Body Map* questionnaire. Data analysis was performed using the *Chi-square* or *Fisher's Exact* test, *Spearman* correlation, and binary logistic regression. **Results:** The results showed that repetitive motion ($p=0.01$) and physical workload ($p=0.04$) were significantly associated with MSDs. Repetitive motion were the most dominant factor associated with MSDs ($OR=2.8$; 95% $CI=1.21-6.42$; $p=0.02$). BMI showed a borderline association with MSDs ($p=0.05$), whereas age, tenure, and exercise habits were not significantly associated. **Conclusion:** Repetitive motion and physical workload were significantly associated with MSDs.

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INTRODUCTION

Musculoskeletal disorders (MSDs) are one of the leading causes of work-related morbidity worldwide and contribute to decreased productivity and increased economic burden on companies (Jensen, 2024). MSDs are common among industrial workers, particularly those involved in manual material handling activities. These conditions are primarily caused by biomechanical factors such as repetitive motion, physical workload, and non-ergonomic working postures (Prasetya et al., 2024). Previous studies have shown that repetitive

Rahmania, N.E.N., Maryiantari, E.S., Kuncoro, A., Irianingtyas, R & Damayanti, R. (2026).. Repetitive Motion: Is A Risk Factor..... physical work and high workload significantly increase the risk of MSDs among workers (Arvidsson et al., 2021).

Repetitive work activities performed continuously over long periods may increase strain on muscles and joints, potentially contributing to musculoskeletal complaints among workers. The ACGIH TLV approach indicates that increased hand activity frequency and force are associated with a higher risk of MSDs (Graziosi et al., 2025). High physical workload increases biomechanical stress and accelerates muscle fatigue, both of which contribute significantly to the development of MSDs (Tanjung et al., 2023). Previous studies have identified repetitive motion, force, and work duration as key determinants of MSDs risk, particularly in industrial and logistics sectors (Greggi et al., 2024; Kee, 2025). In addition to occupational factors, individual factors such as Body Mass Index (BMI) also contribute to MSDs occurrence. Individuals with higher BMI experience additional mechanical load on the musculoskeletal system, increasing the risk of musculoskeletal pain (Zadoń et al., 2024). Ergonomic factors, including work posture and physical workload, have also been shown to significantly influence musculoskeletal complaints (Rahmania et al., 2024). Previous studies conducted among manufacturing workers in Indonesia also reported that physical workload and individual factors such as nutritional status were significantly associated with occupational fatigue, indicating that prolonged physical exposure may adversely affect workers musculoskeletal and physical conditions (Trimala et al., 2023).

In Indonesia, warehouse workers are frequently exposed to manual handling activities with limited ergonomic control, increasing the potential risk of MSDs. However, inconsistencies remain regarding the dominant risk factors for MSDs, particularly in developing countries with high manual work intensity. Sidoarjo, one of the major industrial and logistics areas in East Java, is characterized by warehouse operations that remain highly dominated by manual material handling, repetitive motion, high physical workload, and suboptimal ergonomic practices.

In the present study, the respondents were employed in an animal feed warehouse in Sidoarjo, East Java. Their primary tasks involved lifting, carrying, stacking, and transferring feed sacks weighing approximately 25-50 kg throughout the work shift. These tasks required repetitive bending, twisting, reaching, gripping, and forceful exertion, thereby increasing workers' exposure to ergonomic risk factors associated with musculoskeletal disorders (MSDs). Preliminary observations also indicated that several workers experienced discomfort in the lower back, shoulders, neck, and upper extremities following prolonged manual material handling activities. These findings highlight the need for a context-specific investigation to better understand the occupational factors associated with MSDs in this work environment. This study aimed to analyze the association between repetitive motion, physical workload, body mass index, and musculoskeletal disorders among animal feed warehouse workers in Sidoarjo.

METHOD

This study employed an analytic observational design with a cross-sectional approach. The study was conducted among animal feed warehouse workers in Sidoarjo, East Java, Indonesia, from January to March 2025. The study population consisted of 40 animal feed warehouse workers, all of whom were included using a total sampling technique. The independent variables in this study were repetitive motion, physical workload, Body Mass Index (BMI), years of service, and exercise habits, while the dependent variable was musculoskeletal disorders (MSDs).

