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Original Article

Impact of ergonomic interventions on musculoskeletal health among Thai para rubber workers: evaluating workstation improvements

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ABSTRACT

Introduction: Musculoskeletal disorders (MSDs) are a significant occupational health issue among rubber plantation workers in Thailand. This study evaluates the effectiveness of ergonomic interventions in reducing MSD risks in Ubon Ratchathani Province.

Methods: A quasi-experimental design was used to study 96 workers across urban (UA), semi-urban (SA), and rural (RA) areas. Participants were divided into three groups: a control group (RA), a training-only group (SA), and a group receiving both ergonomic training and workstation improvements (UA). Data were collected using the Nordic Musculoskeletal Questionnaire and Rapid Entire Body Assessment (REBA) tool before and after the interventions. Paired sample t-tests were conducted to analyze changes in REBA scores and ergonomic knowledge.

Results: The UA group, which received workstation improvements, showed a significant reduction in REBA scores from 13.22 (very high risk) to 6.47 (medium hazard) ($p < 0.001$). The SA group exhibited improved training scores ($p < 0.005$) but no significant reduction in ergonomic risks. The RA group showed no significant changes.

Conclusion: The study demonstrates that while ergonomic training improves knowledge, it does not effectively reduce ergonomic risks without corresponding physical modifications to the work environment. Workstation improvements significantly lowered MSD risks in the UA group. These findings suggest that a combined approach of training and environmental interventions is necessary to improve occupational health outcomes in high-risk settings like rubber plantations.

Keywords: Ergonomics, Musculoskeletal disorders, Occupational Health, Workstation improvement, Work safety

Introduction

Southeast Asia has the highest concentration of agricultural workers globally, with significant health impacts stemming from this occupation.[1] A major concern among these workers is the risk of work-related musculoskeletal disorders (WMSDs), which are prevalent due to ergonomic challenges in their work environment. Studies have shown that the prevalence of WMSDs is particularly high in Indonesia (88.39%), Malaysia (81.27%), and Thailand (78.31%).[2] This data underscores the critical need for targeted ergonomic interventions and health monitoring in the agricultural sector within these countries. Ergonomic risks are a significant concern in many occupations, contributing to substantial occupational health and safety challenges. These risks are associated with the development of musculoskeletal disorders (MSDs), which can arise from prolonged sitting, standing, or working in awkward positions. The consequences of such ergonomic stressors can lead to severe acute injuries or chronic musculoskeletal conditions, underscoring the importance of effective ergonomic interventions and workplace modifications.[3] In Thailand, over 11 million individuals, representing 38% of the population, are employed in the agricultural sector. However, the predominance of informal labor within this sector results in considerable disparities in access to healthcare services and the regulation of worker welfare and safety. Consequently, agricultural workers face numerous risks, with significant concerns including ergonomic hazards, chemical exposures, and occupational accidents. These challenges highlight the urgent need for targeted interventions to improve health and safety conditions for agricultural workers in Thailand.[4] Rubber plantation workers endure continuous heavy workloads, especially during the harvesting season. This demanding work environment results in a high prevalence of musculoskeletal disorders (MSDs), with lower back pain being particularly common. Multiple factors contribute to the incidence of lower back pain among these workers, underscoring the need for effective ergonomic interventions and preventive measures to mitigate these risks.[5] Rubber plantation farmers are subjected to high workloads and face significant occupational hazards. Among these workers, 87.00% are exposed to chemicals, and 27.60% encounter venomous animals. Moreover, 87.70% of the farmers suffer from musculoskeletal disorders, 15.70% exhibit symptoms of depression, and 8.90% experience dermatitis on their hands. These findings highlight the diverse health challenges faced by rubber plantation farmers, emphasizing the need for comprehensive occupational health interventions to address these issues.[6] Rubber plantation farmers exhibit a high prevalence of lower back pain, with 55.70% of workers affected. Several factors are significantly associated with this condition, including body mass index (BMI), educational level, and working postures that involve bending below the knee. These associations highlight the multifaceted nature of lower back pain among these workers and underscore the importance of targeted ergonomic interventions and educational programs to mitigate these risks.[7] A study conducted among rubber plantation farmers in Kerala, India, revealed a high prevalence of musculoskeletal disorders (MSDs) across various body regions. The reported prevalence rates were as follows: neck (72.20%), lower back (66.20%), shoulders (44.90%), knees (55.80%), ankles/feet (34.40%), elbows (33.20%), upper back (30.80%), wrists (50.10%), and hips/thighs (15.30%).[8] These findings indicate significant ergonomic challenges faced by rubber plantation workers, necessitating targeted interventions to alleviate the burden of MSDs in this population.[8] In addition, a study conducted among rubber plantation farmers in Nakhon Si Thammarat, Thailand, reported a 71.2% prevalence of lower back pain. This condition was significantly associated with heavy workloads and prolonged standing. These findings highlight the critical need for ergonomic interventions to address these specific risk factors and improve the occupational health of these workers.[9] Ergonomic risk assessment tools are extensively employed across a spectrum of industries, ranging from manufacturing and agriculture to food production and small-scale enterprises. These tools are valued for their ease of use and adaptability in assessing work practices. Among the widely utilized tools are the Ovako Working Posture Analysis System (OWAS), Rapid Upper Limb Assessment (RULA), and Rapid Entire Body Assessment (REBA). Their widespread adoption underscores the importance of ergonomic evaluation in promoting workplace health and safety across diverse sectors.[10] Risk assessments using the RULA and REBA techniques have revealed that various activities performed by rubber plantation farmers pose a high level of risk. These activities have been linked to the development of musculoskeletal injuries.[11] Several organizations have implemented participatory ergonomics initiatives to mitigate workplace risks and enhance work efficiency.

