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Assessing the Effectiveness of Manual Handling Training in Reducing Forceful Exertion for Workers in a Medical Device Manufacturing Company

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Abstract

Workplace ergonomics is important for ensuring employee health and safety, especially in industries involving manual handling tasks. This study evaluates the effectiveness of manual handling training in reducing forceful exertion among workers in a medical device manufacturing company. The primary objectives were to identify the prevalence of forceful exertion injuries, assess the knowledge gained from the training program and provide recommendations to sustain ergonomic practices. The research involved 20 workers from the Test Department, who regularly engage in tasks such as setting up and storing tester fixtures, motor boxes, ICT jigs and relocating stabilizers, all of which require significant physical effort. A mixed-method approach was employed, combining document reviews, self-assessment surveys and pre- and post-training evaluations. An Ergonomic Risk Assessment (ERA) conducted by an external assessor identified forceful exertion as a significant risk factor, recommending manual handling training to mitigate these risks. The findings revealed that lower back and foot discomfort were prevalent among workers, primarily due to repetitive heavy lifting and prolonged standing. The manual handling training significantly improved worker's knowledge, as evidenced by the increase in post-training test scores. The paired t-test analysis confirmed a statistically significant difference between pre- and post-training scores, indicating the knowledge gained from the training. Feedback from participants was overwhelmingly positive, highlighting the training's relevance and applicability to their work. Recommendations include organizing cross-training events, conducting more practical sessions, displaying lifting weight guidelines to enhance ergonomic awareness and implementing scissor lifter trolleys or step stools to reduce ergonomic risks.

1. Introduction

In the modern industrial environment, workplace ergonomics plays a crucial role in safeguarding employee health and safety, particularly in sectors that involve manual handling tasks. A medical device manufacturing company, which designs, develops and supplies medical devices as well as laboratory instruments for fields such as biopharmaceuticals, forensics and clinical diagnostics which must prioritize ergonomic practices to maintain productivity, reduce workplace injuries and enhance overall job satisfaction [1][10]. Ergonomics is the study of optimizing work environments to fit the capabilities and limitations of workers, plays a crucial role in achieving these goals. It involves the design and arrangement of workplaces, products, and systems to ensure health and safety [6]. Known as 'human factors,' this scientific field focuses on understanding human capabilities and limitations [5]. Working in environments that pose ergonomic risks, such as forceful exertion during tasks such as lifting, pushing and pulling heavy equipment, can lead to work-related musculoskeletal disorders (WMSDs) and other health issues [3][4] and decreasing productivity among manufacturing workers [7]. Responsible organizations recognize these challenges and take proactive measures to mitigate ergonomic risks.

Ergonomic Risk Assessments (ERA) was conducted to assess workplace ergonomic risks, particularly in the medical device industry and align with Section 15 of the Occupational Safety and Health Act 1994 (OSHA 1994). The ERA conducted on October 5 and December 11, 2023 by externally trained assessors identified high-risk tasks in the Test Department, involving 20 test engineers and technicians. One of the primary risk factors identified was forceful exertion, especially in tasks such as setting up testers, ICT and stabilizers which require handling heavy machinery and materials. The ERA findings highlight lower back pain as a common concern among Test Engineers and Technicians which arising from forceful exertion. The findings indicate a high prevalence of pain or discomfort, especially in the lower back, feet, neck and shoulders [2] with contributing factors such as repetitive lifting, bending, prolonged standing and awkward postures. While the severity of pain was generally low, it highlighted the need for targeted measure.

Reducing excessive physical effort is important to preventing musculoskeletal injuries and ensuring a safer work environment. This study emphasizes the need for interventions such as Manual Handling Training and Ergonomic Awareness Training to mitigate ergonomic risks, enhance worker safety and ensure compliance with regulatory requirements. Inadequate ergonomic training and practices can lead to musculoskeletal pain which negatively impacting worker’s lives outside of work [1]. Therefore, manual handling training is important to improve ergonomic practices and create a safer work environment and prevent accidents, injuries and ergonomic issues such as MSD pain in the neck, lower back, forearms and feet.

2. Methodology

2.1 Document Review and Self-Assessment of Pain or Discomfort

The analysis involved both a document review and a self-assessment questionnaire to determine the prevalence of forceful exertion injuries among workers in the Test Department. The ERA (2023) report by Amcem Lab, conducted in October and December 2023, highlighted the need for ergonomic and manual handling training to address these injuries. The document review focused on forceful exertion injuries contributing to musculoskeletal disorders (MSDs) with additional references ensuring data accuracy. The self-assessment questionnaire measured pain and discomfort in body parts affected by tasks like setting up testers, ICT, and stabilizers. The combined analysis from both methods provided a detailed understanding of the prevalence and contributing factors of forceful exertion injuries in the department.

2.2 Questionnaire Survey

A questionnaire survey was conducted to evaluate respondent's knowledge and awareness of manual handling training before and after the program. The primary data collected were the scoring results from pre- and post-training surveys, which helped determine knowledge gain from Manual Handling Training program in reducing forceful exertion injuries. The survey aimed to gather information about the respondent's understanding, based on their knowledge scores test. The responses were used to determine the level of improvement in respondent's understanding of manual handling and ergonomic risks. The target respondents were 20 workers from the Test Department, including Test Engineers and Test Technicians, selected based on their involvement in manual handling tasks. Table 1 show a questionnaire survey structured. The questionnaire was structured into sections and available in both Bahasa Melayu and English which ensuring ease of understanding for all respondents. The pre- and post-training surveys allowed for a direct comparison of knowledge before and after the training which helping to determine knowledge gained from Manual Handling Training program.

Table 1: Questionnaire survey structured

Pre-Training		Post Training		Questions Structured
Section	**Item**	**Section**	**Item**	
A	Demographic Information	A	Demographic Information	Single-choice
B	Knowledge Test	B	Knowledge Test	Single-choice
C	Not Applicable	C	Training Feedback	Likert scale
D	Not Applicable	D	Suggestions and Improvements	Open-ended

2.2.1 Content Validity

Content validity is an evaluation of the degree to which each item or question in a questionnaire measure what it is supposed to measure. It ensures that the survey or questionnaire accurately reflects the construct being studied and aligns with the research objectives [11]. To achieve this, the content validity of a questionnaire should be assessed by subject matter experts within the relevant field using a qualitative approach [8]. In this questionnaire has been validated by conduct an experts review including both the academic and industry sectors to ensure its validity and reliability for use in this study. Based on the validation form, feedback from two experts in the industry and one academic expert was collected. All of them agreed with the structure and content of the questionnaire survey. Only minor corrections were suggested, which have since been addressed to improve the clarity and effectiveness of the questions for data collection.

2.3 Manual Handling Training Module

The training modules which based on the Guidelines for Manual Handling at Workplace 2018, teach workers about ergonomic awareness and proper manual handling techniques. The training takes about one hour which covers correct methods for pulling, pushing and lifting loads, with practical demonstrations to minimize the risk of musculoskeletal disorders (MSDs). Workers also provided simple exercises to practice it before starting work. The training helps workers recognize incorrect handling methods and highlights the importance of using proper techniques to prevent long-term risks. The training is conducted using PowerPoint presentations, and Test Engineers and Technicians are required to attend.

2.4 Analytical Procedure

The analytical procedure involves evaluating data from qualitative and quantitative methods, including document reviews, expert reviews, and questionnaire surveys, to ensure data validity and reliability. The data collected, analyzed using Microsoft Excel 2016 and presented in various formats such as tables, graphs and charts.

2.4.1 Qualitative Content Analysis

This analysis is to identify patterns, themes, and trends in qualitative data, such as document reviews, by analyzing the frequency of specific words and phrases. This method helps understand forceful exertion injuries and their impact on workers.

2.4.2 Quantitative Content Analysis

This analysis involves using a self-assessment questionnaire to measure the prevalence and severity of injuries. Pre- and post-training scores are compared to assess the training's effectiveness in improving workers' knowledge of manual handling techniques.

2.4.3 Paired T-test Analysis

This is to compares pre- and post-training scores using a paired t-test in Excel 2016 to determine significant differences in knowledge before and after training. P-Value helps assess the statistical significance of results, with a p-value of less than 0.05 indicating that the results are statistically significant and the null hypothesis can be rejected. Table 2 shows the relationship between the hypothesis and the p-value.