Repetitive motion was assessed using the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV), whereas physical workload was measured using the Cardiovascular Load (%CVL) method. Musculoskeletal complaints were assessed using the standardized Nordic Body Map (NBM) questionnaire, which was also used to identify the body regions most frequently affected. The NBM, adapted from the Nordic Musculoskeletal Questionnaire (NMQ), has demonstrated satisfactory validity and reliability in previous studies, with Cronbach's alpha values exceeding 0.70, indicating acceptable internal consistency. The ACGIH TLV and %CVL methods are internationally recognized ergonomic assessment tools that have been widely applied in occupational health and ergonomics research studies.

Repetitive motion was categorized into low and high exposure based on ACGIH criteria. Physical workload was classified into light and heavy categories according to %CVL assessment results. BMI was classified into normal and overweight according to World Health Organization (WHO) standards. Years of service were categorized into ≤ 5 years and > 5 years, while exercise habits were categorized as regular or occasional. MSDs scores obtained from the Nordic Body Map questionnaire were analyzed as continuous data in correlation analysis and categorized into moderate and high complaint levels based on the median score distribution for bivariate and multivariate analyses.

Data analysis consisted of univariate, bivariate, correlation, and multivariate analyses. Univariate analysis was conducted to describe respondent characteristics and study variables. Bivariate analysis between

Rahmania, N.E.N., Maryiantari, E.S., Kuncoro, A., Irianingtyas, R & Damayanti, R. (2026).. Repetitive Motion: Is A Risk Factor..... independent variables and categorized MSDs levels was performed using the Chi-square or Fisher's Exact test. Correlation analysis between occupational factors and MSDs scores was conducted using the Spearman correlation test. Furthermore, multivariate analysis was performed using binary logistic regression to identify factors associated with MSDs among workers. Statistical analysis was performed using IBM SPSS Statistics version 25 with a significance level of $\alpha = 0.05$. All respondents participated voluntarily and provided informed consent before data collection was conducted.

RESULT

Workers in the animal feed warehouse routinely performed manual material handling activities, including lifting, carrying, stacking, and transferring feed sacks during daily operations. These tasks required repetitive bending, twisting, reaching, gripping, and forceful exertion, potentially increasing biomechanical exposure and musculoskeletal strain, as illustrated in Figure 1.



Figure 1. Repetitive Manual Material Handling Activities Among Animal Feed Warehouse Workers

The study result are presented sequentially, beginning with respondent characteristics, followed by the distribution of study variables, and the result of bivariate, correlation and multivariate analyses.

Table 1. Distribution of Respondent Characteristics (n=40)

Variable	N	%
Age		
Early adulthood	20	50
Middle adulthood	20	50
Year of Service		
New (≤ 5 years)	6	15
Long (> 5 years)	34	85
Exercise Habit		
Regular	16	40
Occasional	24	60
BMI		
Normal	28	70
Overweight	12	30

Source: Primary Data, 2025

Table 1 presents the characteristics of the respondents involved in this study. The respondents were evenly distributed between early adulthood and middle adulthood, with each group accounting for 50.0% of the total sample. Most respondents had long years of service (85.0%), indicating prolonged exposure to occupational activities and potential ergonomic risk factors in the workplace. Regarding lifestyle-related factors, the majority of workers reported exercising only occasionally (60.0%), while 40.0% performed regular exercise. In terms of nutritional status, most respondents had normal BMI (70.0%), although 30.0% were categorized as overweight. The results of this study describe the distribution of individual characteristics that may influence musculoskeletal complaints among the study participants.

Table 2. Distribution of Occupational Risk Factors (n=40)

Variable	N	%
Repetitive Motion		
Low	18	45
High	22	55
Workload		
Light	28	70
Heavy	12	30

Source: Primary Data, 2025

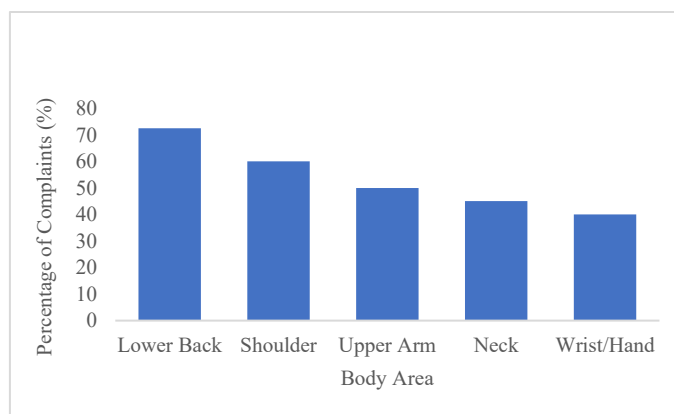
Table 2 described the distribution of occupational risk factors among respondents. More than half of the workers were exposed to high repetitive motion activities (55.0%), while 45.0% experienced lower repetitive motion exposure. In addition, most respondents were categorized as having light workloads (70.0%), whereas 30.0% experienced heavy workloads. This study indicate that repetitive work activities remained common among workers despite the predominance of lighter workload classifications.