These activities typically involve ergonomic training, observation of work behaviors, and environmental improvements in the workplace.[12-13] Furthermore, risk reduction in ergonomics is also achieved through process redesign, equipment development, or workstation modifications. This approach enhances efficiency, convenience, and speed in work processes while improving the skills, capabilities, and safety of workers.[14-16]

Based on the aforementioned study, it has been found that rubber plantation farmers are at a high risk of musculoskeletal injuries. This elevated risk is attributed to improper working postures, repetitive tasks, frequent lifting of heavy objects, work-related fatigue, as well as socio-economic factors such as low levels of education and income.[17] However, the study did not address ergonomic issues faced by employees working in rubber plantation cooperatives. This group is at risk due to improper working postures, repetitive tasks, and frequent lifting of heavy objects during their often rushed and time-pressured work. Given these reasons, the researcher aims to investigate the effects of implementing an ergonomic program for employees in rubber plantation cooperatives in Ubon Ratchathani Province, Thailand. The goal is to reduce the risk factors for this group and to potentially extend the findings to other high-risk work environments with similar conditions.

Methods

This quasi-experimental research aimed at investigating the effects of ergonomic management on employees responsible for lifting and moving rubber in cooperatives in Ubon Ratchathani Province, Thailand. The study was conducted from August 2018 to July 2019, employing multi-stage sampling in three areas: Urban Area (UA), Semi-Urban Area (SA), and Rural Area (RA), with a total of 96 samples. Based on Krejcie and Morgan's formula.[18]

$$n = \frac{x^2 Np(1-p)}{e^2(N-1) + p(1-p)}$$

Where:

- n = required sample size
- x^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (commonly 3.841 for 95% confidence)
- N = population size
- p = estimated proportion of the population (commonly 0.5 when the exact proportion is unknown, as this provides the maximum sample size)
- e = margin of error (commonly 0.05 for a 5% margin)

Breaking Down the Calculation, Given:

- N = 126 (population size)
- x^2 = 3.841 (chi-square value for 95% confidence)
- p = 0.5 (assuming 50% proportion for maximum sample size)
- e = 0.05 (margin of error)

The formula becomes:

$$n = \frac{3.841\ (126)(0.5)(1-0.5)}{0.5^2(126-1) + 0.5(1-0.5)}$$

$$n = 95.06$$

Rounding the result gives the required sample size of approximately 96.