***Table 2*: Relationship between the hypothesis and the p-value.**

Null Hypothesis (H_0):	Alternative Hypothesis (H_a)
The two population means are equal. The average test scores of pre training and post training are equal.	The two population means are not equal. The average test scores of pre training and post training are not equal.
If p-value < 0.05: Reject the null hypothesis (there is a significant difference between the score test).	If p-value ≥ 0.05: Fail to reject the null hypothesis (there is no significant difference between the score test).
H0:(μ1 ≤ μ2)	Ha:(μ1> μ2)

2.5 Thematic Analysis

This analysis was used to interpret the textual data from the workers (respondents) survey and safety officer's discussion to gather qualitative data on their experiences, suggestions and preferences for sustaining awareness and promoting ergonomic practices. This method conducted to fulfil the third objective of the research.

3. Result and Discussion

3.1.1 Demographic of respondent

The demographic and work-related characteristics of a group of 20 respondents are summarized in Table 3. This data provides indicate into various factors such as the respondent's roles, age, gender, education level, marital status, smoking habits, daily working hours, and experience within the company. Understanding these factors is crucial for identifying trends and patterns in the workforce, which can influence organizational decisions, training programs, and overall work culture. The data reflects a diverse range of ages, educational backgrounds, and work experiences, offering valuable perspectives on the workforce's composition and needs.

***Table 3*: The pain or discomfort experienced by workers in the Test Department while performing tasks**

		Frequency	Percentage (%)
Work Unit	Engineer	13	65
	Technician	7	35
Age Range	18-24 years old	1	5
	25-34 years old	12	60
	35-44 years old	5	25
	45-54 years old	2	10
	55-64 years old	0	0
	65 years old and over	0	0
Gender	Male	16	80
	Female	4	20
Level of Education	SPM	0	0
	STPM	0	0
	Diploma	7	35
	Degree	12	60
	Master	0	0
	PhD	0	0
	Others	1	5
Marital Status	Married	9	45
	Single	11	55

Table 3: (continue) The pain or discomfort experienced by workers in the Test Department while performing tasks

		Frequency	Percentage (%)
Smoking Status	Yes	4	20
	No	16	80
Average Working Hours per Day	12 hours	9	55
	8 hours	11	45
Years of Experience in the Company	Less than 1 year	5	25
	1-3 years	13	65
	4-6 years	1	5
	7-10 years	1	5
	More than 10 years	0	0

3.1.2 The prevalence of forceful exertion injuries on worker's body part

Based on the Table 4 show a summary of the pain or discomfort experienced by workers in the Test Department while performing tasks shows the result of questionnaire reported that body parts most frequently experiencing discomfort are the lower back and feet. There 9 (45%) of workers reported experiencing lower back discomfort 1-2 times in the last week, 4 (20%) reported discomfort 3-4 times and others 7 (35%) were no experiencing lower back discomfort reported. This high incidence of lower back pain attributed to repetitive heavy lifting, bending or continued standing which are common in the tasks performed in the Test Department. Similarly, the feet are significantly affected with 11 (55%) of workers reporting discomfort in the right foot, 10 (50%) in the left foot and others 5 (25%) on right foot, 6 (30%) on left foot were no experiencing feet discomfort reported. This shows that the environment of the work possibly involving long periods of standing or inadequate footwear which contributes to the high levels of foot discomfort. In addition to the lower back and feet, the neck and shoulders also show levels of discomfort. The data indicates that 9 (45%) of workers experience neck pain, while discomfort in the shoulders ranges from 6 (30%) to 8 (40%). These issues may arise from awkward postures or overhead tasks, particularly when handling stabilizers or jigs, which require workers to maintain positions that strain these areas. Other body parts such as the upper back, arms, and thighs show little to no reported discomfort. The upper back has a relatively low incidence of pain, with only 4 (20%) of workers experiencing discomfort. The arms and thighs, along with other areas like the knees and lower legs report no discomfort. Its indicate that these body parts are either not heavily involved in the tasks or that ergonomic measures are effectively reduce potential issues. Despite the frequency of discomfort reported, the severity appears to be relatively low. Only a small percentage of workers 1 to 4 (5%-20%) experience discomfort 3-4 times a week and cases of daily or more frequent discomfort are rare. This indicates that while discomfort is prevalent, it has not yet reached a level that significantly disrupts daily activities or tasks.