Table 3. Distribution of Musculoskeletal Disorder Scores

Variable	Mean $\pm$ SD	Min - Max
MSDs score	65.53 $\pm$ 6.80	48 - 77

Source: Primary Data, 2025

Table 3 showed musculoskeletal disorder scores (MSDs) among respondents. The mean MSDs score was 65.53 ± 6.80 , with scores ranging from 48 to 77. This finding indicates that respondents generally experienced considerable musculoskeletal complaints, with several workers showing relatively high complaint scores. Figure 2 below illustrates the body areas most frequently affected by musculoskeletal complaints among animal feed warehouse workers during repetitive manual handling activities.

**Figure 2. Musculoskeletal Complaint Areas among Animal Feed Warehouse Workers**

Based on Figure 2, the most frequently reported musculoskeletal complaints were observed in the lower back (72.5%), shoulders (60.0%), upper arms (50.0%), neck (45.0%), and wrist or hand areas (40.0%). These complaints may reflect the physical demands of repetitive manual handling activities among animal feed warehouse workers.

Table 4. Bivariate Analysis between Independent Variables and MSDs (n = 40)

Variable	Moderate		High		<i>p-value</i>
	n	%	n	%	
Age					
Early adulthood	13	65.0	7	35.0	0.62
Middle adulthood	14	70.0	6	30.0	

Variable	Moderate		High		p-value
	n	%	n	%	
Year of Service					
New	4	66.7	2	33.3	0.91
Long	23	67.6	11	32.4	
Exercise Habit					
Regular	12	75.0	4	25.0	0.38
Occasional	15	62.5	9	37.5	
Repetitive Motion					
Low	15	83.3	3	16.7	0.01*
High	12	54.5	10	45.5	
Workload					
Light	22	78.6	6	21.4	0.04*
Heavy	5	41.7	7	58.3	
BMI					
Normal	21	75.0	7	25.0	0.05 [#]
Overweight	6	50.0	6	50.0	

* $p < 0.05$ = statistically significant ; # borderline significance

Source: Primary Data, 2025

The results of the bivariate analysis are presented in Table 4. Age, years of service, and exercise habits were not significantly associated with MSDs ($p > 0.05$). However, repetitive motion and workload demonstrated significant associations with MSDs, with p-values of 0.01 and 0.04, respectively. Workers exposed to high repetitive motion had a greater proportion of high MSDs complaints compared with those exposed to low repetitive motion. Similarly, respondents with heavy workloads tended to experience higher MSDs complaints than those with lighter workloads. BMI showed a borderline association with MSDs ($p = 0.05$). Overweight respondents demonstrated a higher proportion of severe musculoskeletal complaints compared with respondents with normal BMI, suggesting that excess body weight may contribute to increased musculoskeletal burden among workers.

Table 5. Correlation Analysis between Occupational Factors and MSDs Scores

Variable	R	p-value
Repetitive Motion	0.42	0.01*
Workload	0.31	0.04*
BMI	0.28	0.05 [#]

* $p < 0.05$ = statistically significant ; # borderline significance

Source: Primary Data, 2025

Table 5 presents the results of the Spearman correlation analysis between occupational factors and MSDs scores. Repetitive motion showed the strongest positive correlation with MSDs ($r = 0.42$; $p = 0.01$), indicating that increased repetitive activities were associated with higher musculoskeletal complaint scores. Workload also demonstrated a positive correlation with MSDs ($r = 0.31$; $p = 0.04$). Meanwhile, BMI showed a weaker but borderline significant correlation with MSDs ($r = 0.28$; $p = 0.05$).