The sampling process is detailed as follows:

Stratified sampling was used to divide rubber plantation areas in Thailand into four regions: the North, Central, Northeast, and South. The distribution ratio of rubber plantation areas is 1:3:4:14, respectively. This stratification resulted in the selection of one factory from the North, three from the Central, four from the Northeast, and fourteen from the South. For this study, Ubon Ratchathani in the Northeast was chosen.

Stratified random sampling was used to select rubber plantation cooperatives in Ubon Ratchathani. Three areas were chosen: Urban Area (UA), Semi-Urban Area (SA), and Rural Area (RA). Quota randomization was employed to determine the sample group within the rubber cooperatives. Each area provided an equal number of samples, with 32 from each area, totaling 96 samples. The study groups were divided into a control group with no intervention (RA), a training-only intervention group (SA), and a training and workstation improvement intervention group (UA).

Before the intervention, the prevalence of musculoskeletal discomfort was surveyed using the Standard Nordic Questionnaire. Ergonomics knowledge was tested, and ergonomic risks were assessed using the Rapid Entire Body Assessment (REBA) in all three sample groups.

During this phase, workstation improvements were made in UA, and ergonomics training was conducted for UA and SA. After the interventions, ergonomics knowledge was retested, and ergonomic risks were reassessed using REBA in all three sample groups. All participants voluntarily joined the study and signed consent forms.

The questionnaire consisted of two parts. The first part consists of demographic data from the sample group, including age, gender, years of service, and work experience,[19] to gather the prevalence of musculoskeletal disorders (MSDs) in different body parts over the past 12 months, such as shoulders, neck, hands/wrists, elbows, upper and lower back, hips, and knees.[20-21]

The risk of musculoskeletal disorders (MSDs) for the sample groups from the three areas (urban, rural, semi-urban) was assessed using the Rapid Entire Body Assessment (REBA). The assessment analyzed risks associated with the upper part of the musculoskeletal system (arms, forearms, wrists), trunk, neck, lower part, holding postures, and muscle functions. MSD risks were categorized into five levels: negligible risk with no action required (score 1), low risk with change possibly needed (score 2-3), medium hazard risk with further investigation and change soon (score 4-7), high risk with investigation and implementation of change (score 8-10), and very high risk with immediate implementation of change (score ⩾11). REBA provides a quick assessment of working postures and body movements, with checks defined by Sue Hignett.[22-25]

The ergonomics knowledge assessment consists of three parts: 1) knowledge about ergonomics, 2) evaluation of the work area based on ergonomic principles, and 3) modification of workstations.[26] This assessment was piloted with 30 participants to test the questionnaire used in the study. Based on feedback, certain items in the questionnaire were revised. The test-retest reliability of the questionnaire was good, with kappa coefficients ranging from 0.81 to 0.97. Ergonomics knowledge levels were classified into three categories: high knowledge (scores > 75.0%), moderate knowledge (scores 60.0 - 75.0%), and low knowledge (scores ⩽ 60.0%).[27]

Before the workstation improvements, employees in the rubber plantation cooperatives were responsible for lifting and moving rubber sacks from the vehicles brought by farmers. The tasks involved lifting or dragging the sacks to trucks for further sale. Each lift weighed between 25-30 kilograms, with working hours ranging from 6-8 hours per day, three days per week.

Post-improvement, ergonomic risks were specifically addressed for the UA group. Equipment to reduce ergonomic risks was introduced, including hydraulic manual forklifts to assist in lifting and moving rubber, and a conveyor to transport materials to the trucks. A new pallet was designed with height and width tailored to the hip height and arm length of the workers, using the 95th percentile for these measurements. The load capacity of the new pallet was limited to 250 kg to ensure compatibility with the hydraulic manual forklift and conveyor, as shown in Figure 1.