Table 4: The pain or discomfort experienced by workers in the Test Department while performing tasks

Pain or Discomfort of body part	Never		1-2 Times Last Week		3-4 Times Last Week		Once Every Day		Several Times Every Day		Total Pain Discomfort	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Neck	10	50	9	45	0	0	1	5	0	0	10	50
Shoulder (Right)	10	50	8	40	2	10	0	0	0	0	10	50
Shoulder (Left)	11	55	6	30	0	0	3	15	0	0	9	45
Upper Back	16	80	2	10	0	0	2	10	0	0	4	20
Upper Arm (Right)	20	100	0	0	0	0	0	0	0	0	0	0

Table 4: *(continue).* The pain or discomfort experienced by workers in the Test Department while performing tasks

Pain or Discomfort of body part	**Never**		**1-2 Times Last Week**		**3-4 Times Last Week**		**Once Every Day**		**Several Times Every Day**		**Total Pain Discomfort**	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Upper Arm (Left)	20	100	0	0	0	0	0	0	0	0	0	0
Lower Back	7	35	9	45	4	20	0	0	0	0	13	65
Forearm (Right)	20	100	0	0	0	0	0	0	0	0	0	0
Forearm (Left)	20	100	0	0	0	0	0	0	0	0	0	0
Wrist (Right)	20	100	0	0	0	0	0	0	0	0	0	0
Wrist (Left)	20	100	0	0	0	0	0	0	0	0	0	0
Hip/Buttocks	20	100	0	0	0	0	0	0	0	0	0	0
Thigh (Right)	20	100	0	0	0	0	0	0	0	0	0	0
Thigh (Left)	20	100	0	0	0	0	0	0	0	0	0	0
Knee (Right)	20	100	0	0	0	0	0	0	0	0	0	0
Knee (Left)	20	100	0	0	0	0	0	0	0	0	0	0
Lower Leg (Right)	20	100	0	0	0	0	0	0	0	0	0	0
Lower Leg (Left)	20	100	0	0	0	0	0	0	0	0	0	0
Foot (Right)	5	25	11	55	3	15	0	0	1	5	15	75
Foot (Left)	6	30	10	50	3	15	0	0	1	5	14	70

3.1.3 The Ergonomics Risk Factor

The Test Department activities include setting up and storing testers (fixtures and motor boxes), setting up and managing storage of ICT (jigs) and setting up stabilizers require forceful exertion where workers need excessive force to pull, push, lift manually handling where discomfort occurs in the body. Hence, the ergonomic risk factor faced by workers in the Test Department is caused by forceful exertion. Table 5 show the details of forceful exertion factor to ergonomics injuries.

Table 5: Details of forceful exertion factor to ergonomics injuries.

Category	Factor
Restricted Access for Equipment	Narrow walkways prevent the use of trolleys for transportation, necessitating additional manual effort to carry items.
Repetitive Tasks	Repeated handling of ICT jigs (15–20 minutes per unit, handling 15 units per shift).
Push/Pull Force Requirements	Moving stabilizers requires a push/pull force ranging from 22–136 N, depending on the stabilizer size.
Awkward Postures	Frequent bending, reaching, or lifting to handle items from storage racks or workstations. Actions include lifting above shoulder height or working at floor level.

Table 5: (continue). Details of forceful exertion factor to ergonomics injuries.

Category	Factor
Inadequate Use or Maintenance of Tools	Inefficient use of storage and retrieval systems for ICT jigs, which may result in additional manual handling if not used correctly.

Based on the Table 5 details of forceful exertion factor to ergonomics injuries, the Test Engineers and Technicians are responsible for storing testers, fixtures and motor boxes in a mobile compact cabinet. During this process, technicians will manually lift or lower items weighing between 1.5 to 33 kilograms per unit from storage racks. These items are then transported to their designated locations using a trolley. However, the narrow walkways between the racks restrict trolley access, which required additional manual effort to carry the items to the trolley. The others factor is where manpower is limited and worker will lift the bulky items weighing exceed to 33 kg that handled by a single person which will increases the physical demand on the workers. This task is basically a cause of ergonomic risk, where the main cause is forceful exertion.