Table 6. Binary Logistic Regression

Variable	OR	95% CI	p-value
Repetitive Motion	2.8	1.21 – 6.42	0.02*
Workload	2.1	1.03 – 4.85	0.04*
BMI	1.6	0.98 – 3.92	0.05 [#]

* $p < 0.05$ = statistically significant ; # borderline significance

Source: Primary Data, 2025

Table 6 presents the results of binary logistic regression analysis. Repetitive motion was identified as the factor most strongly associated with MSDs (OR = 2.8; 95% CI = 1.21–6.42; $p = 0.02$). Workers exposed to high repetitive motion had a greater likelihood of experiencing higher MSDs complaints compared with those exposed to lower repetitive motion. Workload was also significantly associated with MSDs (OR = 2.1; 95% CI = 1.03–4.85; $p = 0.04$). In addition, BMI demonstrated a borderline association with MSDs (OR = 1.6; 95% CI = 0.98–3.92; $p = 0.05$). The study showed that occupational factors, particularly repetitive motion, demonstrated the strongest association with MSDs among animal feed warehouse workers.

DISCUSSION

Repetitive Motion and MSDs

This study identified repetitive motion as the strongest occupational factor associated with musculoskeletal disorders (MSDs) among animal feed warehouse workers. Correlation analysis reveals a positive relationship between repetitive motion and MSDs ($r = 0.42$; $p = 0.01$), while binary logistic regression indicates that workers exposed to high levels of repetitive motion are 2.8 times more likely to experience severe musculoskeletal complaints compared to those with lower exposure levels ($OR = 2.8$; $95\% CI = 1.21-6.42$). This demonstrates that repetitive manual material handling is a primary ergonomic risk factor in animal feed warehouse operations.

Workers in this study routinely perform repetitive manual material handling activities, including lifting, carrying, stacking, sorting, and moving feed sacks. Continuous exposure to these activities without adequate recovery time can increase biomechanical loads on muscles, tendons, ligaments, and joints, leading to cumulative tissue microtrauma and muscle fatigue (Punnett & Wegman, 2004). Consistent with these mechanisms, Figure 2 among animal feed warehouse workers, the lower back was the body part most frequently affected by musculoskeletal complaints (72.5%), followed by the shoulders (60.0%), upper arms (50.0%), neck (45.0%), and wrists or hands (40.0%). The prevalence of lower back complaints can be explained biomechanically because repetitive lifting combined with prolonged trunk flexion, twisting, and high force exertion increases the compressive and shear forces acting on the lumbar spine (Anwer et al., 2021). Similarly, repetitive upper-limb movements increase muscular load on the shoulders, upper arms, and wrists, resulting in tendon strain and cumulative trauma disorders. This study aligns with previous research identifying the lower back and upper limbs as the body parts most vulnerable to repetitive manual handling activities (Andersen et al., 2021; Greggi et al., 2024; Kee, 2025).

Research by Evadarianto et al. (2017) showed that repetitive activities combined with unergonomic work postures significantly increase musculoskeletal complaints among manual handling workers. Similarly, Tjahayuningtyas (2019) identified repetitive motions and manual handling activities as important predictors of musculoskeletal complaints among informal sector workers. More recent studies have further strengthened this evidence. Research by Demissie et al. (2024) showed that repetitive work exposure consistently increases the risk of work-related musculoskeletal disorders across labor-intensive occupations and accelerates cumulative musculoskeletal strain through prolonged physical exposure (Liu et al., 2025).

However, research findings on repetitive motions are not entirely consistent across work environments. A systematic review by (Anwer et al., 2021) reported limited evidence regarding the association between repetitive work and musculoskeletal disorders (MSDs) among construction workers, while stronger associations were reported for manual material handling, uncomfortable postures, and prolonged work. These differences can be explained by differences in job tasks, exposure intensity, and ergonomic control measures.

Physical Workload and MSDs

This study showed that physical workload is significantly associated with musculoskeletal disorders (MSDs) in feed warehouse workers. Correlation analysis revealed a weak positive relationship between physical workload and MSDs ($r = 0.31$; $p = 0.04$), while binary logistic regression showed that workers exposed to heavy physical workloads were 2.1 times more likely to experience severe musculoskeletal disorders than those with lighter workloads ($OR = 2.1$; $95\% CI = 1.03-4.85$). This suggests that excessive physical demands contribute significantly to musculoskeletal strain among workers performing manual material handling activities.