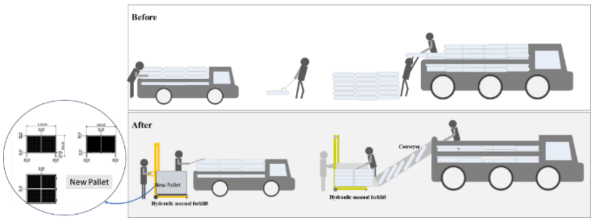

Figure 1. Shows the design of the new workstation of the UA Group

The collected data was analyzed using Statistical Package for the Social Sciences (SPSS) version 22. Descriptive statistics, including frequency distribution and percentage, were utilized to summarize the data. We used Chi-Square test statistics to identify factors associated with musculoskeletal pain in the sample group over the past year.

Comparisons of pre- and post-intervention data for the ergonomic program were conducted using paired sample t-tests. This analysis included

REBA scores and ergonomics training scores. Normality Test, before conducting the paired sample t-test, test the normality of the data distribution to ensure it follows a normal distribution. A paired sample t-test was used to compare the ergonomics training scores before and after the training program. The Ubon Ratchathani Rajabhat University Ethics Committee approved the research proposal (Reference No. HE601021-010/2561). All participants gave written informed consent before enrolment. Registry and the registration no. of the study/trial: N/A. Conflict of interest: The authors declare no conflict of interest for this article.

Results

The data indicates that males report higher instances of pain across all body parts compared to females. Married individuals and those over 50 are more likely to experience pain, particularly in the neck, upper back, and lower back. Higher education correlates with increased pain reports, especially in the neck and lower back. Rural area (RA) shows the strongest association with pain across various body parts, whereas unmarried individuals, those under 50, and those with lower education levels generally report less pain (Table 1).

Table 1: Prevalence of musculoskeletal aches and pains among the sample group in the past 1 year

Body Parts	UA (n=32)	SA (n=32)	RA (n=32)	Total (n=96)
	Number (%)	Number (%)	Number (%)	Number (%)
Neck	10(31.30)	12 (37.50)	18(56.30)	40(41.70)
Shoulder	9(28.10)	7 (21.90)	8(25.00)	24(25.0)
Upper back	14(43.80)	13 (14.60)	14(43.80)	41(42.70)
Lower Back	22(68.80)	18 (56.30)	16(50.00)	56(58.30)
Upper arm	12(37.50)	14 (43.80)	13(14.60)	39(40.60)
Elbow	2(6.30)	2 (6.30)	5(15.60)	9(9.40)
Lower arm	10(31.30)	10(31.30)	10(31.30)	30(31.30)
Hand/Wrist	5(15.60)	5(15.60)	5(15.60)	15(15.60)
hip	7(21.90)	4(12.50)	3(9.40)	14(14.60)
knee	10(31.30)	10(31.30)	9(28.10)	29(30.20)
calf	8(25.00)	4(12.50)	3(9.40)	15(15.60)
foot	3(9.40)	3(9.40)	4(12.50)	10 (10.40)

The results of Table 2 indicate significant associations between demographic factors and musculoskeletal aches and pains among the sample group over the past year. Notably, shoulder pain is significantly linked to gender ($p = 0.019$) and age group ($p = 0.010$), while lower back pain is associated with the level of education ($p = 0.004$). Gender also plays a significant role in hand/wrist pain ($p = 0.025$). Both hip pain and knee pain are significantly associated with age group ($p = 0.005$ and 0.030, respectively) and level of education ($p = 0.007$ and 0.000, respectively). Additionally, calf pain is significantly linked to age group ($p = 0.006$) and education ($p = 0.012$), while foot pain shows a significant association with the level of education ($p = 0.046$), (Table 2).

The risk assessment results using the REBA technique before the implementation of the ergonomic program indicated that the UA, SA, and RA groups had average scores of 13.22, 13.31, and 13.22, respectively, all at a very high-risk level. After implementing the ergonomic program, which included workstation improvements (such as adding a hydraulic manual forklift, conveyor, and new pallet) specifically for the UA group, the average scores were 6.47 (medium hazard) for the UA group, 12.84 (very high-risk level) for the SA group, and 13.12 (very high-risk level) for the RA group. The UA group showed a statistically significant difference in average scores before and after the program (p<.001), (Table 3 and Figures 2-3).

Table 2: Factors associated with musculoskeletal aches and pains among the sample group in the past year.

Body Parts	Gender		Marital status		Age group (year)		Level of education	
	Number (%)	*p-value*	Number (%)	*p-value*	Number (%)	*p-value*	Number (%)	*p-value*
Neck	40(41.70)	0.625	40(41.70)	0.967	40(41.70)	0.647	40(41.70)	0.220
Shoulder	24(25.0)	0.019*	24(25.0)	0.128	24(25.0)	0.010*	24(25.0)	0.221
Upper back	41(42.70)	0.990	41(42.70)	0.022*	41(42.70)	0.617	41(42.70)	0.052
Lower back	56(58.30)	0.494	56(58.30)	0.967	56(58.30)	0.520	56(58.30)	0.004*
Upper arm	39(40.60)	0.854	39(40.60)	0.485	39(40.60)	0.114	39(40.60)	0.303
Elbow	9(9.40)	0.757	9(9.40)	0.596	9(9.40)	0.824	9(9.40)	0.121
Lower arm	30(31.30)	0.138	30(31.30)	0.244	30(31.30)	0.098	30(31.30)	0.726
Hand/Wrist	15(15.60)	0.025*	15(15.60)	0.396	15(15.60)	0.808	15(15.60)	0.061
Hip	14(14.60)	0.094	14(14.60)	0.608	14(14.60)	0.005*	14(14.60)	0.007*
Knee	29(30.20)	0.885	29(30.20)	0.271	29(30.20)	0.030*	29(30.20)	0.000*
Calf	15(15.60)	0.081	15(15.60)	0.555	15(15.60)	0.006*	15(15.60)	0.012*
Foot	10 (10.40)	0.664	10 (10.40)	0.716	10 (10.40)	0.587	10 (10.40)	0.046*

*P<.05, **P<.001

Table 3. Comparison of the differences in REBA scores before and after the ergonomic program

Group	Activity	Mean	SD	Mean difference	95%CI	*p-value*
UA	Before	13.22	0.70	6.750	6.49– 7.00	<0.001*
(n=32)	After	6.47	0.67			
SA	Before	13.31	0.69	0.469	0.01-0.95	0.057
(n=32)	After	12.84	1.42			
RA	Before	13.22	0.71	0.094	0.04-0.23	0.184
(n=32)	After	13.12	0.75			

*P<.001

Before After

Figure 2: Example of Workstation Improvement in UA

The assessment results of ergonomic knowledge scores before the implementation of the ergonomic training program revealed that the UA group had an average score of 56.67 (low level of knowledge), the SA group had an average score of 60.52 (moderate level of knowledge), and the RA group had an average score of 58.85 (low level of knowledge).

Table 4. Comparison of the differences in training scores before and after

Group	Activity	Mean	SD	Mean difference	95%CI	*p-value*
UA (n=32)	Before	56.67	6.92	21.35	19.22-23.49	<0.001**
	After	78.02	9.03			
SA (n=32)	Before	60.52	8.39	14.90	11.98-17.80	0.000**
	After	75.42	11.51			
RA (n=32)	Before	58.85	8.32	3.75	1.49-6.00	0.002*
	After	62.60	9.71			

*P<.05, **P<.001

After the ergonomic training program was conducted for the UA and SA groups, the average scores were as follows: UA group scored 78.02 (high level of knowledge), SA group scored 75.42 (high level of knowledge), and RA group scored 62.60 (moderate level of knowledge). All three groups' average scores before and after the program showed statistically significant differences (p<0.005), as shown in Table 4 and Figure 3.

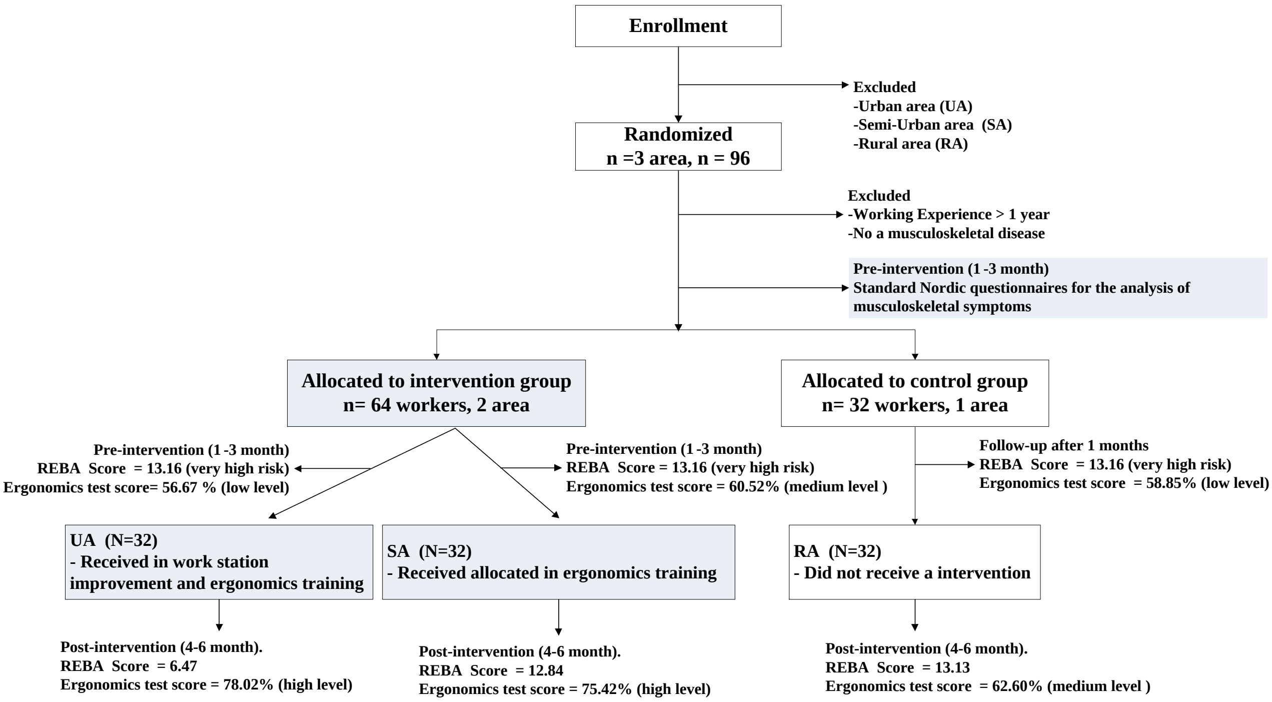

Figure 3. Results from the implementation of the Ergonomic Program

Discussion

Ergonomic interventions, encompassing both workstation improvements and educational training, play a crucial role in reducing musculoskeletal risks in physically demanding jobs. Workstation improvements, such as the introduction of assistive devices and workspace redesign, directly address the physical demands placed on workers, promoting better posture and reducing strain. Meanwhile, ergonomic training aims to enhance workers' awareness and behavior toward workplace safety, although its effectiveness can be limited if not combined with practical environmental changes. Additionally, demographic factors such as age, marital status, and education level significantly influence the prevalence of musculoskeletal pain, highlighting the need for tailored interventions that consider the specific needs of different worker groups. Therefore, our discussion is as follows:

The significant reduction in musculoskeletal risks observed in the UA group following workstation improvements underscores the critical role that physical modifications play in enhancing occupational health. Specifically, the introduction of hydraulic manual forklifts and conveyors addressed key ergonomic challenges by reducing the need for workers to engage in repetitive heavy lifting and awkward postures, which are well-documented contributors to musculoskeletal disorders (MSDs). According to previous research, such physical interventions are essential in alleviating the biomechanical load on workers, thereby decreasing the likelihood of MSDs.[12-13] The UA group's notable decrease in REBA scores from very high risk to a medium hazard level further validates the effectiveness of these interventions.[28] This aligns with findings from other studies, which have shown that ergonomic tools and workstation adjustments can significantly reduce ergonomic risk levels, improving both safety and productivity in the workplace.[14-16] These results highlight the necessity of implementing comprehensive ergonomic programs that prioritize physical workplace modifications to effectively mitigate musculoskeletal risks.[29-30]

The findings from this study indicate that ergonomic training, when implemented without accompanying physical changes to the work environment, may not be sufficient to reduce musculoskeletal risks effectively. This was evident in the SA and RA groups, where despite significant improvements in ergonomic knowledge following the training, there was no corresponding reduction in REBA scores. This suggests that while training can enhance workers' understanding of proper ergonomic practices, it does not necessarily lead to behavioral changes that reduce physical strain if the work environment itself remains unchanged. Previous studies have shown similar outcomes, where ergonomic training alone did not significantly impact musculoskeletal injury rates, particularly in high-risk occupations where the physical demands of the job are substantial.[32] For example, a study involving neurological surgeons found that despite receiving ergonomic training, there was no significant decrease in reported musculoskeletal injuries, underscoring the limitations of education without environmental support. [31] This evidence suggests that ergonomic training should be part of a broader strategy that includes workstation modifications and other physical interventions to effectively lower the risk of musculoskeletal disorders.[32]

The study's findings revealed that certain demographic factors, such as age, marital status, and education level, significantly influenced the prevalence of musculoskeletal pain among workers. Older workers reported higher instances of pain, particularly in the neck, upper back, and lower back. This trend may be due to age-related physical decline, which makes them more susceptible to musculoskeletal disorders. Additionally, married individuals might experience increased physical strain due to additional responsibilities at home, which could exacerbate work-related pain. Interestingly, higher education levels were also associated with increased reports of pain, particularly in the neck and lower back. This may be because more educated workers are likely more aware of their health and better able to articulate and report their discomfort. These findings highlight the need for ergonomic interventions to consider the specific demographic characteristics of workers, as different groups may have varying susceptibilities to musculoskeletal disorders. Tailoring ergonomic strategies to these factors could enhance the effectiveness of interventions and improve overall worker health outcomes.[29-30]

The study's findings strongly advocate for a holistic approach to ergonomic risk reduction, emphasizing the need to integrate both educational and physical interventions to achieve meaningful improvements in worker safety and health. While ergonomic training is essential for increasing workers' knowledge and awareness of proper practices, the results indicate that training alone is insufficient to reduce musculoskeletal risks, particularly in environments where physical stressors remain unaddressed. For example, the SA and RA groups, despite receiving ergonomic training, did not show significant reductions in their REBA scores, highlighting that without accompanying workstation improvements, the physical demands of their tasks continued to pose a high risk. This aligns with previous research that demonstrates the effectiveness of combining ergonomic education with practical modifications in the work environment to reduce ergonomic risks effectively.[25] By incorporating physical changes such as the introduction of ergonomic tools, as seen in the UA group, workers are better equipped to apply their knowledge in a safer and more supportive environment, leading to a substantial reduction in musculoskeletal disorders. Therefore, a comprehensive approach that includes both educational programs and tangible environmental modifications is crucial for achieving long-term reductions in ergonomic risks and improving overall workplace safety.[30,33]

Conclusion

This study highlights the critical importance of adopting a holistic approach to ergonomic interventions in reducing musculoskeletal risks among workers in the rubber industry. The findings demonstrate that while ergonomic training significantly improves workers' knowledge, it alone is insufficient to mitigate the physical risks associated with their tasks. The substantial reduction in REBA scores observed in the UA group, which benefited from both ergonomic education and workstation improvements, underscores the effectiveness of combining educational programs with practical, environmental modifications. This integrated strategy not only enhances workers' ability to apply ergonomic principles but also directly addresses the physical demands of their work, leading to a meaningful reduction in musculoskeletal disorders. Therefore, to achieve sustained improvements in occupational health, especially in physically demanding environments like rubber plantations, organizations should prioritize a comprehensive approach that merges educational initiatives with targeted ergonomic modifications. This dual strategy is essential for ensuring long-term reductions in ergonomic risks and fostering a safer, healthier workplace.

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