Besides that, the other task that contribute to forceful exertion is workers setting up and managing storage of ICT (jigs) by using a storage and retrieval system. This task does not indicate high severity but may come if employees no longer use the system provided. During this process, workers will remove the cables attached to the jigs and then transport them to the storage area using a trolley. The storage and retrieval system is utilized to organize and access the jigs efficiently. For retrieval, workers operate the system to locate the required jigs, which are then moved back to the workstation by a trolley which will ensuring smooth transitions between storage and operational use. Hence, this force for task is not a high severity but still need to maintain its action. The other task is Setting up a Stabilizers which involves to relocated of stabilizers within a 10-meter distance and its usually within the same production line. The process begins with technicians unplugging the cables connected to the stabilizers. Workers then move the stabilizers to the new location using wheel safe locks, which require push or pull force from a location to the another. Once relocated, the technicians plug in the cables and power up the stabilizers, ensuring they are ready for use in their new position. Hence, this task also not a high severity because they have a trolley to use but still need to maintain its action.

3.1.4 Knowledge Test Score

The collected data is a test score to assess the improvement of respondent knowledge which is conducted during pre and post training. The data presented the different scores on pre-training and compared with the post-training scores. Table 6 presents the total test scores of 20 respondents before and after the training.

Table 6: Total test scores of 20 respondents

Respondent	**Total test score of respondents**	
	Pre-test	**Post-test**
1	7	10
2	7	10
3	4	10
4	5	9
5	6	10
6	7	10
7	4	10
8	6	10
9	8	10
10	5	10
11	9	10
12	8	10
13	7	10
14	4	10
15	7	10
16	6	10
17	7	10
18	6	10
19	8	10
20	8	10

Before the training, many respondents did not achieve full marks. The majority of respondents answer correctly shows they had limited knowledge of ergonomics. After the training, almost all respondents achieved full score of 10. This data highlights the significant increase in the total of correct answers after the training. This can conclude that the majority of respondents were lack a basic understanding of ergonomics before the training, which made it difficult for them to gain a deeper understanding of the subject. Figure 1 show the average of training results a significant improvement in participant's knowledge from the pre-test to the post-test which covered 10 questions. The data collected indicate before the training average test score was 6 which is show respondent with a basic understanding of the subject. Some participants may not have been aware or may have forgotten of certain details that required proper guidelines for manual handling practices. However, after the training the average test score increased to 10, show an improvement in participant's knowledge and understanding of the training given.

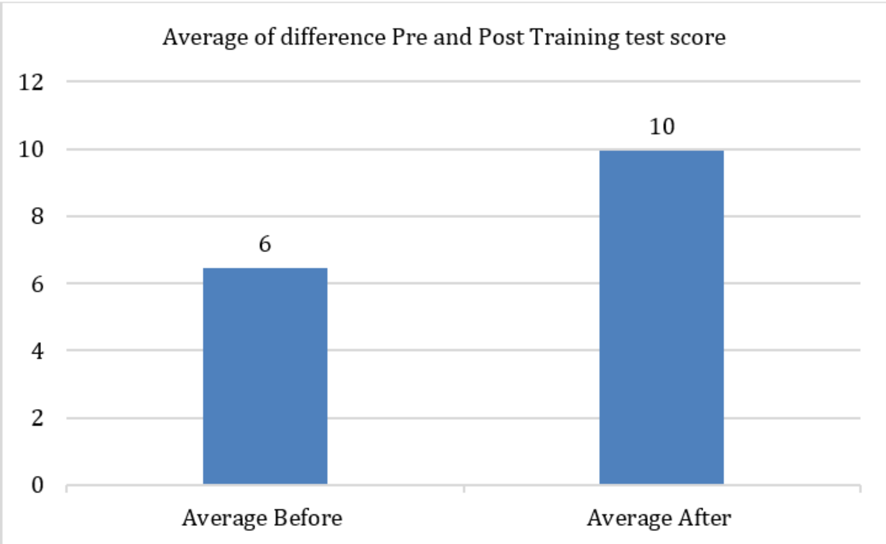

Fig. 1: The average of training results

3.1.5 Paired T Test on difference in mean of pre and post training score test

A paired t-test was conducted to determine there was a significant difference between participant's scores pre and post training session. This test is suitable because it is the same group of participants was measured twice (pre-training and post-training). Table 7 show the paired T test of pre- and post-training score test. The result show that had a significant difference between pre- and post-training score test.