The workers in this study routinely lifted, carried, stacked, and moved feed sacks, all of which required significant physical effort throughout the working day. Continuous muscular exertion and repetitive manual handling increase the biomechanical load on muscles and joints, accelerate muscle fatigue, and reduce recovery capacity, thus increasing the risk of musculoskeletal disorders (MSDs) (Tarwaka, 2014). These job demands are particularly relevant in feed warehouses, where most material handling activities are still performed manually with limited mechanical equipment.

This finding is also consistent with previous research showed that excessive physical workload is strongly associated with musculoskeletal disorders. Research by Putri et al. (2024) showed that workers exposed to heavy physical workloads experienced higher rates of musculoskeletal disorders than workers with light workloads. Similarly, Cui et al. (2026) stated that prolonged exposure to physically demanding work increases muscle tension and musculoskeletal strain among industrial workers. A recent systematic review by Santos et al. (2025) concluded that heavy physical workloads, repetitive work activities, and manual material handling remain the dominant occupational risk factors for MSDs in labor-intensive industries. Overall, this study strengthens existing research, which suggests that excessive physical workload is a significant factor in the development of musculoskeletal disorders among workers.

However, (Sundstrup et al., 2020) reported that ergonomic modifications, workplace redesign, and organizational interventions substantially reduced musculoskeletal symptoms among employees performing physically demanding jobs. This study demonstrated that the effects of physical workload can vary depending on ergonomic control measures, workload management, and workplace organization. In this study, workers performed manual material handling activities with limited mechanical assistance and minimal ergonomic interventions, which may explain the significant association observed between physical workload and MSDs.

Body Mass Index and MSDs

Body mass index (BMI) showed a borderline association with musculoskeletal disorders (MSDs) among animal feed warehouse workers. Correlation analysis revealed a weak positive correlation ($r = 0.28$; $p = 0.05$), while binary logistic regression showed that overweight workers had a higher risk of MSDs compared to workers with a normal BMI (OR = 1.6; 95% CI = 0.98–3.92). This study suggests that excess weight may contribute to musculoskeletal strain, although the effect appears weaker than occupational factors such as repetitive motion and physical workload.

Excess body weight increases the biomechanical load on muscles and joints, particularly in weight bearing areas such as the lumbar spine, hips, knees, and lower extremities. During repetitive manual material handling activities, increased body mass may increase compressive forces, alter postural stability, and accelerate muscle fatigue, thereby increasing the risk of musculoskeletal disorders (Andersen et al., 2021). These findings are in line with previous research showing that workers with a higher BMI are more susceptible to MSDs because excess weight increases biomechanical stress during work activities (Nugraha et al., 2024). Similarly research by Boocock et al. (2024) explained that overweight workers experience greater mechanical loads during repetitive physical tasks, which increases the likelihood of musculoskeletal symptoms. Overall, the above findings suggest that BMI may exacerbate the impact of workplace ergonomic exposures rather than acting as an independent risk factor.

However, the role of BMI in MSDs remains complex. Viester et al. (2013) showed that the relationship between BMI and musculoskeletal symptoms is modified by physical workload, indicating that overweight workers are more likely to experience MSDs when exposed to physically demanding jobs than workers performing less physically demanding tasks. This may explain why repetitive motion and physical workload demonstrated stronger associations with MSDs than BMI in the present study.

The relatively weak association observed in the present study suggests that just BMI may not be sufficient to explain MSD occurrence. Instead, its influence may become more pronounced when combined with high repetitive motion and heavy physical workload, indicating a possible interaction between individual and occupational risk factors.

Age, Years of Service, and Exercise Habits

Based on the results of this study, age ($p=0.62$), years of service ($p=0.91$), and exercise habits ($p=0.38$) were not significantly associated with musculoskeletal disorders (MSDs). These results suggest that occupational ergonomic exposures, particularly repetitive motion and physical workloads, may contribute more to musculoskeletal complaints than demographic and lifestyle characteristics among warehouse workers.

Although increasing age and longer years of service are theoretically associated with cumulative musculoskeletal exposure, the relatively similar work activities among respondents showed no statistically significant association in this study. Workers in the present study routinely performed similar manual material handling activities during their daily work processes. This is in line with research by Tjahayuningtyas (2019), which explains that exposure to ergonomic risks shows a stronger relationship with musculoskeletal disorders than demographic factors among workers. However, previous studies have reported contrasting findings. Palmer et al. (2015) identified that increasing age can contribute to MSDs due to degenerative changes in the musculoskeletal system, while Gregg et al. (2024) concluded that workplace exposure can increase cumulative biomechanical loading and MSD risk. This difference may be due to the relatively similar work activities and ergonomic exposures among respondents in this study, which may minimize the influence of age and years of service on MSD incidence.

