Journal of Associated Medical Sciences 2024; 57 (1): 10-19

JAMS
Journal of Associated Medical Sciences

Scopus Indexed & Thai-Journal Citation Index Centre (TCI)

Journal of Associated Medical Sciences

Journal homepage: https://www.tci-thaijo.org/index.php/bulletinAMS/index

The effects of workplace intervention programs to manage work-related musculoskeletal pain among poultry slaughterhouse workers: A randomized controlled trial

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ARTICLE INFO

Article history:
Received 30 June 2023
Accepted as revised 27 September 2023
Available online 2 October 2023

Keywords:
Work-related musculoskeletal pain (WMSP), workplace intervention programs, poultry slaughterhouse workers (PSW), health promotion, workability, and disability.

ABSTRACT

Background: The prevalence rate of work-related musculoskeletal pain (WMSP) among poultry slaughterhouse workers (PSW) has been reported in the shoulder, arm, and hand due to the involvement of repetitive and forceful upper limb movements. An intervention program is needed to reduce upper limb pain and improve upper limb functions among PSW.

Objectives: This study aimed to investigate the effectiveness of workplace intervention programs on musculoskeletal pain, upper limb functions, and work ability among PSW.

Materials and methods: A total of 48 participants (21 males and 27 females) who met the inclusion criteria were recruited into the study. The participants were allocated into two groups: The workplace intervention group (WIG, N=24; 10 males; 14 females) and the control group (CG, N=24; 11 males; 13 females). The WIG performed the exercise training with elastic resistance bands (ERB) and stretching exercises for eight weeks, and the CG did not perform any activity. The Visual Analogue Scale (VAS), shoulder reach flexibility test, active range of motion (AROM), the disability of the Arm, Shoulder, and Hand (KKU-DASH), and Thai Work Ability Index (Thai WAI) were used as outcome evaluations. The two-way analyses of variance (ANOVAs) with repeated measures (group x time) were used for statistical analyses, and the statistical significance was set at $p<0.05$.

Results: Approximately 79.1% (N=19) of the participants in WIG reported significantly decreased pain intensity of upper limb 3.06 (0.83 to -5.4) in the right side ($p<0.01$) and 1.96 (1.6 to -5.6) in the left side ($p<0.001$) after the 8-week intervention. Meanwhile, shoulder flexibility in WIG significantly increased ($p<0.001$) to around 3.55 cm. (0.67 to 8.20) on the right side and 5.61 cm. (2.0 to 10.67) on the left side. For AROM in WIG, neck flexion, lateral neck flexion, neck rotation, and left shoulder flexion significantly increased ($p<0.05$), as well as KKU-DASH and Thai WAI scores ($p<0.001$). There was no significant difference within-group in all variables in CG.

Conclusion: The workplace intervention program significantly reduced upper limb pain and increased neck movement and shoulder flexion among PSW. The training programs also improved work ability and reduced disability with upper extremity musculoskeletal conditions among PSW.

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doi: 10.12982/JAMS.2024.002
E-ISSN: 2539-6056

Introduction

Work-related musculoskeletal pain (WMSP) represents the most common occupational diseases that have a direct effect on employee health, work disability, and sickness absence.[1] The poultry industry in Thailand is rapidly

expanding to the global demand for chicken products.[2] Conversely, the constant drive for higher profit and production creates adverse factors (i.e., increased working hours, increased production line speeds, or decreased break time), which contribute to WMSP at the workplace and affect the health and well-being of the PSW.[3] The prevalence of WMSP, especially in slaughtering and meat processing operations, was found in the shoulder, neck, and upper extremities due to a high degree of repetitive and forceful upper limb movements, lack of sufficient recovery, and awkward postures.[3] In a recent cross-sectional study among Thai PSW, approximately 97% of PSW had WMSP in at least one body region.[4] The highest prevalence rate was found at the shoulders and wrists/hands regions around 61.5% and 60.3%, respectively. In comparison, 83% of PSW reported work disability due to upper limb pain, emphasizing the functional consequences of arm, shoulder, and hand on daily work.[4] Some previous studies also reported that PSW had pain and discomfort in at least one of the body regions, which includes the shoulder, neck, upper or lower back, forearm, arm, wrist, and hand.[3, 5-7]

Current evidence to reduce or prevent WMSP at the workplace includes physical exercise, ergonomics, participatory ergonomics, and multifaceted interventions.[8] Previous systematic reviews on WMSP were reported among the general working population, such as sedentary employment, office workers, health care workers, or labor.[8] However, the general working population has vastly different working conditions than slaughterhouse workers, and previous findings may, therefore, not be directly transferable to slaughterhouse workers. Unfortunately, only a few previous studies have investigated the effect of workplace interventions among PSW.[9-11] The studies of Sundstrup *et al* found that strength training exercises in high intensity can improve pain, work disability, and strength of the shoulder and wrist muscles among PSW with upper limb chronic pain.[9-11] However, there are many factors, such as the nature of the work environment, physical demands at work, work organization, or the support of the workplaces that vary among PSW from industry to industry, that affect transferring the findings across studies.[8] On the other hand, industry-specific interventions are suggested to have the better potential to reduce WMSP.[8] Workers, workplaces, and other relevant stakeholders such as employers, health care practitioners, managers, and social care workers have to get knowledge on effective industry-specific interventions to protect and promote the health, safety, and well-being of their workers and the sustainability of their workplace.[12]

Theoretically, increasing physical capacity by resistance training (RT) of the shoulder, arm, and hand muscles may provide an alternative way of reducing chronic pain and work disability in PSW.[9-11] Recently, elastic resistance bands (ERB) have been used for resistance training to improve physical capacity in many populations, not only in athletes but also in injured patients and sedentary people.[13,14] ERB is relatively inexpensive, safe, easy to use, portable, and requires little space, and could represent an attractive and feasible alternative to free weights and training machines for RT, especially at the workplace. Several studies have shown the effects of training with ERB to improve muscle strength and functional ability.[15-17] ERB can provide similar therapeutic outcomes to exercises performed with training equipment, such as resistance training machines or free weights.[17,18]

Further, upper limb pain in PSW has commonly tended to shorten the muscle-tendon unit such as the upper trapezius and levator scapulae which are the most commonly resulting in limited neck and shoulder mobility.[19] Also, there are many studies that supported stretching exercises as a beneficial intervention to manage various musculoskeletal conditions.[19,20] While stretching exercises can improve joint range of motion and flexibility,[19,20] its benefits in managing WMSP among PSW have not been investigated to date. To our knowledge, only a few studies have evaluated the effects of exercise interventions among PSW with WMSP.[9-11] There is a need for using a specific package of exercise programs in the workplace setting, which can be effectively used for relief of neck and shoulder pain, under feasible for implementation. An exercise program that combines resistance training with ERB and stretching exercises would benefit the PSW with WMSP. Therefore, the aim of this study was to investigate the effectiveness of workplace intervention programs on musculoskeletal pain, upper limb functions, and work ability among PSW.

Materials and methods

Study design and setting

The current study was an assessor-blinded, repeated measure, randomized controlled trial (RCT) with two parallel groups. The study protocol was registered in the RCT registry (TCTR20230123001) and approved by the institutional ethical committee according to the standards of the Declaration of Helsinki (Ethical approval number AMSE64EX-112). All participants were informed about the study and signed a written informed consent prior to their participation in the study. Participants were randomly allocated to one of two groups (1:1 ratio): 1) workplace intervention group (WIG) and 2) control group (CG). The randomization was stratified by the severity of upper limb pain (i.e., pain intensity). An internet randomized scheme generator, which generated block randomization with a random sequence of permuted blocks of 4, was used for allocating the participants for the intervention groups. An independent research staff undertook randomization and allocation of the participants in the trial. The group assignment number was written on paper, placed in an opaque envelope, and sealed. The staff members who conducted these processes did not have any roles in data collection or intervention assignments. The opaque sealed envelopes were opened after the completion of the baseline assessment. The outcome assessor was blinded. This study was a continuation of the initiatives from the Sustainable Measures for Assessment and Rehabilitation Drive (SMART Drive) research networking group which had been working to improve musculoskeletal health and

well-being for people at the workplace.

Participant characteristics

The study was conducted in the poultry slaughterhouse factory located in the northern parts of Thailand during the period of November 2022 - March 2023. The factory had 120 workers, including 24 office staff, six storage workers, and 90 PSW. The inclusion criteria of the study were as follows: 1) males and females aged between 18 and 59 years, 2) working at a poultry slaughterhouse factory for at least one year, 3) working in a standard full-time job for at least 7 hours per working day, 4) presence of moderate pain intensity (VAS = 3/10 to 7/10) at least one body region including; shoulder, elbow/forearm, or hand/wrist during the last three months and 5) communicating in Thai fluently. The exclusion criteria include participants who had 1) radicular pain or numbness at upper and lower extremities, 2) impaired sensation at the body and lower extremities, 3) specific spinal disorders or nerve root compression, 4) previous spine surgery or upper and lower extremities surgery, 5) history of injury from an accident in the previous three months, 6) pregnancy, 7) severe medical conditions such as cardiovascular disease, or hypertension, and 8) those who received any pain-relieving medication in the previous three months.

Figure 1 shows the CONSORT flow diagram of PSW recruitment. There were 60 PSW reported WMSP at the upper limb region. Twelve PSW were excluded because 5 PSW have been working at this factory for less than one year, 2 PSW had hypertension condition, 1 PSW had a history of back surgery, 1 PSW had a recent motorcycle accident, and 3 PSW was not willing to participate in the study. The personal characteristics (e.g., age, sex, weight, and height) of the participants were collected using a study form. Furthermore, the study form included additional factors such as work experience, working hours per day, type of task, and tools (i.e., knives and scissors) used. The weight was measured by a mechanical weighing scale (Camry (DT-613), China), and the height was measured by a portable stadiometer (Health-O-Meter Mechanical Beam Scale, United States of America).

Interventions

Two qualified physiotherapists experienced in exercise training provided the interventions. Blinding of participants was not possible due to the nature of the interventions. Participants were advised to inform if they would experience any discomfort during the interventions

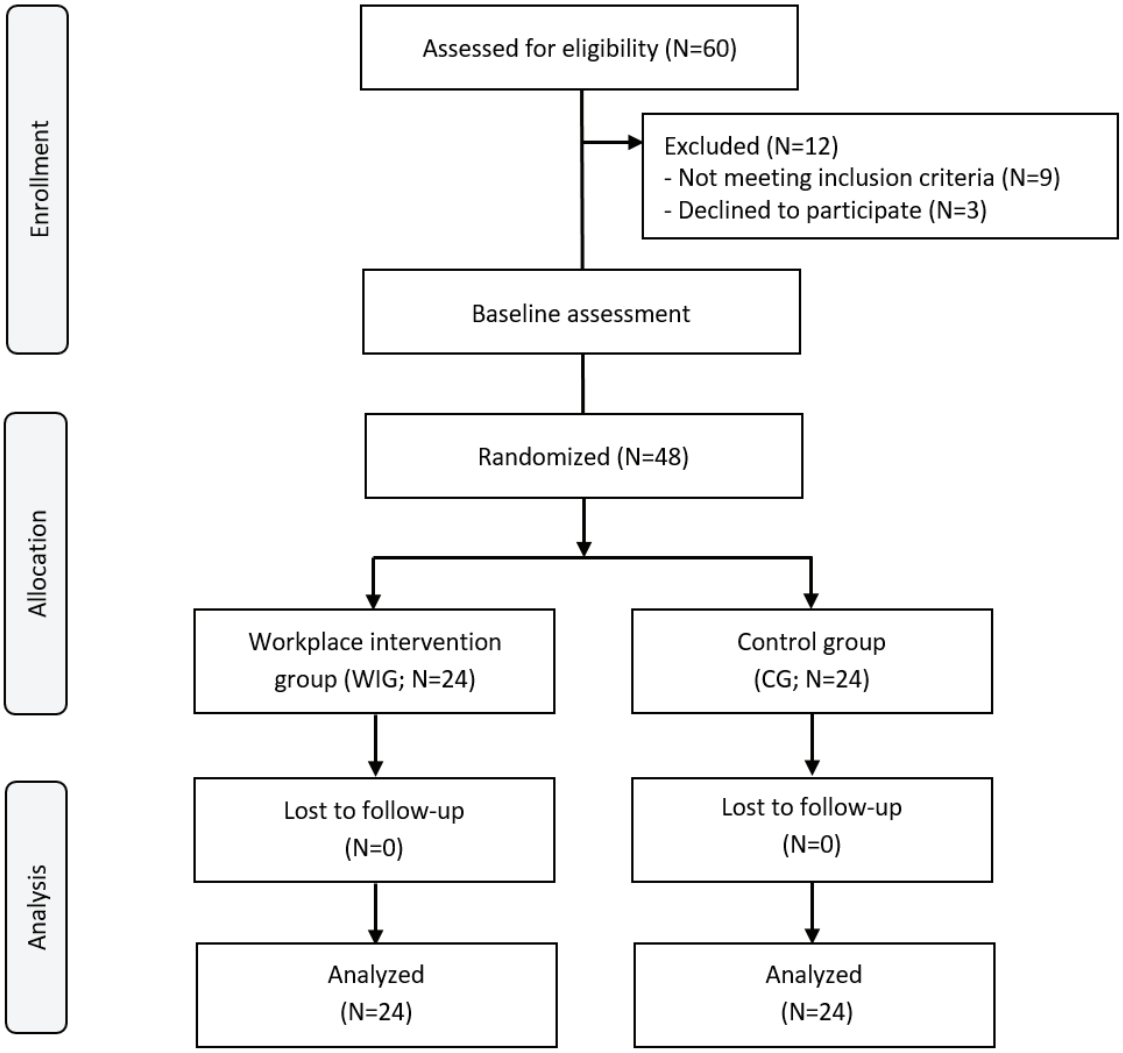

Figure 1. *The Consolidated Standards of Reporting Trials (CONSORT) flow diagram of poultry slaughterhouse workers recruitment.*

and were allowed to leave the experiment if the participants requested to leave the study due to any personal reasons or any reported worsening of symptoms. The participants were allocated to the workplace intervention group (WIG) and control group (CG).

Group 1: Workplace intervention group (WIG)

Participants in this group (N=24; 10 males; 14 females) performed resistance exercise training with ERB and stretching exercises for the upper body part. Table 1 shows a detailed description of the exercise program. The training protocol was accepted in content validity, the Index of Item Objective Congruence (IOC) was 0.94. The elastic bands (Decathlon elastic bands, Decathlon Sports, Thailand) used in this study were three colors for three levels of resistance: green, red, and blue. The elastic band is 1.90 meters long with a difference in resistance of 15 to 25% among the bands.[21] Each individual began with the lowest elastic load (green color) and increased to the medium (red color) and hard resistance (blue color). The participants were advised to choose and progress the resistance of the bands based on the self-perception of effort.[22,23] All participants were instructed to exercise at a moderate intensity level and still maintain the repetition of exercise according to the program.

Table 1 Workplace intervention programs: the combination of exercise training with elastic resistance bands (ERB) and stretching exercises.

Workplace intervention programs*		
Warm-up exercises	1) Arm circles 2) Side bends 3) Shoulder rolls	5 minutes
Exercise training with elastic resistance bands (ERB)	1) Arms stretch (10 repetitions x 2 set) 2) Shoulder diagonals pull (10 x 2) 3) Arms pull-down (10 x 2) 4) Shoulder horizontal abduction-adduction (10 x 2) 5) Elbow extension (10 x 2) 6) Elbow flexion (10 x 2) A 60-second rest interval between sets	15 minutes
Stretching exercises	1) Neck stretching (10 repetitions x 1 set) 2) Shoulder stretching (10 x 1) 3) Triceps stretching (10 x 1) 4) Biceps stretching (10 x 1) 5) Wrists and hands stretching (10 x 1) 6) Chest stretch (10 x 1) Hold each stretch for 20 seconds	15 minutes
Cool-down exercises	1) Deep breath 2) Self-stretching (e.g., back and leg stretch)	5 minutes

**participants performed three sessions (before - during break - after work time) per day, three days per week, for eight weeks.*

All training sessions took place in designated private training rooms at the worksites. Before the training started, all participants were instructed not to take any pain-relieving medication during the interventions. All sessions were supervised by qualified physiotherapists, who instructed the participants to correctly perform the exercises and helped with exercise adjustment when needed. Participants were asked to record the exercise frequency in a logbook and bring them to a researcher at the end of the study to monitor exercise compliance.

Group 2: Control group (CG)

Participants in this group (N=24; 11 males; 13 females) received the usual care provided by the occupational health services at their workplace. The usual care involved healthcare advice and pain medication, if necessary. The participants were re-evaluated after eight weeks. However, all participants received the combination of exercise training with ERB and stretching exercises after completing the study.

Outcome measurements

Primary outcome measures

The intensity of pain in this study was measured at the upper limb using a VAS. The measurement consists of a 0-10 VAS scale, which is a horizontal line anchored with two opposite labels; 'no pain' (0) and 'worst pain imaginable' (10).[24,25] Participants were asked to draw a vertical mark on the horizontal line. The VAS was reported to have excellent reliability (ICC=0.995).[25] The flexibility of the shoulders was measured using the shoulder reach flexibility test. The participant placed one hand behind the back and the other over the shoulder, behind the head, and participants were asked to reach as far as possible.[26,27] The test administrator measured the distance between the tips of two middle fingers using a tape measure. The score was positive when the hands overlapped each other and negative when the hands stayed apart from each other.[27] The test was performed in three times, and the best trial was noted. The interpretation of shoulder reach flexibility test values are reported as good level when

fingertips are touching, fair level when fingertips were not touching but were less than 5 cm. apart, and poor level when fingertips are more significant than 5 cm. apart.[27] A universal goniometer (NIIGATA SEIKI (SK), Japan) was used to measure AROM in the neck region and shoulder, elbow, and wrist joints.[26,28] The test was performed three times, and the best trial was noted in degrees.[28] The reliability of assessors was assessed using the Intraclass correlation coefficients (ICC). The inter-tester reliability of the shoulder reach flexibility test and AROM measurement were 0.96 (range 0.95-0.98), and 0.92 (range 0.91-0.94), respectively. The intra-tester reliability of the shoulder reach flexibility test and AROM measurement were 0.97 (range 0.96-0.98) and 0.95 (range 0.93-0.97), respectively. The level of reliability of assessors can be regarded as excellent.

Secondary outcome measures

The Thai Version of Disability of the Arm, Shoulder and Hand Questionnaire (KKU-DASH) was used to measure disability related to WMSP in the upper extremity region.[29] The total scores of KKU–DASH were summarized in ranging from 0-100 scores. A score of zero '0' represents no disability, and '100' scores represents the most severe disability.[29] The KKU–DASH had been shown to have moderate reliability (ICC= 0.52).[29] The Thai version of Work Ability Index (Thai WAI) was used to measure self-reported ability to work.[30] Possible scores range from 7-49 and are classified as follows: 7-27 (poor), 28-36 (moderate), 37-43 (good), and 44-49 (excellent).[30] The WAI was determined based on the interaction between the health and capacities of the individual, their competence or skill level, their values and attitudes, and the demands of the work they are required to do.[30] The level of reliability of WAI can be regarded as good reliability (ICC=0.89).[30]

Statistical analysis

The sample size was calculated on pain intensity (between-group differences) based on Sundstrup *et al* by G * Power 3.1.9.4. with an effect size of 0.49, 80 % power, and alpha error of 0.05.[11] A total sample size was 48 individuals (24 per group) which included a 10% drop out was determined to be appropriate for the study. The statistical analyses were performed using the SPSS version 24.0 for Windows (SPSS, Inc., Chicago, IL, USA). The normality and homogeneity of variances within the data were confirmed with the Shapiro–Wilk and Levene tests, respectively. The demographic data (e.g., age, sex, weight, height, BMI) were summarized in frequency, mean (M), standard deviation (SD), and percentages. All dependent variables (pain intensity, shoulder flexibility, AROM, KKU-DASH scores, and Thai WAI scores) were analyzed by two-way analyses of variance (ANOVAs) with repeated measures (group x time). Bonferroni correction was used for post hoc pairwise comparisons. Between-group effect sizes (ES) were also calculated with partial eta squared (η_p^2), where $0.01<\eta_p^2<0.06$ constitutes a small effect, $0.06\leq\eta_p^2\leq0.14$ constitutes a medium effect, and $\eta_p^2>0.14$ constitutes a large effect.[31] Statistical significance was set at $p<0.05$.

Results

A total of 48 PSW participated in this study; 43.7% (N=21) were men, and 56.3% (N=27) were women. There was no adverse event reported during the intervention, and all participants completed the exercise compliance. The baseline characteristics of PSW are shown in Table 2. There were no significant differences between groups for all variables ($p>0.05$). The complete results of the study are shown in Table 3. The results showed significant group x time interaction for pain intensity ($p\leq0.05$). After eight

Table 2 Baseline characteristics of poultry slaughterhouse workers (PSW) in workplace intervention group (WIG) and control group (CG).

Characteristics	WIG (N=24) (Mean±SD)	CG (N=24) (Mean±SD)	*p* value
Sex			
Males - N (%)	10 (41.7%)	11 (45.8%)	
Females - N (%)	14 (58.3%)	13 (54.2%)	
Age (years)	39.96±10.42	40.29±7.38	0.118
Weight (kg)	61.42±13.78	57.50±9.65	0.200
Height (centimeters)	161.54±10.68	161.16±8.39	0.451
Body mass index (kg/m²)	23.68±5.56	22.77±3.46	0.089
Work experience (years)	4.40±3.75	4.54±3.70	0.853
Work hours (hours)	10.13±1.62	10.50±1.69	0.604
Job section			
Slaughtering - N (%)	3 (12.5%)	3 (12.5%)	
Evisceration - N (%)	9 (37.5%)	10 (41.7%)	
Cut-up - N (%)	12 (29.5%)	11 (45.8%)	
Tool use (i.e., knives and scissors)			
No - N (%)	11 (45.8%)	12 (50.0%)	
Yes - N (%)	13 (54.2%)	12 (50.0%)	

There were no significant differences between groups for all variables (p>0.05).

Table 3 Between- and within-group differences in pain intensity of upper extremities (UE) (Visual analog scale; VAS 0-10 scales), shoulder flexibility, and active range of motion (AROM) of neck, shoulders, elbows, and wrist regions in the workplace intervention group (WIG) and control group (CG) before and after the 8-week intervention. Data was presented as the mean±SD.

	WIG (N=24)				CG (N=24)				*p* value		Effect size (η_p^2)	
	Baseline		Post-intervention		Baseline		Post-intervention					
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
VAS of UE (cm.)	5.42±1.14	3.38±2.88	2.36±0.84	1.42±1.23	5.27±1.26	3.92±2.75	5.02±1.44	3.95±2.65	0.003* <0.001#	<0.001* <0.001#	0.196	0.154
Shoulder flexibility (cm.)	0.90±2.33	-3.17±3.63	4.45±1.27	2.53±2.11	1.08±2.74	-2.92±2.87	0.95±2.82	-2.71±2.97	<0.001* <0.001#	<0.001* <0.001#	0.126	0.151
AROM (degree)												
Neck flexion	44.33±4.74		48.79±4.91		45.88±3.25		46.11±3.32		<0.001*		0.007	
Neck extension	33.52±2.30		34.09±2.43		33.20±4.32		33.81±4.58		NS		0.002	
Lateral neck flexion	43.80±2.60	39.66±3.67	45.70±1.09	43.49±2.68	42.52±1.75	41.66±2.07	42.77±1.72	41.75±1.63	NS <0.001#	<0.001* 0.009#	0.075	0.138
Neck rotation	54.12±5.40	52.36±4.61	58.51±5.30	56.95±5.00	54.12±5.40	50.27±3.32	53.12±3.28	50.91±3.12	<0.001* 0.024#	0.002* 0.018#	0.055	0.097
Shoulder flexion	173.49±3.30	171.73±1.24	175.70±1.18	175.18±1.31	175.90±1.16	172.80±2.25	175.42±0.91	172.94±2.14	NS	0.014#	0.001	0.125
Shoulder extension	34.41±4.17	32.94±3.59	34.27±3.34	33.73±3.11	34.76±3.83	33.62±3.45	35.19±3.78	33.65±3.42	NS	NS	0.008	0.001
Elbows flexion	155.06±2.77	155.36±2.25	156.02±2.14	155.06±1.87	155.84±1.30	155.52±1.98	156.04±2.81	155.54±1.60	NS	NS	0.009	0.002
Wrist flexion	55.81±1.92	55.01±2.11	55.50±2.19	55.61±2.47	55.38±1.51	54.04±2.12	54.97±1.46	54.33±2.10	NS	NS	0.005	0.003
Wrist extension	41.49±3.12	39.54±4.19	42.23±3.48	40.98±3.47	42.02±4.40	39.40±3.55	42.16±4.47	39.27±3.71	NS	NS	0.001	0.002

*Note: *significantly different within-group (WIG), p<0.05. #significantly different between-group at the post-intervention, p<0.05, There was no significant difference within-group in all variables in CG (p>0.05), and no significant difference between-group at the pre-intervention (p >0.05), NS: no significant difference within-group (WIG) (p>0.05), and no significant difference between-group at the post-intervention (p>0.05),cm: centimeters, η_p^2 : partialmeta squared.*

weeks of intervention, 79.1% (N=19) of the participants in WIG demonstrated a significant reduction in pain scores in both arms compared to CG (p<0.001). The shoulder flexibility also showed a significant group x time interaction (p<0.001). Post-hoc analysis showed that the WIG had significantly increased shoulder flexibility than the CG (p<0.001). Also, there were significant group x time interactions for the active range of motion as follows: neck flexion (p<0.001), lateral neck flexion (left side (p<0.001)), and neck rotation in both sides (right side - (p<0.001) and left side - (p=0.002)). Post-hoc analyses showed that at the end of 8 weeks, the WIG had significantly increased range of motion of lateral neck flexion on both sides (right side - (p<0.001) and left side - (p=0.009)), neck rotation in both sides (right side - (p=0.024) and left side - (p=0.018)) when compared to the CG. Active range of motion between groups of left shoulder flexion in WIG had significantly increased than the CG (p<0.001).

The findings of the secondary outcomes are shown in Table 4. There were significant group x time interactions for upper disability scores (p<0.001). After eight weeks of intervention, the WIG demonstrated a significant reduction in KKU-DASH scores compared to CG (p<0.001). KKU-DASH scores in the WIG were decreased from baseline (p<0.001), while it did not change for CG. Finally, the results showed a significant group x time interaction for the Thai work ability index scores (p<0.001). At the post-intervention, the WIG had significantly increased WAI scores compared to the CG (p<0.001). However, the WAI scores in the CG did not change at the post-intervention.

Table 4 Between- and within-group differences in disability of the Arm, Shoulder and Hand (KKU-DASH scores) and Thai Work Ability Index (Thai WAI scores) in workplace intervention group (WIG) and control group (CG) before and after the 8-week intervention. Data was presented as the mean±SD.

	WIG (N=24)		CG (N=24)		*p* value	Effect size (η_p^2)
	Baseline	Post-intervention	Baseline	Post-intervention		
KKU-DASH Scores	26.71±2.19	15.46±1.57	25.71±2.19	25.93±1.57	<0.001* <0.001#	0.083
Thai WAI Scores	37.62±5.78	43.08±4.92	37.66±3.72	38.12±3.27	<0.001* <0.001#	0.065

**Significantly different within-group (WIG), p<0.05, # Significantly different between-group at the post-intervention, p<0.05*
There was no significant difference within-group in both variables in CG (p>0.05), and no significant difference between-group at the pre-intervention (p>0.05), η_p^2: partialmeta squared

Discussion

Results of the present study demonstrated that the combination of exercise training with ERB and stretching exercises significantly reduced upper limb pain and increased neck, shoulders, and upper limbs functions, which were evaluated using shoulder reach flexibility and AROM test among PSW. Our results showed that 79.1% (N=19) of the participants in WIG demonstrated improvement in pain symptoms; meanwhile, the CG did not. A previous study reported that change in pain intensity is a primary efficacy of interventions for chronic pain.[32] In patients with chronic pain, a change in pain intensity of 2 scales on a 0-10 scale is considered moderately clinically meaningful. In contrast, a change of one is considered a minimal change.[32] The study of Sundstrup *et al* showed that average pain intensity in the resistance training group decreased by 1.8, with 73% of the PSW in the resistance training group reporting some or much improvement in pain.[11] Another study showed that the pain intensity of the hand/wrist decreased by 1.6 in the strength training group, with 41% of PSW reporting a reduction of pain. In the present study, the absolute change in average VAS scores was 3.06 and 1.96 for the right and left upper limb, respectively, with almost 79% improvement in pain with a large effect size (η_p^2>0.14), which showed that effects of the intervention were higher than previous studies.[11] The possible mechanisms of exercise programs to reduce the severity of pain may be that exercise enhances the release of endogenous opioids, such as endorphins hormone, which is the pain-killer substance.[33] Consequently, the endogenous opioids would inhibit the chemical substances (i.e., bradykinin, prostaglandin, histamine) that activate the pain receptor.[33] However, 21% (N=5) of the participants in WIG did not find any changes in pain intensity that were likely due to the effects of other factors, such as psychosocial elements.

The study findings of the intervention program agree with previous research.[9-11] The results of exercise training with ERB in this study have shown an effective reduction in upper limb pain and improving physical capacity among PSW. Evidence supports that exercise training with ERB device utilized in training can produce muscle activation and strength gains that are equivalent to those observed with free weights and conventional-device training.[13,14] ERB is a viable option to conventional resistance training equipment for the exercise's lateral pull-downs and unilateral rows, as it induces similar muscular activations for these exercises.[17] In other studies, ERB also provides additional unique training features including ability to perform exercises similar to a sport-specific pattern, providing eccentric and concentric resistance regardless of gravity,[14] and ability to perform quick motion and change direction.[15] Moreover, previous studies have concluded that exercise training with ERB has also previously been proven to be effective in improving physical capacity, whole-body strength and functional activities.[15-17] Therefore, ERB was used as an easy and feasible choice for the workers to perform their exercise at their workplace.

Moreover, there were significant improvements in workability and disability with upper extremity musculoskeletal conditions among PSW. The results of the current study are consistent with previous findings, which reported that the resistance training intervention decreased work disability as assessed by the DASH questionnaire in PSW.[11] The average change of DASH score improved by a score of 6.5 (13.2 to 0.1). However, the improvement of DASH score in the current study was 11.26 (35.83 to 3.14), with a medium effect size (η_p^2=0.083). Similarly, the WAI score (43.08) reported by the participants was also higher than a WAI score (39.7) reported by a past study that investigated the effects of strength training or usual-care ergonomics among slaughterhouse workers.[9] With workability related to musculoskeletal pain, chronic disease, productivity, sickness absence, early retirement, and all causes of mortality, the improvement in the WAI reported among PSW may be considered as a positive outcome of the intervention.[34]

Additionally, when muscles are repeatedly used, such as while performing repetitive tasks, the muscles contract according to the sliding filament theory. Eventually, the muscle would be shortened and tight[35,] which can lead to increased muscle tension and limited neck and shoulder ROM.[19,20] Thus, stretching exercises would benefit people to maintain the viscoelastic properties of the muscles and to maintain joint flexibility.[36,37] Also, past studies showed that stretching exercises not only gain range of motion but also reduce shoulder tightness pain and dysfunction in workers with chronic neck and shoulder pain.[36,37] Therefore, stretching exercises were designed and included as part of the exercise regime for the intervention in the current study. The results from the intervention program demonstrated that holding each stretch for 20 seconds showed statistically significant improvements in shoulder flexibility neck and shoulder ROM, especially in neck flexion, lateral neck flexion, neck rotation, and shoulder flexion. The acute effect of stretching on flexibility is apparent. Stretching creates an acute increase in joint range of motion that persists for 60 to 90 minutes.[38] Holding stretches for 20 to 30 seconds is a good standard because most stress relaxation in passive stretches occurs in the first 20 seconds.[19] Subjects can feel this decrease in muscle tension when they hold a static stretch.[19,20] Stress relaxation following stretching provides an acute 10-30% decrease in passive tension.[38] All these stretching effects might explain the improved range of motion obtained by the study participants.

The study findings have implications for clinical practice and industry. In this study, we prioritized a training program design based on the concept of industry-specific intervention.[8] The current study was a continuation of the previous part of the project, which investigated the WMSP among PSW.[4] Our training programs were created under the feasibility of the workplace environment, organizations, and support from the workplaces. Moreover, the need of workers were also included. Therefore, our programs were cost-efficient and utilized easy-to-use exercises and training equipment to be implemented in any environment. The worksites can implement our programs based on the easily adopted and inexpensive.

Limitations

The study has some limitations. Participants in this study were recruited from one slaughterhouse industry in northern Thailand. However, the results were generalizable to a broader group of PSW because similar work environments and working conditions were found. The current study did not consider the medium- and long-term effects of the intervention. Hence, the transferability of findings for the long-term benefits is not known. Also, the study did not investigate the lived experience of workers, such as psychosocial or occupational elements, which may contribute to the pain problem. The intervention has room for improvement, especially regarding the biopsychosocial aspects of intervention. Therefore, further studies are needed to evaluate the psychosocial elements (i.e., job satisfaction or job stress) or occupational elements (i.e., working hours, intensity of work, or years of experience). In addition, the modulation of our exercise intensity was not based on a percentage of one-repetition maximum (1-RM) evaluation.[39] However, there was the concern that the 1-RM test could cause a physical overload and trigger a flare-up of symptoms.[22,23] Hence, our modulation of exercise intensity followed the guidelines recommended, based on the self-perception of effort, progressively from low-load with low intensity.[19] The guidelines of the self-perception of effort also described the validity of this scale for the prescription of exercises and suggested its use instead of 1-RM.[22,23,40]

Conclusion

The workplace intervention programs which include resistance exercise training with ERB and stretching exercises, induced clinically relevant improvements in pain symptoms and increased neck movement, shoulders flexion, and upper limb functions among PSW. The training programs also improved work ability and reduced disability related to upper extremities among PSW with WMSP.

Conflict of interest

No conflict of interest to declare.

Funding

This study was supported by an internal university research grant from the Faculty of Associated Medical Sciences and the Graduate School, Chiang Mai University, Chiang Mai Province, Thailand.

Acknowledgements

The authors sincerely thank the PSW, the supervisors and the managers of the chicken meat factories for their support in the study. This study was supported by an internal university research grant from the Faculty of Associated Medical Sciences and the Graduate School, Chiang Mai University, Chiang Mai, Thailand.

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