Table 7: Paired T test of pre- and post-training score test

	Pre-Training	*Post Training*
Mean	6.45	9.95
Variance	2.155263158	0.05
Observations	20	20
Pearson Correlation	0.232476601	
Hypothesized Mean Difference	0	
df	19	
t Stat	-10.92515329	
P(T<=t) one-tail	6.21226E-10	
t Critical one-tail	1.729132812	
P(T<=t) two-tail	1.24245E-09	
t Critical two-tail	2.093024054	

Based on the Table 7 Paired T test of pre- and post-training score test, the results showed a statistically significant increase in scores after the training (Mean Before = 6.45, Mean After = 9.95, t = -10.93, $p < 0.001$). Mean score of pre the training was 6.45, while the mean score of post training increased to 9.95. This is indicated that have an increase of 3.50 points in participant’s performance after the training. The P(T ≤ t) two-tail value is the p-value for a two-tailed t-test. It represents the probability of observing a test statistic such calculated t-value under the null hypothesis. The p value is 1.24245E-09 which is less than the standard significant level of 0.05 (<0.05). Since the p-value is extremely small ($p < 0.05$), the null (H_0) hypothesis rejected which states that there is no difference between pre- and post-training scores. This data indicates that the training program led to a significant improvement in participant's knowledge and as evidenced by the increase in test scores.

3.1.6 Training feedback

Training feedback were collected to analysis respondent's agreement levels regarding the manual handling training session. Figure 4.12 shows the training feedback of respondents. For the first question was ask a participation and interaction were encouraged indicates 9 (45%) of respondents strongly agreed and (11) 55% agreed, indicating most participants felt actively engaged during the training. Second question was evaluating the training experience will be useful in their work. The data indicate (9) 45% strongly agreed and (11) 55% agreed. This is showing participants found the training relevant to their work. Other than that, the materials distributed were helpful evaluation were (11) 55% strongly agreed, (9) 40% agreed, and (1) 5% were neutral. Besides, respondents will be able to apply the knowledge learned statement were (11) 55% strongly agreed and (9) 45% agreed which is shows confidence in utilizing the knowledge from the training. For the training met my expectations were also indicate the same data which is (11) 55% strongly agreed and 45% respondents agreed. Lastly, the contents were clear and easy to understand were (11) 55% strongly agreed and (9) 45% agreed, indicating the materials were effectively communicated. Overall, the feedback was positive responded with strong agreement across most categories.

3.1.7 Thematic analysis

Thematic analysis was used to interpret the textual data from the workers (respondents) survey and safety officer's discussion to gather qualitative data on their experiences, suggestions and preferences for sustaining awareness and promoting ergonomic practices. Table 4.14 show respondent's suggestions for sustaining awareness and promoting ergonomic practices. This method conducted to fulfil the third objective of the research. The primary data collected from respondents highlighted several suggestions to improve ergonomic practices and safety in the workplace. Key recommendations included organizing cross-training events, providing more practical manual handling training, and displaying weight-lifting guidelines through posters. Respondents also emphasized the need for ergonomic training for production workers.

Secondary data from an Ergonomic Risk Assessment Report led to discussions on implementing ergonomic solutions. One proposed solution was a scissor lifter trolley for storage and retrieval, but its high cost made it impractical. As an alternative, a step stool was suggested, which would assist in handling items at higher levels safely. Additionally, signage indicating weight capacities for different shelf levels proposed to ensure safe handling of items. The Safety Officer also recommended implementing Ergonomic Awareness Training and encouraging physical exercises, such as stretching.

4. Conclusion

In conclusion, the study evaluated the effectiveness of manual handling training in reducing forceful exertion injuries among workers in a medical device manufacturing company. The results showed that while discomfort reported, particularly in the lower back, neck, and shoulders, the severity was generally low and did not significantly disrupt work. The training program proved effective in improving knowledge about safe manual handling techniques, which helped minimize ergonomic risks. The study also provided recommendations to further enhance workplace ergonomics such as implementing ergonomic training, promoting physical exercises, improving storage systems, and displaying lifting guidelines. While administrative controls like training and posters are beneficial, engineering controls like scissor lifter trolleys or step stools are more effective in reducing injuries. For future research, it is suggested to conduct long-term studies and expand the sample size to assess the sustainability of the training's impact and explore personal factors that could influence injury risks. This study highlights the importance of continuous ergonomic training to ensure a safer, healthier work environment.

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