Based on the results of this study, exercise habits also did not show a statistically significant relationship with MSDs. However, respondents who only exercise occasionally tended to report higher rates of musculoskeletal disorders than those who exercise regularly. Regular physical activity can improve muscle flexibility, blood circulation, muscle strength, and musculoskeletal endurance, potentially reducing musculoskeletal strain during work activities. However, the frequency, duration, intensity, and type of exercise were not comprehensively evaluated in this study. This limitation explains the lack of a statistically significant association between exercise habits and MSDs. Therefore, while regular exercise remains beneficial for

Rahmania, N.E.N., Maryiantari, E.S., Kuncoro, A., Irianingtyas, R & Damayanti, R. (2026).. Repetitive Motion: Is A Risk Factor..... maintaining musculoskeletal health, reducing ergonomic hazards in the workplace should remain a primary strategy for preventing MSDs among feed warehouse workers.

Practical Implications

The findings of this study suggest that ergonomic interventions should primarily focus on reducing repetitive motions and excessive physical workload, which have been identified as key occupational factors associated with musculoskeletal disorders (MSDs) among feed warehouse workers. Interventions such as task rotation, stretching programs, workload adjustments, and the use of mechanical lifting aids can help reduce biomechanical stress during repetitive manual material handling activities. Previous studies have shown that workplace ergonomic intervention programs effectively reduce musculoskeletal complaints while improving worker safety and productivity (Mgbemena et al., 2020). Therefore, regular ergonomic risk assessments and the implementation of engineering and administrative controls should be prioritized to reduce the risk of MSDs and promote safer manual material handling practices in animal feed warehouses.

Study Limitations and Future Research

This study has several limitations that should be considered when interpreting the findings. First, the cross-sectional design allowed the identification of associations between occupational factors and musculoskeletal disorders (MSDs) but did not permit conclusions regarding causal relationships. Second, the study was conducted in a single animal feed warehouse; therefore, the findings should be interpreted within the context of similar work environments. In addition, musculoskeletal complaints were assessed using the standard Nordic Body Map questionnaire, which relies on workers' self-reported symptoms. Furthermore, this study did not include psychosocial factors or detailed assessments of the frequency, duration, intensity, and type of exercise, which may also influence musculoskeletal complaints among workers.

Future studies are recommended to include workers from a variety of warehouse environments, employ a longitudinal study design, and incorporate psychosocial, organizational, and lifestyle factors to provide a more comprehensive understanding of the determinants of MSDs. The result of this research could support the development of more effective ergonomic intervention strategies to prevent MSDs among warehouse workers.

CONCLUSION

The results of this study indicate that repetitive motion and physical workload are significantly associated with musculoskeletal disorders (MSDs) among feed warehouse workers in Sidoarjo. Repetitive motion was identified as the strongest factor associated with MSDs (OR=2.8; $p=0.02$), indicating that repetitive manual activities remain a major ergonomic problem in feed warehouse work environments. Workers exposed to high repetitive motions and heavy physical workloads tend to experience higher rates of musculoskeletal complaints compared to workers with lower exposure. Body mass index (BMI) also showed a near-significant association with MSDs (OR=1.6; $p=0.05$), indicating that excess weight may increase musculoskeletal strain during repetitive physical activity. In contrast, age, year of service, and exercise habits were not significantly associated with MSDs. Overall, repetitive work exposure remains a significant ergonomic problem among warehouse workers and should be a priority in workplace prevention programs.

RECOMMENDATION

Warehouse management is advised to implement ergonomic interventions aimed at reducing repetitive manual activities and excessive physical workload among workers. Some preventative measures that can be implemented include workload adjustments, task rotation, pre-shift stretching programs, ergonomics education, and the provision of mechanical handling aids to support safer manual handling activities. Regular ergonomic assessments are also needed to identify occupational risk factors and improve workers' occupational health conditions. Future studies are recommended to involve larger sample sizes and include additional variables such as psychosocial factors, work organization, and work posture to gain a more comprehensive understanding of the factors associated with musculoskeletal disorders among warehouse workers. Longitudinal studies are also needed to better evaluate the long-term effects of occupational exposures on musculoskeletal health.

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