Evaluating the effectiveness of a participatory programme for preventing work-related musculoskeletal disorders among slaughterhouse workers in Thailand

ABSTRACT

Aims: This study aimed to develop a model for injury prevention through a participatory work-related musculoskeletal disorders (WMSDs) program designed to reduce localized pain across various body regions among workers in pig production slaughterhouses in Thailand.
Materials & Methods: A quasi-experimental study was conducted involving 40 slaughterhouse workers who participated in a program designed to prevent WMSDs. The prevention program comprised four core activities. Self-administered questionnaires were used to assess the prevalence of WMSDs before and after the intervention.
Findings: This study showed a significant reduction in WMSDs following the prevention programme in four areas: upper arms ($p < 0.001$), hands/wrists ($p = 0.049$), calf ($p = 0.031$), and foot ($p = 0.007$). Furthermore, the severity of pain associated with WMSDs was significantly reduced post-intervention ($t = 7.654$, $p < 0.001$).
Conclusion: After a three-month pilot study implementing a WMSDs prevention programme among workers in pig production slaughterhouses, the participatory model proved effective and may serve as a framework for similar programs in other agricultural factories.

Keywords: Ergonomic, Participation, Prevention programme, Slaughterhouse, Work-related musculoskeletal

Introduction

Work-related musculoskeletal disorders (WMSDs) have a significant impact on mobility and physical function, often leading to early retirement, reduced quality of life, and limited social participation. With the growing population and aging workforce, the prevalence of WMSDs and associated disabilities is rapidly increasing, making it a critical occupational health issue globally. Several countries, including the United States, the United Kingdom, Germany, and Japan, officially recognize WMSDs as occupational diseases eligible for compensation [1, 2]. In the United States, WMSDs are among the most common occupational diseases, particularly affecting workers in jobs requiring prolonged standing or sitting. In 2020, WMSDs accounted for 31.0% of all occupational illnesses [3]. In 2021, a study conducted in Venezuela found that 77% of the population experienced musculoskeletal discomfort. The most commonly affected areas were the shoulders, back, hands/wrists, and neck, with prevalence rates ranging from 83.3% to 90.2%, respectively [4]. Similarly, data from Thailand's Social Security Office indicate that injuries and illnesses related to musculoskeletal disorders ranked highest in incidence for five consecutive years, from 2018 to 2022. According to the Social Security Administration, the incidence rates of WMSDs in Thailand were 2017 (84.54%), 2018 (80.70%), 2019 (80.79%), 2020 (84.66%), and 2021 (72.59%) [5, 6, 7, 8, 9].

The meat processing industry involves the slaughtering, processing, and packaging of pork for human consumption. The process begins with slaughtering the animal and extracting the blood. The carcass is then opened to remove internal organs and thoroughly cleaned. Afterward, the meat is divided into various cuts. Workers in the observed facilities manually cut the meat. Finally, semiautomated production lines weigh and package, depending on the specific product requirements. The industry is particularly susceptible to WMSDs due to the high physical demands of the job. Tasks such as repetitive lifting, prolonged standing, and manual handling of raw materials are associated with musculoskeletal discomfort and injuries [10]. Studies from Iran and Poland revealed high prevalence rates among meat industry workers, with common complaints including lower back pain (38.0%, 64.0%), knee pain (40.00%, 24.0%), and neck pain (24.0%, 42.0%). Similarly, 64.9% of meat processing workers in New Zealand reported hands/wrists pain, while 54.8% experienced pain in multiple body regions, including the limbs and neck [11]. In Denmark, slaughterhouse workers reported high rates of pain in the neck (48.0%), shoulders (60.0%), elbows (40.0%), and hands/wrists (52.0%) [12]. Nigerian butchers exhibited a prevalence of 66.7% for lower back pain and 45.1% for hands/wrists, with age identified as a significant risk factor [13, 14].

The meat processing industry is characterized by factors that contribute to a high prevalence of musculoskeletal discomfort among workers. These include high production volumes, physically demanding tasks, manual handling of raw materials, frequent lifting of heavy weights, and the need for sustained mental concentration due to the variety of products being processed. Also emphasize that meat cutters face significantly higher risks of injuries and musculoskeletal problems compared to most other occupational groups. The regulatory standards for slaughter and meat processing industries recommend implementing job rotations to improve worker safety and reduce risks. These rotations should meet at least one of the following criteria: changing working positions, alternating the use of muscle groups, performing tasks that minimize repetitive motions, or reducing the physical strain caused by lifting and handling heavy loads [15, 16]. According to a previous study, approximately 13% of tasks in slaughterhouses were identified as high-risk for upper extremity work-related musculoskeletal disorders (WMSDs), with risk levels exceeding 21.5%. Moreover, a moderate level of risk was observed in tasks with risk levels ranging from 10.8% to 21.5% [17].

Therefore, this study aims to evaluate the effectiveness of intervention programs for pig slaughterhouse workers, emphasizing ergonomic strategies, training, and posture support. By addressing the physical, environmental, and organizational contributors to WMSDs, this research seeks to mitigate their impact, ultimately enhancing worker health and productivity.

Materials and Methods

A quasi-experimental study was conducted from November 2021 to January 2022, focusing on the implementing a participatory programme to prevent work-related musculoskeletal disorders (WMSDs). The study involved forty participants working in pig production slaughterhouses located in the Muang Ang Thong district, Thailand. The primary objective of this research was to evaluate and compare the severity of WMSDs among participants before and after the intervention. The participatory approach emphasized worker involvement in identifying ergonomic risks, developing preventive measures, and implementing solutions tailored to the specific tasks and challenges of the workplace. The participatory program included five main components: (1) identifying WMSDs using a body map, (2) defining and demonstrating proper work procedures, (3) distribution of WMSDs by body region: pre- and post-intervention analysis, (4) providing knowledge on WMSDs prevention and management, and (5) the comparison of WMSDs severity among participants before and after the quasi-experimental study (Figure 1).

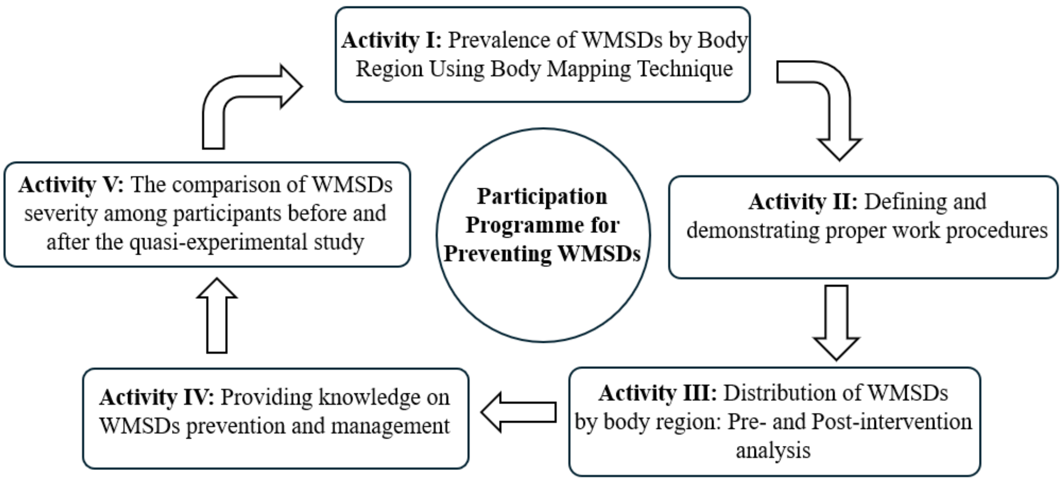

Figure 1. Participatory program for preventing WMSDs among workers in slaughterhouses, Thailand

As a research instrument to measure the prevalence of WMSDs, all participants completed a self-administered questionnaire comprising three sections: Sociodemographic, include gender, age, marital status, body mass index (BMI), smoking, alcohol consumption and work-related information include, work duration, additional occupatinal posittion/job task, and a modified version of the standard Nordic Musculoskeletal Questionnaire (NMQ) adapted for the Thai context. This questionnaire assessed musculoskeletal symptoms across twelve anatomical regions: neck, shoulders, upper back, lower back, upper arm, elbows, lower arm, hands/wrists, hips/thighs, knees, calf and feet. Participants reported soft tissue pain or discomfort experienced within two time frames: the past twelve months and the past seven days. The NMQ, developed by Kuorinka (1987), is a widely validated and reliable tool for diverse populations and settings. Its brevity and ease of completion—taking approximately five minutes—make it especially advantageous for occupational health studies [18]. The analysis of occupational tasks and work processes was conducted with the participation of ten individuals, each possessing over one year of professional experience and demonstrating a comprehensive understanding of their respective roles. Data collection was carried out through structured interviews utilizing closed-ended questions to elicit detailed insights into their task characteristics. The training on the prevention and management of musculoskeletal disorders was conducted by two experts specializing in occupational health and safety.

The study population comprised 108 workers from a pig slaughterhouse in Muang Ang Thong district, Thailand. The sample size was calculated based on the proportion of work-related musculoskeletal disorders (WMSDs) from a quasi-experimental study conducted by KrungKraipetch [19]. Using the comparative proportional formula, a minimum sample size of 37 participants was required. To account for potential attrition, the sample size was increased by 10.0%, resulting in 40 participants who were selected through quota sampling, following the methodology of Chow et al. (2017) [20].

Statistical analyses were performed using SPSS version 17.0 for Windows. Descriptive statistics, including frequencies, percentages, means, and standard deviations (SD), were calculated to summarize the data. The prevalence of work-related musculoskeletal disorders (WMSDs) in different body regions before and after the intervention was compared using Chi-square test. Differences in WMSDs severity scores between pre- and post-intervention were analyzed using paired t-tests, as the data met the normality assumption verified using the Shapiro-Wilk test. A significance level of $p < 0.05$ was applied to all analyses.

Findings

The study included a total of 40 participants, with a gender distribution of 52.5% males and 47.5% females. The majority of participants (37.5%) were aged 34–38 years, followed by those aged 39 years and above (22.5%). Regarding marital status, 62.5% were married, 35.0% were single, while 2.5% were windowed. Most participants had completed primary education (42.5%), junior high school (40.0%), and high school/vocational (17.5%). The most common job positions were stunning/head-cutting operators (27.5%), red pork offal portioning operators

(17.5%), white pork offal portioning operator (15.0%), and carcass cutting/trimming operator (15.0%). Work experience was evenly distributed, with 32.5% of participants each having less than one year and three to four years of experience (mean = 2.40, SD = 1.38). None of the participants reported having secondary employment. In terms of health indicators, 45.0% of participants had a normal BMI (18.5 - 22.9 kg/m^2), while 20.00% were classified as obesity level 1 (25.0 - 29.9 kg/m2), (mean = 23.61, SD = 4.31). The majority were non-smokers (55.0%), current smoker (40%), former smoker (5%), while did not consume alcohol (65.0%), less than monthly (30%), and daily or almost daily (5%) shown in Table 1.

Table 1. Characteristics of slaughterhouse workers in Muang Ang Thong District, Thailand (n = 40)

Varivable	**Frequency**	**Percentage**
Gender		
Male	21	52.5
Female	19	47.5
Age (Years(		
18 - 25	8	20.0
26 - 33	8	20.0
34 - 38	15	37.5
≥ 39	9	22.5
Min. = 19 Max. = 48, Mean = 34.15, S.D. = 8.273		
Marital status		
Single	1٤	35.0
Married	25	62.5
Windowed	1	٢.5
Education		
Primary school	17	42.5
Junior high school	16	40.0
High school/Vocational	7	17.5
Position/Job Task		
Pig inspector	3	7.5
Stunning/Head cutting operator	11	27.5
Half cutting operator	3	7.5
Red pork offal portioning operator	7	17.5
White pork offal portioning operator	6	15.0
Carcass cutting/Trimming operator	6	15.0
Basket cleaning operator	2	5.0
Weighing/Quick chill operator	2	5.0
Working duration (Years)		
< 1	13	32.5
1 - 2	10	25.0
3 - 4	13	32.5
≥ 5	4	10.0

Varivable	Frequency	Percentage
Min. = 1.0, Max. = 5.0, Mean = 2.40, SD = 1.38		
Additional occupations		
No	40	100.0
Yes	0	0.0
BMI)kg/m^2(		
< 18.5	4	10.0
18.5 - 22.9	18	45.0
23.0 - 24.9	5	12.5
25.0 - 29.9	8	20.0
≥ 30	5	12.5
Min. = 17.0 Max. = 34.8, Mean= 23.61 S.D. = 4.31		
Smoking		
Never smoked	22	55.0
Former smoker	2	5.0
Current smoker	16	40.0
Alcohol consumption		
Never	26	65.0
Daily or almost daily	2	5.0
Less than monthly	12	30.0

Note. BMI: Body mass index

Prevalence of WMSDs by body region using body mapping assessment. Analysis of WMSDs symptoms revealed varying levels of severity ranging from mild to severe across different body regions. The highest prevalence was observed in the hand/wrist (n = 30), followed by the lower arms (n = 21), shoulder (n = 17), upper arms (n = 11), and neck (n = 10). Lower prevalence was found in the upper back (n = 8), lower back (n = 5), elbow (n = 3), hip/thigh (n = 3), knee (n = 2), calf (n = 2), and foot (n = 2), as shown in Table 2.

Defining and demonstrating proper work procedures. The study Occupational task analysis and work process documentation included an exchange of experiences related to working methods and equipment for each step of the 10 tasks, which included guiding pigs for slaughter, electrical stunning, hanging legs and stabbing the neck, head cutting, half cutting, scrape fur and cleaning, weighing and sorting the carcasses, red pork offal portioning, white pork offal portioning, and basket cleaning, as shown in Table 3.

Table 2. Prevalence of WMSDs by body region using body mapping assessment (N =40)

Body region	Symptoms of WMSDs				
	No symptoms n (%)	Experiencing symptoms n (%)	Mild n (%)	Moderate n (%)	Severe n (%)
Neck	30 (75.0)	10 (25.0)	5 (50.0)	5 (50.0)	0 (0.0)
Shoulders	23 (57.5)	17 (42.5)	12 (70.6)	4 (23.5)	1 (5.9)
Upper back	32 (80.0)	8 (20.0)	4 (50.0)	4 (50.0)	0 (0.0)
Lower back	35 (87.5)	5 (12.5)	4 (80.0)	1 (20.0)	0 (0.0)
Upper arms	29 (72.5)	11 (27.5)	7 (63.6)	3 (27.3)	1 (9.1)
Elbows	37 (92.5)	3 (7.5)	3 (100.0)	0 (0.0)	0 (0.0)
Lower arms	19 (47.5)	21 (52.5)	12 (57.1)	8 (38.1)	1 (4.8)
Hands/Wrists	10 (25.0)	30 (75.0)	22 (73.4)	7 (23.3)	1 (3.3)
Hip/Thigh	37 (92.5)	3 (7.5)	1 (33.3)	2 (66.7)	0 (0.0)
Knee	38 (95.0)	2 (5.0)	2 (100.0)	0 (0.0)	0 (0.0)
Calf	38 (95.0)	2 (5.0)	2 (100.0)	0 (0.0)	0 (0.0)
Foot	38 (95.0)	2 (5.0)	2 (100.0)	0 (0.0)	0 (0.0)

Table 3. Occupational task analysis and work process

Task	Tools	Work Process
Guiding pigs for slaughter	-	Gently guide the pigs out of the holding pen, leading them along the walkway to the electric stunning point. Close the gating system to confine one pig at a time.
Electrical stunning	- Electric stunning device	Activate the electric stunning machine and check its operational readiness, apply a voltage range of 150–300 volts to the area behind the ears of the pig until it becomes unconscious. Once stunned, unlock the gate to release the pig onto the receiving tray.
Hanging legs and stabbing the neck	- Leg-hanging hook - Neck-sticking knife - Blood-collection equipment	Attach a hook to the hind leg of the pig and use an electric hoist to suspend the pig. Then, use a knife to sever the artery blood vessels in the neck area and allow the blood to drain for approximately 5 minutes. Afterward, transfer

Task	Tools	Work Process
		the pig to the automatic processing system for scalding, dehairing, drying, and wet spinning.
Scrape fur and cleaning	- Hair-scraping knife	Wait for the carcass to descend onto the receiving tray. Use a knife to manually scrape any remaining hair missed by the automatic machine. Following this, use a hook to suspend the carcass by its hind legs.
Head cutting	- Pointed knife for head removal	Stabilize the carcass by holding its hind leg or back with one hand. Use a knife to make an incision at the base of the tail near the anus, then extract the internal organs. Subsequently, hold the foreleg, cut along the head area, and make a longitudinal incision along the chest cavity to remove the internal organs. Place the organs into a tray or basket to be transferred to the cleaning room for further processing.
Half cutting	- Carcass-splitting saw	Stabilize the pig carcass suspended on the conveyor rail to keep it steady. Use a saw to bisect the carcass longitudinally along the spinal column, dividing it into two halves.
Weighing and sorting the carcasses	- Cleaning hose - Weighing scale	After the carcass is halved, move the halved carcass to the workstation and use a hose to clean the carcass halves. Subsequently, transfer the cleaned carcass halves on the conveyor rail to the refrigeration room for chilling and storage.

Task	Tools	Work Process
Red pork offal portioning	- Pointed knife - Basket/packaging bag - Water faucet - Weighing scale	Clean the white organs thoroughly. Trim and cut the organs according to specifications. Place the cleaned organs into baskets for weighing, then package them in bags and record their weight.
White pork offal portioning	- Pointed knife - Basket/packaging bag - Water faucet - Weighing scale	Clean the white organs thoroughly, trimming and cutting them according to specified standards. Place the cleaned organs into baskets for weighing, then package them in bags and weigh them again for record-keeping.
Basket cleaning	- Hose - Cleaning brush/equipment	Rinse the baskets thoroughly using a hose, and scrub them clean with a brush. Occasionally, crouching may be necessary to scrub certain areas effectively. Once cleaned, arrange the baskets on pallets or shelving units to air dry.

This intervention aimed to enhance participants' knowledge regarding preventive measures and operational process optimization. The educational session was conducted by two occupational health and safety experts, curriculum encompassed ergonomic principles and workplace environmental modifications. The two-day training programme, comprising both theoretical instruction and practical applications, focused on postural correction and muscular conditioning for work-related musculoskeletal disorders (WMSDs) prevention. The study included a total of 40 participants.

The analysis revealed statistically significant differences ($p < 0.05$) across all body regions examined. In the upper extremities, a substantial reduction in symptoms was observed ($p < 0.001$), with prevalence decreasing from 28 participants (70.0%) to 16 participants (40.0%). The hands/wrists region also showed a statistically significant decline in symptoms ($p = 0.049$), reducing from 25 participants (62.5%) to 16 participants (40.0%). Similarly, symptoms in the calf region significantly decreased ($p = 0.031$), with prevalence dropping from 20 participants (50.0%) to 10 participants (25.0%). The most pronounced improvement was found in the foot region ($p = 0.007$), where the number of symptomatic participants decreased from 20 (50.0%) to 7 (17.5%) post-intervention.

Conversely, no significant changes were observed in the upper back and lower arms. This lack of improvement could be attributed to the persistent use of these muscle groups for reaching and handling tools, despite the intervention and workstation modifications, as shown in Table 4.

Table 4. Distribution of WMSDs by body region: Pre- and Post-intervention analysis (n = 40)

Body Region	Symptoms of WMSDs				*p*-value
	Pre-intervention (n)		Post-intervention (n)		
	Yes	No	Yes	No	
Neck	3	37	1	39	0.500
Shoulders	27	13	19	21	0.153
Upper back	10	30	10	30	1.000
Lower back	20	20	15	25	0.383
Upper arms	28	12	16	24	<0.001*
Elbows	13	27	8	32	0.302
Lower arms	10	30	10	30	1.000
Hands/Wrists	25	15	16	24	0.049*
Hip/Thigh	17	23	8	32	0.093
Knee	17	23	9	31	0.096
Calf	20	20	10	30	0.031*
Foot	20	20	7	33	0.007*

*notes: *p<0.05*

The analysis of work-related musculoskeletal disorders (WMSDs) severity among participants before and after the quasi-experimental study was conducted using paired t-tests. The findings revealed a statistically significant reduction in WMSDs severity ($t = 7.654$, $p < 0.001$). This reduction highlights the effectiveness of the intervention program, which included ergonomic training, task-specific behavioral modifications, and revised work-rest schedules. These components likely contributed to improved postural awareness and reduced physical strain during work activities.

Discussion

The present study revealed that meat processing workers predominantly performed tasks requiring repetitive hand/arm movements, resulting in the highest prevalence of hands/wrists pain (75.0%), followed by lower arms (52.0%) and shoulder (42.5%) discomfort that is slightly similar to slaughterhouse workers study in the South Island, who reported a 64.9% prevalence of musculoskeletal disorders among meat processing workers, with hands/wrists symptoms accounting for 54.8% of cases [20]. Similarly to findings from a study on poultry slaughterhouse workers in Santa Catarina, Brazil, the most frequently affected body regions were the shoulders (62.6%), neck (46.2%), spine (36.4%), forearms (31.3%), arms (29.2%), and hands/wrists (25.6%) [21]. In the region of northern

Thailand, reported that the prevalence of work-related musculoskeletal pain (WMSP) among poultry slaughterhouse workers was highest in the shoulder region (61.5%) over the past 7 days, followed by the wrists/hands (60.3%) and the lower back (35.9%)[22]. Similarly, for the past 12 months, the prevalence remained high in the same regions, with the shoulder (61.5%), wrists/hands (60.3%), and neck (37.1%) being the most affected areas. Overall, the severity of WMSP across all body regions was classified as mild to moderate, underscoring the significant yet manageable impact of musculoskeletal discomfort on this workforce [23].

Following the three-month intervention, the factory introduced revised work protocols, including mandatory 15-minute rest breaks after every two hours of continuous work. This approach aligns with the findings of Dias et al. [24], who reported that a work-rest schedule comprising six 10-minute breaks was more effective than three 20-minute breaks in reducing the risk of upper limb WMSDs among poultry slaughterhouse workers. As a result of the intervention, a significant reduction in WMSDs was observed, particularly in the upper arms ($p < 0.001$), hands/wrists ($p = 0.049$), calves ($p = 0.031$), and feet ($p = 0.007$). These improvements are attributed to behavioral modifications, including ergonomic training, enhanced manual handling techniques, and the structured work-rest schedule. Ergonomic education played a crucial role in increasing awareness of occupational hazards and mitigating muscle fatigue [25]. These findings are consistent with previous studies by Hancharoenkul et al. [26] and Denadai et al. [27], which demonstrated the effectiveness of ergonomic training in reducing musculoskeletal complaints and pain intensity among both novice and experienced meat industry workers. Denadai et al. further emphasized that training was more accessible for novice workers and that biomechanical exposures varied by experience level, especially in cutting room tasks. These insights underscore the importance of tailoring ergonomic interventions to the worker's experience and task characteristics to optimize effectiveness and promote long-term adoption.

Conclusion

This study demonstrated the effectiveness of a workplace-based WMSDs prevention program in reducing musculoskeletal discomfort and improving ergonomic practices among workers. Positive outcomes included symptom reduction, improved awareness, and behavioral change, supported by rest breaks and ergonomic adjustments. Although limited by its setting and short-term scope, the findings suggest that participatory interventions, combined with organizational support, can enhance occupational health. Future studies should explore long-term effects and integrate psychosocial and work-related factors to strengthen generalizability and impact.