Relationship between risk factors at workplace and upper limb work-related musculoskeletal pain among poultry slaughterhouse workers: A cross-sectional study

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ABSTRACT

Background: Poultry slaughterhouse workers (PSW) are exposed to various risk factors at work that contributes to upper limb work-related musculoskeletal pain (UL-WMSP) at workplace.

Objective: This study evaluated the relationship between various risk factors at workplace and UL-WMSP among PSW.

Materials and methods: A cross-sectional descriptive study was conducted in Thailand among 98 PSW (52 women and 46 men). A self-reported form was used to collect demographic factors and job task profile among PSW. Rapid upper limb assessment (RULA) was used to evaluate the risk of poor posture at work. The relationship between the risk factors and prevalence of UL-WMSP was evaluated through univariate logistic regression analysis (AMSEC-64EX-112).

Results: About 86.7% (N=85) of PSW reported UL-WMSP over the last 12 months, and 68.4% (N=67) reported UL-WMSP during the period of the last 7 days. Around 91.8% (N=90) of PSW exhibited a poor posture at work with RULA scores at 7 or more indicating a high level of risk for UL-WMSP. Risk factors such as age ($p<0.04$) was significantly related with prevalence of UL-WMSP over the period of the last 7 days. A significant relationship was also found between job tasks such as poultry abdominal slitting task ($p<0.02$), poultry cutting-up task ($p<0.03$), types of tool use ($p<0.01$), poor posture ($p<0.01$) and prevalence of UL-WMSP over the last 12 months.

Conclusion: Risk factors such as age, job tasks and poor posture are related to UL-WMSP among PSW at workplace. There is an essential need to develop musculoskeletal health and wellbeing program for the PSW to reduce UL-WMSP at the workplace and to create a healthy working environment.

Introduction

Work-related musculoskeletal pain (WMSP) is a common occupational disease which involves all parts of the body such as neck, upper limbs, and back region among poultry slaughterhouse workers (PSW).[1] Globally, PSW had high prevalence of upper limb work-related musculoskeletal pain (UL-WMSP) especially in the shoulder, arms, forearms, wrists and hand regions.[2-4] Amid the global competitiveness, the poultry industry in Thailand is rapidly expanding with the poultry exporters vigorously stretching their markets to meet the global demand for chicken products.[5] The constant drive for higher profit and poultry meat production requirements due to rapid

expansion of the poultry industry creates adverse factors such as increase in working hours, production line speeds and a decrease in breaking hours for PSW.[3,4,6,7] Thus, the workplace and job nature of PSW is exposed to several risk factors such as rapid work pace, repetitive movements, heavy lifting, sustained holding, forceful manual exertions and insufficient recovery time, which may contribute to UL-WMSP.[4,7-9]

The work nature of the PSW involves job tasks which include hanging poultry and head cutting, defeathering and cleaning, abdominal slitting and lastly, cutting-up of the poultry.[10] In addition, the nature of poultry processing tasks involves repetitive movements, excessive use of force, and specific tools such as knives and scissors which can contribute to UL-WMSP among PSW. Various UL-WMSP such as shoulder impingement syndrome, carpal tunnel syndrome and epicondylitis are reported among PSW.[7, 11-14] Recent evidence from Thailand indicates that 97% of the PSW have reported a high prevalence of WMSP at least in any one body region at a given time.[10] The highest prevalence of WMSP was reported at the shoulder region (61.5%) followed by wrists/hands (60.3%). Approximately 83% of PSW reported disability at upper limbs including shoulder, wrist and hands).[10]

Consequently, the UL-WMSP encountered by PSW may lead to reduced work capacity, long-term musculoskeletal illness, sickness absenteeism, and early retirement.[15-18] Despite steps to reduce UL-WMSP at the workplace through implementing several control measures such as occupational safety, engineering controls, use of technology and quality equipment at work, the risk factors that contributes to UL-WMSP needs further investigation for prevention strategies.[7,8] The Occupational Safety and Health guidelines for poultry processing plants recommends prevention of musculoskeletal disorders and protection of poultry workers health.[8] The Health and Safety Executive, United Kingdom suggests that adequate evaluation of risk factors is necessary to tackle UL-WMSP and protect the health of the wokers.[19]

Therefore, there is an immediate need to understand the risk factors behind UL-WMSP among PSW to develop people's health and wellbeing,[20] reduce UL-WMSP at the workplace and create a healthy working environment.[16, 21-24] The employers and employees need to develop a basic understanding of the prevention of risk factors that contributes to the UL-WMSP among the PSW. Therefore, the main aim of the study was to investigate the risk factors at workplace that are related to UL-WMSP among PSW. The information obtained from the study would be helpful to design and develop a prevention program to reduce UL-WMSP among PSW at workplace.

Materials and methods
Study design and setting
This was a cross-sectional descriptive study which was conducted among PSW in the northern parts of Thailand. There were three poultry slaughterhouse factories located in this region. A simple random method was used to select one of the three poultry slaughterhouse factories.

This study was conducted between the periods of March-August 2023 and approved by the institutional ethical committee according to the standards of the Declaration of Helsinki (Ethical approval number AMSE64EX-112). The purpose of the study and the study protocol was informed to the department manager, occupational safety officer, and PSW who worked in the factory. The PSW signed a written inform consent prior to their participation in the study.

Participant characteristics
The poultry slaughterhouse factory had 148 workers, including 28 office staff, 109 PSW, 8 storage workers and 3 maids. The inclusion criteria of the study were as follows: 1) males and females who worked in slaughtering tasks, 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, and 5) willing to participate in the study voluntarily. Any PSW with a previous history of any musculoskeletal surgeries, a recent history of injury and accidents in the last three months and those workers who started working less than one year of duration in the industry were excluded. There were 109 PSW who worked in slaughtering tasks. About 11 PSW were excluded due to; working at this factory less than 1 year (N=5), had history of back surgery (N=1), recent motorcycle accident (N=2), and did not willing to participated in the study (N=3). A total of 98 participants (52 women and 46 men) who met the inclusion criteria were recruited into the study.

Measures
All participants completed a self-reported form which collected several demographic information related to individual factors such as age, sex, smoking status, alcohol consumption, years of work experience and number of working hours. The information related to the job task profile such as type of job tasks performed at work (hanging poultry and head cutting, defeathering and cleaning, abdominal slitting and lastly, cutting up of the poultry) and types of tools used at the work were also collected. 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). The body mass index (BMI) of the PSW was calculated by dividing the weight (kg) by height squared (m²).[25]

The Standardized Nordic Musculoskeletal Questionnaire (SNMQ) was used to collect the presence of UL-WMSP over the last 7 days and 12 months.[26] The Rapid Upper Limb Assessment (RULA) was used to evaluate the risk of poor posture at work.[27] The RULA score categorizes the levels of risk into three categories such as low risk, medium and high risk and represents the risk of poor posture. The minimum RULA score was 1, and the maximum RULA score was 7. The interpretation of the RULA scores are as follows; Level 1 (1-2 scores): Posture is acceptable, Level 2 (3-4 scores): Low risk, further investigation is needed, and changes may be needed, Level 3 (5-6 scores): Medium risk, investigation and changes are required soon, and

Level 4 (7 scores): High risk, investigation and changes are required immediately. All the data was collected at the factory during the working hours of the PSW by a qualified physiotherapist. The average assessment time was 20 minutes for each participant.

Statistical analysis

The sample size for the study was based on the Krejcie and Morgan Table[28] which demonstrated a sample size of 98 PSW were needed for the study. Statistical analyses were performed using the SPSS version 27.0 for Windows (SPSS, Inc., Chicago, IL, USA). The normality of the data distribution was confirmed with the Kolmogorov-Smirnov test. The demographic data were reported in frequency, mean (M), standard deviation (SD), and percentages. The prevalence of WMSP for the past 7 days and 12 months were reported by the descriptive statistics. The association between the risk factors and UL-WMSP for the past 7 days and 12 months was evaluated through the univariate logistic regression analysis. The relationship between prevalence of UL-WMSP for the past 7 days and

12 months and independents variables were shown by the Cox & Snell R square (R^2). The odds ratios (ORs) in the current study were reported by exponential coefficients (β). Statistical significance was set at $p \leq 0.05$.

Results

A total of 98 PSW participated in the study. Around 47% (N=46) were men and 53% (N=52) were women. The mean age of the PSW was 38.12±8.83 years. Their average weight and height were 60.90±12.79 kg and 161.69±10.05 cm, respectively. Among the participants, about 39% (N=38) were smokers, and 65% (N=64) had alcohol consumption. Regarding profiling of job tasks, 7% (N=7) worked in hanging and head cutting task, 20% (N=20) worked in defeathering and cleaning task, 38% (N=37) worked in abdominal slitting task, and 35% (N=34) worked in cutting-up process. The mean work experience and working hours/day were 3.68±3.69 years, and 11.28±0.89 hours, respectively. Approximately 74.5% (N=73) used knives and scissors to perform their tasks. The demographic data and job factors were reported in Table 1.

Table 1. Demographic characteristics of poultry slaughterhouse workers.

Characteristics (N=98)	Mean±SD
Gender	
Males, N (%)	46 (46.9%)
Females, N (%)	52 (53.1%)
Age (years)	38.12±8.83
Weight (kg)	60.90±12.79
Height (cm)	161.69±10.05
Body mass index (kg/m^2)	23.32±4.54
Underweight (<18.5), N (%)	10 (10.2%)
Normal (18.5-22.9), N (%)	42 (42.9%)
Overweight (23-24.9), N (%)	17 (17.3%)
Obese (≥25.0), N (%)	29 (29.6%)
Previous injury at upper limbs	
No, N (%)	84 (85.7%)
Yes, N (%)	14 (14.3%)
Smoking	
No, N (%)	60 (61.2%)
Yes, N (%)	38 (38.8%)
Alcohol consumption	
No, N (%)	34 (34.7%)
Yes, N (%)	64 (65.3%)
Task section	
Hanging and head cutting, N (%)	7 (7.1%)
Defeathering and cleaning, N (%)	20 (20.4%)
Abdominal slitting - N (%)	37 (37.8%)
Cut-up process, N (%)	34 (34.7%)

Table 1. Demographic characteristics of poultry slaughterhouse workers (*continued*).

Characteristics (N=98)	Mean±SD
Work experience (years)	3.68±3.69
1-5, N (%)	74 (75.5%)
5.1- 10, N (%)	13 (13.3%)
>10, N (%)	11 (11.2%)
Work hours (hours)	11.28±0.89
Tool use (i.e., knives and scissors)	
No, N (%)	25 (25.5%)
Yes, N (%)	73 (74.5%)

The prevalence rate of UL-WMSP reported by the PSW over the period of the last 7 days and the last 12 months were shown in Table 2. The highest prevalence rate of WMSP was reported to be at shoulders region, 38.8% (N=38) over the period of the last 7 days and 78.86% (N=77) over the last 12 months. The prevalence rate of UL-WMSP at wrists and hands was 32.7% (N=32) over the period of the last 7 days and 59.2% (N=58) over the last 12 months. Moreover, approximately 68.4% (N=67) of participants reported UL-WMSP, i.e., shoulder, elbow/forearm, or hand/wrist during the period of the last 7 days and 86.7% (N=85) reported UL-WMSP over the last 12 months.

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

Total participants (N=98)	WMSP in the past 7 days		WMSP in the last 12 months	
	N	Prevalence (95%CI)	N	Prevalence (95%CI)
Neck	23	23.5 (15.3-31.6)	51	52.0 (42.9-61.2)
Shoulders	38	38.8 (29.6-49.0)	77	78.6 (70.4-86.7)
Elbows	3	3.1 (0.1-7.1)	7	7.1 (2.0-13.3)
Wrists and hands	32	32.7 (23.5-42.9)	58	59.2 (49.0-69.4)
Upper back	12	12.2 (6.1-18.4)	21	21.4 (14.3-29.6)

About 8% (N=8) of the PSW were identified to have a poor posture and presented a medium risk of developing UL-WMSP (Table 3). About 91.8% (N=90) of the PSW scored a RULA score of 7, presenting a poor posture and a high risk of developing UL-WMSP (Table 3). Table 4 shows the RULA scores among the PSW classified into 4 different job tasks including handing and head cutting task, defeathering and cleaning task, abdominal slitting task, and finally cutting up task. Table 5 and 6 shows the univariate logistic regression analysis of risk factors related with UL-WMSP for the past 7 days and over the last 12 months, respectively. In the Table 5, age (R^2=0.043, β=1.055, *p*=0.045) showed significant relationship with prevalence of UL-WMSP over the period of the last 7 days.

The finding showed that increasing age was associated with UL-WMSP up to 1.05 times. In the Table 6, abdominal slitting task (R^2=0.060, β=8.500, *p*=0.028) and cutting-up task (R^2=0.060, β=7.750, *p*=0.036), tool use (i.e., knives and scissors) (R^2=0.055, β=4.343, *p*=0.017), and RULA scores (R^2=0.116, β=17.083, *p*<0.001) showed significant relationship with prevalence of UL-WMSP. Abdominal slitting task and cutting-up task showed the relation with UL-WMSP up to 8.50 and 7.75 times more than the other tasks, respectively. Moreover, the tools such as knives and scissors, were associated with UL-WMSP up to 4.34 times more than who no tools. Finally, the high RULA scores had related with UL-WMSP up to approximately 17.08 times.

Table 3. Rapid Upper Limb Assessment scores among the poultry slaughterhouse workers.

RULA scores range	Classification	N (%)
1-2	Posture is acceptable	-
3-4	Low risk, change may be needed	-
5-6	Medium risk, further investigation, change soon	8 (8.2%)
7	High risk, implement change now	90 (91.8%)

Table 4. Rapid upper limb assessment scores among the poultry slaughterhouse workers that classified into four tasks; 1) hanging and head cutting task (N=7), 2) defeathering and cleaning task (N=20), 3) abdominal slitting task (N=37) and 4) cut-up process (N=34).

Classification	Hanging and head cutting task (N=7)	Defeathering and cleaning task (N=20)	Abdominal slitting task (N=37)	Cut-up process (N=34)
1-2: Posture is acceptable	-	-	-	-
3-4: Low risk, change may be needed	-	-	-	-
5-6: Medium risk, further investigation, change soon	3 (42.8%)	-	2 (5.4%)	3 (8.8%)
7: High risk, implement change now	4 (57.2%)	20 (100%)	35 (94.6%)	31 (91.2%)

Table 5. The univariate binary logistic regression analysis of factors related with upper limbs work-related musculoskeletal pain for the past 7 days (N=98).

No pain=31(31.6%), UL-WMSP =67(68.4%)	R^2	Exp(β)	*p* value
Gender	0.004	1.315	0.529
Age (years)	0.043	1.055	0.045[*]
Body mass index (kg/m^2)	0.006	1.007	0.890
Previous injury at upper limbs	0.026	3.164	0.149
Smoking	0.031	0.458	0.079
Alcohol consumption	0.001	0.853	0.731
Task section			
Hanging and head cutting			
Defeathering and cleaning	0.002	0.743	0.757
Abdominal slitting	0.002	0.833	0.841
Cut-up process	0.002	0.960	0.965
Work experience (years)			
1-5			
5.1-10	0.023	2.979	0.176
>10	0.023	1.444	0.609
Work hours (hours)	0.001	1.095	0.707
Tool use (i.e., knives and scissors)	0.023	2.082	0.127
RULA scores	0.013	2.333	0.255

Note: [*]*significance difference at p<0.05, R^2: Cox & Snell R square, Exp(β): exponential coefficients.*

Table 6. The univariate binary logistic regression analysis of factors related with upper limbs work-related musculoskeletal pain for the last 12 months (N=98).

No pain=13(13.3%), UL-WMSP=85(86.7%)	R^2	Exp(β)	*p* value
Gender	0.000	0.964	0.951
Age (years)	0.020	1.046	0.167
Body mass index (kg/m^2)	0.002	1.028	0.687
Previous injury at upper limbs	0.006	2.167	0.476
Smoking	0.004	1.500	0.527
Alcohol consumption	0.009	1.745	0.355
Task section			
Hanging and head cutting			
Defeathering and cleaning	0.060	3.000	0.246
Abdominal slitting	0.060	8.500	0.028*
Cut-up process	0.060	7.750	0.036*
Work experience (years)			
1-5			
5.1-10	0.006	1.875	0.566
>10	0.006	0.703	0.679
Work hours (hours)	0.014	0.653	0.261
Tool use (i.e., knives and scissors)	0.055	4.343	0.017*
RULA scores	0.116	17.083	< 0.001*

Note: *significance difference at p<0.05, R^2: Cox & Snell R square, Exp(β): exponential coefficients.

Discussion

The study findings showed a high prevalence of UL-WMSP among the PSW with the shoulder region most affected followed by wrist and hand regions. With 78% of PSW reported shoulder pain and 58% reported pain at the wrist and hands over the period of last 12 months, the current study provided insight on the chronic pain condition of UL-WMSP among the PSW. This high prevalence of chronic UL-WMSP reported by the workforce in the poultry industry clearly raises alarm and calls for appropriate prevention and management strategies to tackle UL-WMSP for the health and wellbeing of the workforce in poultry industrial sector. Therefore, an understanding of risk factors among PSW is an important first step towards developing prevention and management strategies to tackle UL-WMSP among the workforce in the poultry sector. Thus, the current study and its findings contributed to a quality of work that has international relevance, significance, originality and rigor for the workforce in the poultry industry. For instance, the poultry industry is expected to see a strong growth across various continents and over 50 countries in the next few years expanding from $385.37 billion in 2024 to $494.55 billion in 2028 at a compound annual growth rate (CAGR) of 6.4%. This rapid market expansion will require increased demand and aggravates risk factors at work for PSW globally, hence the current study that focuses on understanding risk factors for supporting health and wellbeing of PSW by prevention of risk factors related to UL-WMSP is of global relevance. The current study is also original and significant as it is the first

study that investigated the risk factors related to UL-WMSP among PSW in an Asian context, however the findings are still transferrable to the global poultry workforce sector. Considering the important focus of the study, several measures were followed to enhance the study rigor. Firstly, all end users such as supervisors, managers, PSW and local stakeholders were engaged and consulted in terms of explaining the benefit and rationale of the study. Secondly, the end users contributed to develop the study methods by sharing their views into study setting, shifts time of the PSW, recruitment strategies, data collection procedures and RULA measurements. Thirdly, the researcher underwent a training to use the RULA tool and conducted some pilot data collection to familiarize with the tool prior to the original data collection. All the said measures contributed to the study rigor.

Increase of age was a significant risk factor for UL-WMSP (p=0.045, ORs=1.05) in PSW. Previous studies reported that age was associated with WMSP such as rotator cuff syndrome and carpal tunnel syndrome among PSW.[13,29] Increasing age has been shown to negatively impact muscle function such as muscle power, muscle strength and muscle endurance.[30,31] These negative changes directly affect muscle performance and function contributing to musculoskeletal stress in both men and women.[30] Other risk factors such as specific job tasks performed by the PSW which includes abdominal slitting task and cutting up task (*p*=0.028, ORs=8.500, and *p*=0.036, ORs=7.750) also showed a significant relationship with UL-WMSP than other tasks (Hanging and head cutting

and Defeathering and cleaning). The nature of abdominal slitting task involves dissecting the abdominal part and remove internal organs, while the arms of the PSW have to pull out the internal organ and repeat motion in the same position.[7,8] The cutting up task involves repeatedly moving both arms to cut the chicken wings and legs.[7] Perhaps, if chicken were big sizes, PSW required a lot more force to cut the chicken part before it breaks into pieces.[7] PSW performed these two tasks always using force during the task and performed the task repetitively. Previous evidence also supported that 87.6% of PSW performed repetitive tasks and 67.2% of PSW felt discomfort in at least one body region, and the symptoms most often reported were pain, fatigue and tingling.[32] The body regions most frequently reported were shoulders (62.6%), neck (46.2%), forearms (31.3%), arms (29.2%), wrists (25.6%) and hands (25.6%).[4,9,32] Therefore, the current study highlights the importance of evaluating job tasks of PSW as part of developing prevention strategies for UL-WMSP.

Evidence suggests that the tools such as knives, saws, scissors, and knife-sharpeners used by the PSW were identified as the risk factors for prevalence of UL-WMSP.[6,11] Past studies indicated that 40% of PSW used hand tools (e.g., a knife and a knife-sharpener) and 65% of PSW reported bodily discomfort.[6,11] In the current study, about 75% (N=73) of PSW used a knife or scissors as part of their task. However, about 87% of PSW reported musculoskeletal pain in the upper body region which suggests that the tools used might be a significant risk factor for UL-WMSP (p=0.017, ORs=4.343) over the last 12 months than who no tools. Thus, PSW who reported using an equipment (i.e., knives and scissors) had higher prevalence of UL-WMSP. Therefore, addressing the tools used by the PSW could be a potential area for the poultry industry to tackle UL-WMSP. PSW must wear the rubber gloves when working, due to the standard procedure of slaughtering plants.[7,8] PSW could have difficulty holding an equipment with the rubber gloves because the gloves were quite slippery.[8] PSW have to grab on to equipment very hard and use excessive of force for griping and sustained the position for long periods of time especially when the size of the tool is too small which might contribute to the UL-WMSP.[8] RULA was used in this study to evaluate the risk of poor posture contributing to UL-WMSP among the PSW.[27,33] The RULA scores indicated approximately 91.8% (N=90) of PSW had high risk of poor posture which was a significant risk factor for UL-WMSP (p<0.001, ORs=17.083). This could be because the workstations of PSW were fixed and lacked ergonomic adjustments to the workforce requirements. Evidence suggests that ergonomic risk factors such as awkward posture, static loading, prolonged and forceful mechanical strain contributes to musculoskeletal pain.[6,11,34,35] Therefore, strategies to tackle musculoskeletal pain may need to consider ergonomic evaluation and posture assessments among the PSW.

Practice and industry implications

Ergonomic risk is multi-dimensional, the magnitude of risk attributable to various factors can be of importance to therapist and policy makers in designing countermeasures to reduce injury incidence.[36,37] The findings of the study are useful to suggest some recommendations to tackle UL-WMSP among the workforce in the poultry industry. For instance, with certain tasks such as abdominal cutting tasks increases the risk of PSW developing UL-WMSP. Therefore, the study recommends task rotation for the PSW during a shift as a necessary measure to reduce the risk of developing musculoskeletal pain. This might possibly reduce the higher musculoskeletal strain associated with abdominal slitting task. With age being identified as another risk factor in this study, the task rotation policy at workplace when introduced specially among the experienced and aged workforce might further reduce the risk of UL-WMSP among the PSW. Simple interventions such as providing a rubber glove with enhanced gripping features might reduce the demand on the musculoskeletal force needed to hold the tools while at work. Similarly, making provisions for different sizes of tools with different grips and for different hand sizes might further lessen the musculoskeletal strain while handling the tools in their workplace. Employers should provide a healthy work environment by assessing the risk factors to manage and prevent occupational disease.[37-39] An induction program incorporating the knowledge on UL-WMSP and risk factors is recommended for the workforce and the industry. In addition, the managers and supervisors should be encouraged to undertake additional training for tackling UL-WMSP through prevention, risk identification and health education strategies. There is an essential need to develop musculoskeletal health and wellbeing program for the PSW to reduce WMSP at the workplace and to create a healthy working environment.[20,37-39]

Limitations

The study has a few limitations. The data were collected from only one slaughterhouse factory in northern Thailand. It would have been ideal to have the data collected from various slaughterhouse factories. However, the study findings and recommendations are transferrable to a wider group of PSW and poultry industry because of the similar of work conditions. The current study did not investigate environmental factors such as noise, cold temperature, vibration, light, and clothing, hence, future studies should incorporate environmental risk factors related to UL-WMSP. Last but not the least, the study did not measure biomechanical risk factors such as force exertion and organization risk factors such as workplace policies, job support etc., which needs to be studies as UL-WMSP are multidimensional problems. Nevertheless, the study findings contributed to useful practice implications and recommendations for the poultry industry globally.

Conclusion

The PSW reported a high prevalence of UL-WMSP which was contributed by significant risk factors such as age, job tasks such as abdominal slitting task, cutting up tasks, types of tools used and poor posture. The study findings help creating and developing a healthy

work environment to improve working condition for the workforce in the poultry industry.

Consent to participate

All the participants gave written consent prior to their participation in the study.

References

[1] Bertozzi L, Villafañe JH, Capra F, Reci M, Pillastrini P. Effect of an exercise programme for the prevention of back and neck pain in poultry slaughterhouse workers. Occup Ther Int. 2015; 22(1): 36-42. doi: 10.1002/oti.1382.

[2] Caieiro TTM, de Assis DB, Mininel VA, Rocha FLR, Hortense P. Musculoskeletal pain: comparison between administrative and production employees of a poultry farming company. Rev Bras Med Trab. 2020; 17(1): 30-8. doi: 10.5327/Z1679443520190277.

[3] Sowcharoensuk C. Industry Outlook 2020-2022: Frozen and processed chicken. 2022 [cited 2023 July 26]. Available from: https://www.krungsri.com/th/research/industry/industry-outlook/food-beverage/frozen-processed-chicken/io/io-frozen-processed-chicken.

[4] Tirloni AS, Reis DCD, Borgatto AF, Moro ARP. Association between perception of bodily discomfort and individual and work organisational factors in Brazilian slaughterhouse workers: a cross-sectional study. BMJ Open. 2019; 9(2): e022824. doi: 10.1136/bmjopen-2018-022824.

[5] Office of the National Economic and Social Development Council (NESDC). National income of Thailand 2020, chain volume measures. 2021 [cited 2023 Sep 5]. Available from: https://www.nesdc.go.th/ewt_dl_link.php?nid=12298&filename=ni_page.

[6] Dias NF, Tirloni AS, Reis DCD, Moro ARP. Risk of slaughterhouse workers developing work-related musculoskeletal disorders in different organizational working conditions. Int J Ind Ergon. 2020; 76: 102929. doi: 10.1016/j.ergon.2020.102929.

[7] Harmse JL, Engelbrecht JC, Bekker JL. The impact of physical and ergonomic hazards on poultry abattoir processing workers: a review. Int J Environ Res Public Health. 2016; 13(2): 197. doi: 10.3390/ijerph13020197.

[8] Occupational Safety and Health Administration. Prevention of musculoskeletal injuries in poultry processing. 2013 [cited 2023 July 21]. Available from: https://www.osha.gov/Publications/OSHA3213.pdf.

[9] Tirloni AS, Reis DCD, Ramos E, Moro ARP. Association of bodily discomfort with occupational risk factors in poultry slaughterhouse workers. DYNA. 2017; 84(202): 49-54. doi: 10.15446/dyna.v84n202.62168.

[10] Hancharoenkul B, Joseph L, Khamwong P, Pirunsan U. An investigation of the prevalence of work-related musculoskeletal pain and related disability among poultry slaughterhouse workers: a cross-sectional study. Int Arch Occup Environ Health. 2022; 96(3): 463-72. doi: 10.1007/s00420-022-01940-x.

[11] Reis DCD, Tirloni AS, Ramos E, Moro ARP. Assessment of risk factors of upper-limb musculoskeletal disorders in a chicken slaughterhouse. Jpn J Ergon. 2017; 53 (Suppl 2): S458-S61. doi: 10.5100/jje.53.S458.

[12] Reis PF, Peres L, Tirloni AS, Reis DCD, Estrázulas JA, Rossato M, Moro ARP. Influence of anthropometry on meat-packing plant workers: an approach to the shoulder joint. Work. 2012; 41(Suppl 1): 4612-7. doi: 10.3233/wor-2012-0077-4612.

[13] Rosenbaum DA, