

Title page**An investigation of the prevalence of work-related musculoskeletal pain and related disability among poultry slaughterhouse workers – A cross sectional study.**

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Abstract

Purpose: The poultry slaughterhouse workers (PSW) are at substantial risk of developing work-related musculoskeletal pain (WMSP) at workplace due to their work. This study investigated the prevalence rate of WMSP and related disability among the PSW.

Methods A cross-sectional descriptive study was conducted among 78 PSW (40 women and 38 men) in the region of northern Thailand. The prevalence rate of WMSP was evaluated using the Standardized Nordic Musculoskeletal Questionnaire (SNMQ). The disability related to the MSP was evaluated using a series of disability questionnaires. Descriptive statistics were used to evaluate the WMSP. Data on the disability were summarized in frequency, mean (M), standard deviation (SD) and percentage.

Results The prevalence rate of WMSP in the past 7 days were higher in the shoulder region (61.5%, N=48) followed by wrists/hands (60.3%, N=47), and lower back region (35.9%, N=28). The WMSP over the past 12 months was also high at the shoulder (61.5%, N=48), wrists/hands (60.3%, N=47), and neck region (37.1%, N=29) respectively. The overall disability related to WMSP among PSW was found to be mild to moderate across different body regions.

Conclusion PSW had a high prevalence rate of WMSP in the shoulders, wrists/hands, lower back, and neck regions. However, the PSW with WMSP reported only mild to moderate disability in the work.

Introduction

Globally, the poultry sector continues to grow in production due to increased demand for animal protein consumption in human population (Harmse et al. 2016). In the United Kingdom (UK), approximately 1.12 billion broilers are slaughtered every year, producing 1.97 million metric tons of meat in the year 2021 alone contributing to a £2.97 billion industry (Shahbandeh 2022). In Thailand, poultry slaughterhouse industry is one of the largest sectors of the food industry. Poultry industries in Thailand employ around 80-100 thousand workers in 606 poultry slaughterhouse industries to produce approximately 5.03 million tons of chicken meat per day (Office of Agricultural Economics 2022). The job tasks in the poultry industry include slaughtering, evisceration, and cutting-up (Harmse et al. 2016). Slaughtering involves placing an unconscious chicken on a moving line and cutting the neck. Evisceration includes removal of feathers, abdominal slitting, and removal of internal organs. The cutting-up task involves special and fine cutting of the chicken into assorted products like chicken wings, chicken breasts, and packing (Harmse et al. 2016). The poultry slaughterhouse industry is a key industry worldwide, which employs tens of thousands of workforces in different countries. From an occupational health perspective, keeping good health and working conditions are important to maintain individuals at work, health and well-being at work place, and prevent disability retirement (Denadai et al. 2021). Therefore, the current study focuses on investigating the work-related musculoskeletal pain (WMSP) among the poultry slaughterhouse workers (PSW) who works in the poultry industry.

The work force in the poultry slaughterhouse industry has a substantial risk for WMSP (Tirloni et al. 2017). A range of factors such as repetitive tasks, forceful movements, and awkward postures are associated with

WMSP which affects the health and well-being of the workers in the poultry slaughterhouse industry (Harmse et al. 2016). Other factors such as insufficient recovery time, and use of inappropriate tools also contribute to WMSP among PSW (Occupational Safety and Health Administration 2013). All these work activities affect various body regions contributing to WMSP among PSW (Bertozzi et al. 2015). The prevalence rate of the WMSP among PSW has been reported scarce in the literature and remains an under explored area for musculoskeletal research. A past study suggested approximately 87.6% of workers performed repetitive tasks and forceful movements, and complained WMSP in shoulders (62.6%), neck (46.2%), spine (36.4%), forearms (31.3%), arms (29.2%), wrists (25.6%) and hands (25.6%) approximately (Tirloni et al. 2012). An association between WMSP and repetitive tasks (OR=1.81; 95% CI 1.12 to 2.91) was reported by 81% of workers had at least any one type of body pain compared to those workers who did not perform repetitive tasks (Tirloni et al. 2019). While some studies focused on cold related pain among PSW at work place, other studies have reported WMSP focusing only on the upper limbs (Auttanate et al. 2020; Phanprasit et al. 2021; Rosenbaum et al. 2013; Schulz et al. 2013). Therefore, a fuller understanding of various WMSP and related disability encountered by the PSW in the spine, upper and lower extremities are warranted to design targeted health interventions.

Work disability is a major public health problem and has a serious consequence for stakeholders and society (van Oostrom et al. 2009; van Oyen et al. 2018). Evidence of the Global Burden of Disease (GBD) suggests a high prevalence of musculoskeletal disorders among workers in their working years are the main reason for about 18.5% of occupational disability (GBD 2015 Disease and Injury Incidence and Prevalence Collaborators 2016). Workers with musculoskeletal problems such as back pain and upper extremity pain have reduced work performance and work absenteeism (van Vilsteren et al. 2015). A previous study on the poultry industry reported that disability due to musculoskeletal problems has contributed to sickness absentees among the working population (Harmse et al. 2016; van Vilsteren et al. 2015). Also, an elevated risk of WMSP leads to disability at work among PSW (Sundstrup et al. 2016). Looking at the causes for work disability, intense physical work is reported to increase the risk of disability retirement due to musculoskeletal problems (Halonen et al. 2020; Kärkkäinen et al. 2013). The poultry slaughterhouse industry is no exception for intense physical work. With an average rate at 6.9 chickens slaughtered per minute, amounting to a total of 75,000 per day (Campos 2016), repetitive movements, accelerated pack of work, static contraction of muscles and awkward postures are reported to cause WMSP and disability (Harmse et al. 2016; Mendes et al. 2017). Therefore, it is important to understand the occurrence of WMSP and related disability among PSW as it will help for better management of the musculoskeletal health. The aim of this study was to investigate a 12-month prevalence of WMSP and associated disability among PSW.

Methods

Study design and setting

This cross-sectional study was conducted among PSW in the northern parts of Thailand between the period of 2021 and 2022. A simple random selection procedure was used to select a poultry slaughterhouse factory from a sampling frame of three major poultry slaughterhouse industries in the region. The study information sheet and procedures were informed to the department manager, occupational safety officer, and PSW. The PSW who gave consent and agreed to participate were recruited for the study. All the participants gave written consent prior to

the participation in the study. The ethical approval for the study was obtained from a university institutional ethics committee, according to the Declaration of Helsinki (Ethical approval number AMSE-64EX-112). 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 on a series of projects to enhance and improve musculoskeletal health and wellbeing for people at the work place (Joseph L et al. 2020; Joseph L et al. 2021; Kasemsan et al. 2021; Sattasuk et al. 2021).

Participant characteristics

The factory had 120 workers, including 24 office staff, 6 storage workers and 90 PSW. This study recruited 78 PSW who met the inclusion and exclusion criteria. Inclusion criteria for the study were as follows: (1) age between 18-59 years (2) working at a poultry slaughterhouse factory for at least 1 year (3) working in a standard full-time job for at least 7 hours per working day. Exclusion criteria were history of any sensory deficits, history of back surgery, any recent traumatic injuries to neck, back, extremities and pregnancy. The study also excluded any PSW who sought medical help and were under any pain medication at the time. As the SMART Drive research group encourages the local stakeholders and participants to establish equal partnership and engagement in musculoskeletal research and service development (Fearnley et al. 2022), the final study report and summary of study findings were agreed to be shared with the PSW managers, work supervisors and participants who would be the end users of the study. The participants at the study plant did not rotate jobs and all the data was collected on time during the working hours of a current job.

Measures

All the study participants completed a study form which collected personal characteristics of the participants such as age, sex, height, weight, educational level, history of smoking and alcohol consumption. The height was measured using a portable stadiometer (Health-O-Meter Mechanical Beam Scale, United States of America) and the weight was measured by a mechanical weighing scale (Camry (DT-613), China). As per a previously established protocol, the Body Mass Index (BMI) was calculated by dividing the weight (kg) by height squared (m^2) and was rounded to the nearest 0.1 (kg/m^2) (Kasemsan et al. 2021). The BMI was categorized into four groups according to the Asia Pacific Guidelines as follows; Underweight: BMI < 18.5, Normal: BMI 18.5–22.9, Over-weight: BMI 23–24.9 and Obese: BMI \geq 25 (World Health Organization 2000). In addition, additional factors such as work experience, number of working hours per day, job task, working posture and tools used to work were collected in the study form.

Standardized Nordic Musculoskeletal Questionnaire (SNMQ) is a valid instrument used to measure the prevalence of musculoskeletal pain (Pugh et al. 2015). SNMQ has a total of 9 items, and it was used in the study to evaluate the prevalence of the WMSP among the study participants. Using the SNMQ, the participants were asked to report of any WMSP in nine body areas which includes neck, shoulder, elbows, wrist and hands, upper back, lower back, hips and thighs, knees, and ankles and feet. The SNMQ was administered among the PSW who performed various job tasks in the poultry industry, which includes slaughtering, evisceration, and cutting-up (Figure 1). The prevalence of the WMSP was collected over the period of the last 7 days and the last 12 months. Only those participants who had WMSP for 12 months completed the disability screening tools

The term “disability” is defined as an umbrella term, covering impairments, activity limitations, and participation restrictions (Rondinelli and Eskay-Auerbach, 2019). Therefore, disability may be conceptually interpreted as functional impairment as these two terms are used interchangeably (Rondinelli and Eskay-Auerbach, 2019). In the current study, the disability associated with the WMSP in different body regions was measured by various valid and body region specific disability questionnaires. The Thai Versions of the Neck Disability Index (NDI-TH), Disability of the Arm, Shoulder and Hand questionnaire (KKU-DASH) and Roland-Morris Disability Questionnaire (RMDQ-TH) were used to investigate the disability associated with the WMSP in the neck, upper extremities and back regions. The 10-items NDI-TH had been shown to have excellent reliability (ICC= 0.74–0.91) (Uthaikhup et al. 2011). The severity of disability from NDI-TH scores were classified into five categories; 0 to 4 was no disability, 5 to 14 was mild disability, 15 to 24 was moderate disability, 25 to 34 was severe disability, and above 34 was complete disability. The KKU-DASH has a total of 30 items which has three measures namely physical activities (21 items), severity of symptoms (5 items) and the impact of the problem (4 items). The KKU-DASH was reported to be a reliable tool to evaluate the disability related to WMSP in the upper extremity region (Jianmongkol et al. 2011). KKU-DASH scores were summarized and transformed to a 0–100 scale with a score of ‘0’ indicated as no disability and ‘100’ indicated as most severe disability. The RMDQ-TH has a total of 24 items, and it had excellent reliability to evaluate the disability associated with low back pain (Jirattanaphochai et al. 2005). The measurement tool did not provide descriptions of the varying degrees of disability, but the scores would be presented in the percentage of improvement. In addition, the Thai versions of the Hip disability and Osteoarthritis Outcome Score (HDOS-TH) with a total of 40 items, knee osteoarthritis outcome scores (KOOS-TH) with a total of 42 items and Foot and Ankle Ability Measure (FAAM-TH) with a total of 29 items were used to evaluate the disability associated with WMSP in the lower extremities. The total duration of the study visit was for 6 weeks and it took 30–45 minutes to complete all study related details per person. In the current study, all the tools were administered by a qualified physiotherapist and the data from the participants were collected in a private room.

Statistical analysis

The sample size for the study was calculated using Krejcie and Morgan Table (Krejcie and Morgan 1970). The study's sampling frame was about 90 PSW working in the factory. According to Sample Size Determination Using Krejcie and Morgan Table, a total sample size of 73 was required for the study. The data were analyzed using SPSS version 24.0. The Kolmogorov–Smirnov test confirmed the normality of the data distribution. The demographic data (e.g., age, sex, weight, height, BMI) were summarized in frequency, mean (M), standard deviation (SD), ranges and percentages. Descriptive statistics were applied to demonstrate the prevalence of WMSP among PSW. Prevalence of WMSP was reported for the past 7 days and 12 months in different body regions. Prevalence of WMSP for each body region was presented with 95% confidence interval (CI) at an alpha level of 0.05. Data on the disability were summarized in frequency, mean (M), standard deviation (SD) and percentage.

Results

Among the 78 PSW participated in the study, 49% (N=38) were men and 51% (N=40) were women. The average age of the PSW was 39.12±9.33 years. The participants worked in three different job tasks in the industry with

11.5% (N=9) performed the slaughtering task, 41% (N=32) carried out the evisceration task and 47.4% (N=37) did the cutting-up task as part of their work. About 12 PSW did not participate in the study as 9 workers did not meet the study criteria as they worked in the plant less than a year, one person had a history of back surgery, another person had a motorbike cycle recently and last person did not participate citing her pregnancy. Table 1 shows the demographic characteristics of the study participants involved in this study. The mean work experience was 4.33 ± 4.04 years, and the mean working hours per day was 10.42 ± 1.59 hours. About 96.1% (N=75) of the participants worked in a standing position for more than 3 hours, and about 26.9% (N=21) of participants used knife as a tool to perform their job task at the workplace.

Among the 78 PSW, 97% (N=76) reported WMSP in at least one body region. About 37% (N=29) workers reported WMSP in at least 2 body regions, 18% (N=14) and 17% (N=13) of workers reported WMSP in 3 and 4 body regions respectively. The highest prevalence rate of WMSP reported in the past 7 days were in the regions of shoulders (61.5%; N=48), followed by wrists/hands (60.3%; N=47), and lower back (35.9%; N=28). In addition, the prevalence rate of MSP reported over the past 12 months were highest in the shoulder region (61.5%; N=48), followed by wrists/hands (60.3%; N=47), and neck region (37.1%; N=29). Table 2 shows the prevalence of WMSP for the past 7 days and 12 months by the study participants. Figure 2a and 2b illustrates the distribution of the prevalence of the WMSP in upper and lower body regions over the period of last 7 days and 12 months. Additionally, Figure 3a and 3b shows the prevalence of WMSP for the last 7 days and 12 months, according to the three job tasks performed by the PSW.

In terms of disability associated with the WMSP, most of the participants (83.3%, N=65) reported disability at the shoulder, wrist and hands over the last 12 months as measured by the KGU-DASH (Mean score 21.64 ± 16.14). The second most common body region that presented with disability due to the WMSP was the neck region with approximately 35.9% (N=28) of the PSW reported disability due to neck pain with 57% of participants had mild disability, 14% had moderate disability, 7% and 4% had severe and complete disability, respectively. The disability scores from the different body regions among PSW with the 12 months prevalence of the WMSP were presented in Table 3.

Discussion

This cross-sectional study investigated the prevalence of WMSP and related disability among the PSW. A key finding of the study was that almost 97% (N=76) of the PSW reported WMSP in at least one body region. The findings on the WMSP prevalence over the last 7 days showed that the shoulder, wrist/hands and lower back region were the most affected region with 61.5%, 60.3% and 35.9% of the PSW reported having WMSP at the work. Over the 12-month period, shoulder and wrist/hands were still the most common areas affected with WMSP with 61.5% and 60.3% of the workers reported having WMSP at the work. Poultry processing jobs involve repeated use of extremities and overexertion suggested to contribute to WMSP, especially in the upper extremity and spine region (Tirloni et al. 2019). Shoulder region is the most affected region to have WMSP among the PSW at work. The high prevalence of WMSP observed in the shoulder region among the PSW in the current study was similar to the prevalence rate reported among other studies (Tirloni et al. 2012; Caieiro et al. 2019). An average

height of the conveyor belt in the poultry industry was reported to be 1.74 meters (Reis et al. 2012). Anthropometric characteristics of the workers were reported to cause WMSP, especially when the worker's height was less than the conveyor belt (Reis et al. 2012). In the current study, the average height of the PSW was 1.61 metres which might have contributed to WMSP in the shoulder region. Next to the shoulder region, lower back and neck are the two other regions reported by other studies which are common among PSW to develop WMSP (Caieiro et al. 2020; Reis et al. 2012). With only few studies reporting on the prevalence of WMSP among PSW, it becomes important to report on the prevalence data of WMSP among the workforce in this industry as it contributes to the evidence on the magnitude of WMSP in this occupational sector.

The study findings also showed that PSW reported increased prevalence of WMSP in the ankle and feet region. PSW must stand for extended periods of time without being able to walk or sit during the work shifts (Waters and Dick 2015). Prolonged standing is an important risk factor for MSP at work place (Bertozzi et al. 2015). PSW performs tasks such as cutting, eviscerating and packing along the production line in standing position for 8 to 11 hours (Occupational Safety and Health Administration 2013). Prolonged standing as a working posture and standing workstations have been widely reported as a risk factor for development of MSP in back as it increases static muscle contraction of back muscles, reduces blood flow to the muscles and increases intervertebral disc pressure (Dianat et al. 2018; Halim and Omar 2012; Nagaraj et al. 2019). Prolonged standing working posture also causes fatigue of calf muscles, peripheral pooling of blood in the lower extremities, swelling and discomfort around ankle and lower leg (Smith et al. 2022). Previous studies have also found the prevalence of musculoskeletal symptoms among workers who worked in standing position, 30 minutes to more than 4 hours per day, also have impacts on the WMSP, especially at the knee (48.7%), lower back (42.3%), hips and thighs (28.5%), and ankles and feet (27.9%) (Dianat et al. 2018). According to Dutch ergonomic guidelines, the criterion of prolonged standing is classified into three categories (Meijssen and Knibbe 2007). Green category, where workers are exposed to continuous standing less than 1 hour or total work time per day less than 4 hours. Amber category, workers are continually standing more than 1 hour or total work time per day less than 4 hours. Finally, red category, where workers are continuously standing more than 1 hour and total work time per day more than 4 hours (Meijssen and Knibbe 2007). Therefore, PSW falls under the red category as their total work time per day was more than 4 hours. All the above facts might contribute to the WMSP in the back and lower leg among the PSW.

Practice and Industry Implications

The findings of the current study clearly have some recommendations and implications for the stakeholders, health care practitioners and poultry slaughterhouse industry globally. The study findings provide evidence that the WMSP is more prevalent among the PSW in the upper extremities when compared to the lower extremities (Figure 2a and 2b), and suggests that the health interventions to improve musculoskeletal health and preventive measures might need to target on the upper extremity among the PSW. The study findings are novel as it is the first study to report on the patterns of WMSP among PSW during different working tasks (Figure 3a and 3b). For the global workforce of PSW and their managers, the study makes a policy recommendation that the industrial managers and supervisors need to consider rotation of the work force across the three different working tasks as it might minimize the risk of WMSP to certain specific job tasks. While the participants in the current study do not rotate

occupational tasks at their work place, the policy of rotating the tasks should be encouraged. PSW should be trained to work in different occupational tasks as it might prevent repetitive strain to certain specific joints and distribute the physical risk factors evenly to other major joints. A report from Health and Safety Executive, 2022 recommends that the height of the conveyor belt should be approximately 1.075 meters. The report further recommends that the reach distance should be approximately 45 centimeters (Health and Safety Executive 2022). While the above report may inform occupational health and ergonomists on the recommended work station design, an individual worker based work station assessment and adaptation is needed to develop a best fit for the PSW and their individual workstation, which should be evaluated by the occupational health and safety practitioners in the workplace. Similarly, optimal break for PSW who work in a prolonged standing could be implemented, and work station adjustments with seated work stations could be explored to manage the adverse effects of prolonged standing. The participants in this study with WMSP over the last 12 months reported mild to moderate disability at work (Table 3). For health care practitioners and managers, an annual screening of musculoskeletal health for the PSW may help to identify the musculoskeletal problems at the earliest stage which may prevent chronicity of the problem. The prevalence of WMSP among the PSW also warrants the need to develop occupation specific musculoskeletal health and wellness programs to the workforce in the poultry slaughterhouse industry. The current study was a part of the SMART drive research network project where a team of researchers with musculoskeletal and occupational health expertise across countries had been working together to develop a musculoskeletal wellness program for the PSW. The study findings would help the researchers to work with the PSW community and industry to form a team of equal partnership, engagement and involvement of the PSW workforce in the development of an appropriate intervention. It is recommended that any musculoskeletal health and wellness programs should incorporate a partnership approach engaging PSW as equal workers (Fearnley et al. 2022), so that the specific needs and expectation of the PSW can be captured in the design and implementation of any musculoskeletal health wellness programs.

The study has some limitations. The PSW who participated in the study was from a single poultry slaughterhouse industry from a specific geographical region, but it did not involve the overall industry in the Country. However, the findings of the study were generalizable to a wider PSW as the working conditions and work environment was similar to the other poultry slaughterhouse industries in the region. Although the study reported on the prevalence of the WMSP, it did not investigate any mechanism and risk factors that contribute to the problem. Therefore, additional studies investigating the risk factors for the WMSP among PSW are needed. The current study provided only an epidemiological data on the prevalence of WMSP among the PSW, however, it did not provide any intervention to address the problem. Furthermore, the current study did not focus on the lived experience of the PSW with WMSP and how it affects their day-to-day life. Further studies are needed to evaluate the living experiences of PSW with WMSP along with their needs and expectations on managing WMSP so that interventions targeting health and wellbeing of the PSW can be implemented to manage WMSP in the workplace.

Conclusion

The PSW had a high prevalence rate of WMSP in the shoulders, followed by wrists/hands, lower back, and neck regions. However, the PSW reported only mild to moderate disability related to WMSP at the work.

Stakeholders and employers should provide a healthy work environment by assessing the musculoskeletal health risk assessment and develop musculoskeletal health for the prevention and management of WMSP among PSW.

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Statements and Declarations

Competing interests - No conflict of interest to declare.

Ethical approval - The study was ethically approved by a university institutional ethics committee (Ethical approval number: AMSEC-64EX-112 as per the Helsinki declarations).

Consent to participate - All the participants gave written consent prior to the participation in the study.

Consent for publication - All participants and researchers have given consent for publication

Author contributions - *All* the authors have equal contribution in terms of planning, designing, running the study. The authors also equally contributed in terms of analyzing the data, writing the manuscript and reviewing the script.

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Availability of data and material - Data will be available upon request.

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Table 1 Demographic characteristics of poultry slaughterhouse workers

Characteristics (N=78)	Mean ± SD
Sex	
Males - N (%)	38 (48.7%)
Females - N (%)	40 (51.3%)
Age (years)	39.12 ± 9.33
Weight (kg)	61.44 ± 13.03
Height (centimeters)	161.91 ± 10.14
Body mass index (kg/m ²) ^a	23.46 ± 4.63
Underweight (< 18.5) - N (%)	9 (11.5%)
Normal (18.5 – 22.9) - N (%)	28 (35.9%)
Overweight (23 – 24.9) - N (%)	15 (19.2%)
Obese (≥ 25.0) - N (%)	26 (33.3%)
Education level	
Primary school - N (%)	27 (34.6%)
Secondary school - N (%)	29 (37.2%)
High School/Vocational Certificate - N (%)	21 (26.9%)
Bachelor Degrees - N (%)	1 (1.3%)
Underlying diseases	
No - N (%)	55 (70.5%)
Yes - N (%)	23 (29.5%)
Previous injury	
No - N (%)	67 (85.9%)
Yes - N (%)	11 (14.1%)
Smoking	
Never - N (%)	49 (62.8%)
Ex-smoker - N (%)	7 (8.9%)
Regular smoker - N (%)	22 (28.2%)
Alcohol consumption	
Never - N (%)	27 (34.6%)
Occasionally - N (%)	38 (48.7%)
Weekly - N (%)	9 (11.5%)
Everyday - N (%)	4 (5.1%)
Job section	
Slaughtering - N (%)	9 (11.5%)
Evisceration - N (%)	32 (41%)
Cut-up - N (%)	37 (47.4%)
Work experience (years)	4.33 ± 4.04
1 – 2 - N (%)	38 (48.7%)
2.1 – 5 - N (%)	16 (20.5%)
5.1 – 10 - N (%)	10 (12.8%)
> 10 - N (%)	14 (17.9%)
Work hours (hours)	10.42 ± 1.59
0 – 8 - N (%)	18 (23.1%)
8.1 – 10 - N (%)	19 (24.3%)
> 10 - N (%)	41 (52.6%)
Working posture	
Standing ≥ 3 hours - N (%)	75 (96.1%)
Sitting - N (%)	3 (3.8%)
Tool use	
No - N (%)	57 (73.1%)
Yes - N (%)	21 (26.9%)

^a Classified according to Asia-Pacific guidelines (World Health Organization 2000)

Table 2 Prevalence of work-related musculoskeletal pain among poultry slaughterhouse workers

Total participants (N=78)	WMSP in the past 7 days		WMSP in the last 12 months	
	N	Prevalence (95%CI)	N	Prevalence (95%CI)
Neck	27	34.6 (24.2 – 46.2)	29	37.1 (25.3 – 47.6)
Shoulders	48	61.5 (49.8 – 72.3)	48	61.5 (49.8 – 72.3)
Elbows	9	11.5 (5.4 – 20.8)	9	11.5 (5.4 – 20.8)
Wrists and hands	47	60.3 (48.5 – 71.2)	47	60.3 (48.5 – 71.2)
Upper back	19	24.4 (15.3 – 35.4)	19	24.4 (15.3 – 35.4)
Lower back	28	35.9 (25.3 – 47.6)	28	35.9 (25.3 – 47.6)
Hips and thighs	6	7.7 (2.9 – 16)	6	7.7 (2.9 – 16)
Knees	17	21.8 (13.2 – 32.6)	17	21.8 (13.2 – 32.6)
Ankles and Feet	25	32.1 (21.9 – 43.6)	25	32.1 (21.9 – 43.6)

Table 3 The disability scores reported by the poultry slaughterhouse workers with work-related musculoskeletal pain over the last 12 months

Disability questionnaires	Body region applied	N (%)	Mean \pm SD (range)
NDI-TH	Neck	29(37.1%)	11.54 \pm 8.03 (1-34)
KKU-DASH	Shoulders/elbow/wrist and hands	65(83.3%)	21.64 \pm 16.14 (1-85)
Thai version of the RMDQ	Upper and lower back	35(44.8%)	5.06 \pm 3.84 (1-16)
Thai version of HOOS	Hips and thighs	6(7.7%)	80.06 \pm 11.59 (67-96)
Thai version of KOOS	Knees	17(21.8%)	72.28 \pm 17.56 (44-96)
Thai FAAM	Ankles and feet	25(32.1%)	78.81 \pm 15.61 (44-98)



A. Slaughtering task

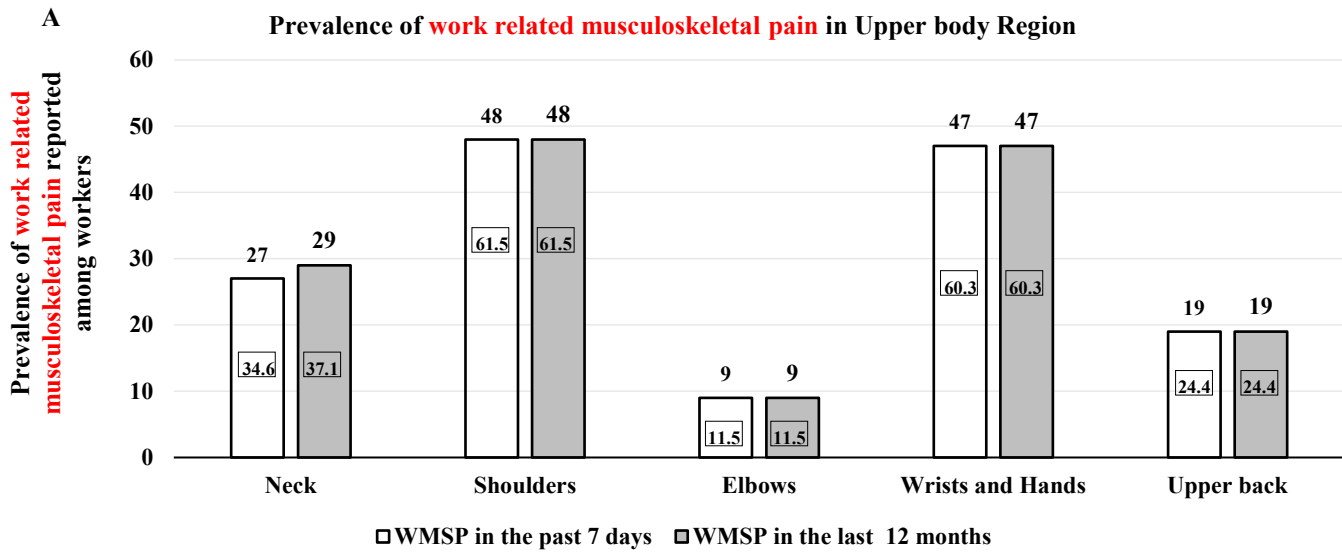


B. Evisceration task

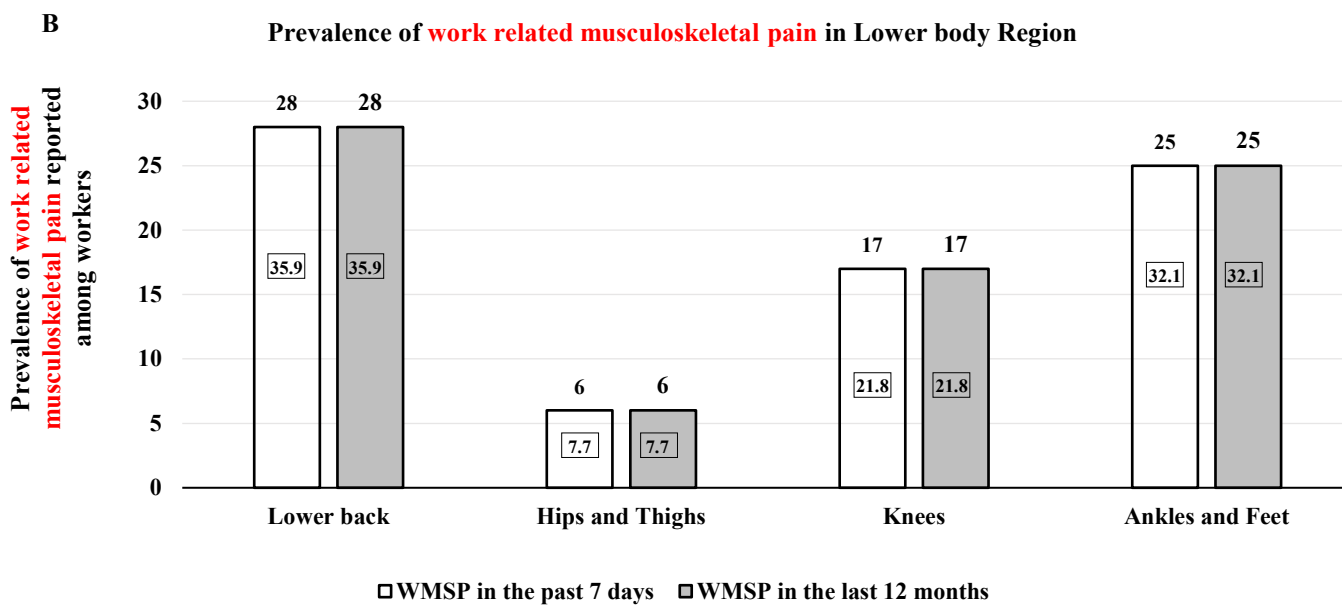


C. Cutting-up task

Fig. 1 The three different job tasks performed by the poultry slaughterhouse workers

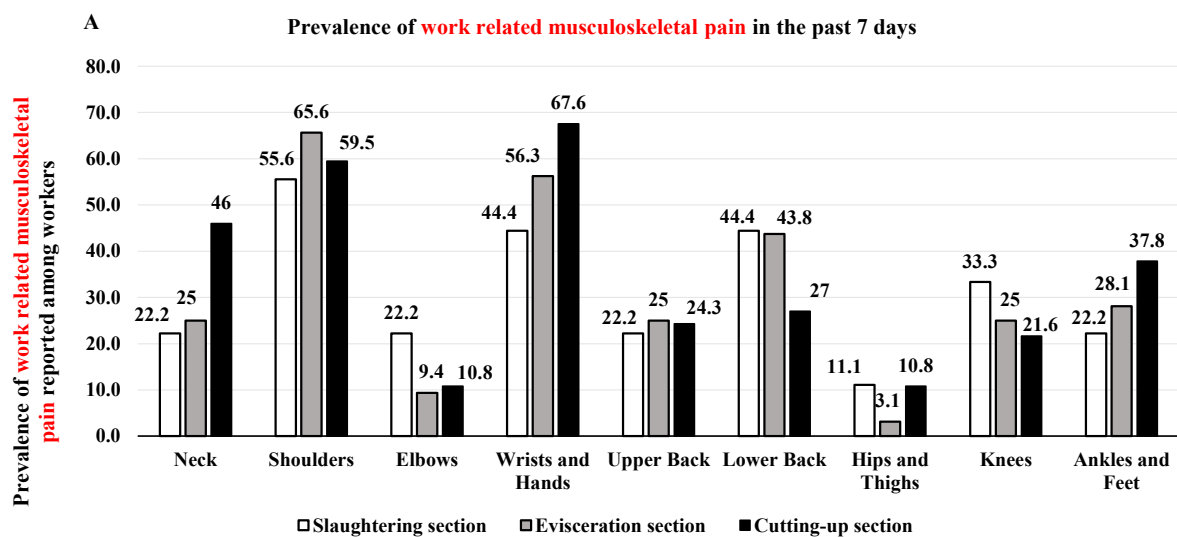


- Number of participants are indicated on the top of the boxes in the chart
- Percentage (%) is indicated inside the boxes in the chart

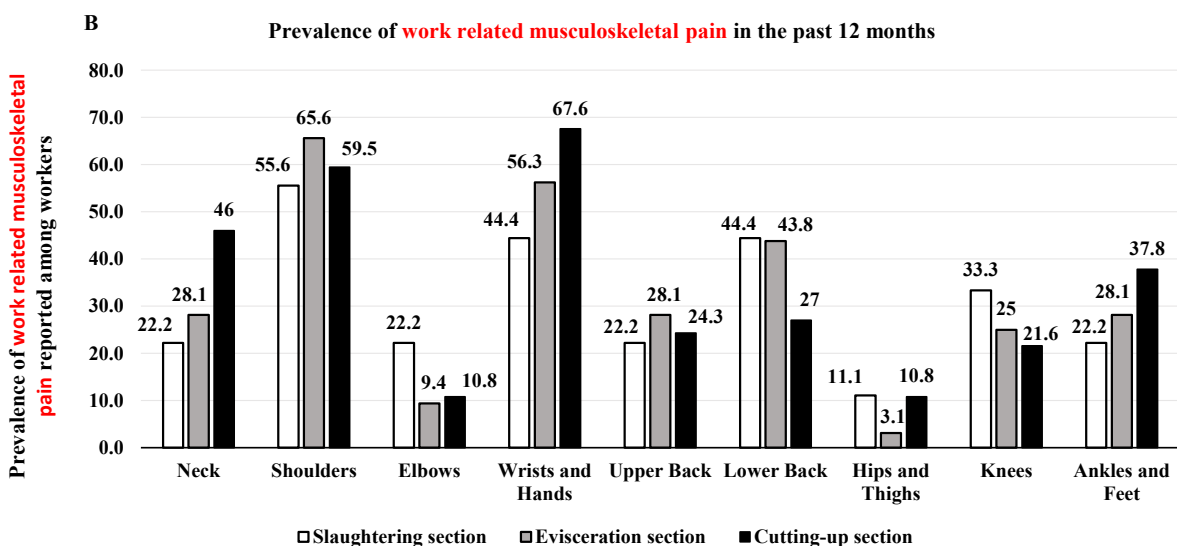


- Number of participants are indicated on the top of the boxes in the chart
- Percentage (%) is indicated inside the boxes in the chart

Fig.2 a Prevalence of work-related musculoskeletal pain (WMSP) in upper body region among poultry slaughterhouse workers. **b** Prevalence of work-related musculoskeletal pain (WMSP) in lower body region among poultry slaughterhouse workers.



- Percentage (%) is indicated on the top of the boxes in the chart



- Percentage (%) is indicated on the top of the boxes in the chart

Fig.3 Prevalence of **work-related musculoskeletal pain** among **poultry slaughterhouse workers** that classified into three job sections 1) slaughtering section (N=9) 2) evisceration section (N=32) and 3) cutting-up section (N=37)

a Prevalence of **work-related musculoskeletal pain** in the past 7 days.

b Prevalence of **work-related musculoskeletal pain** in the last 12 months.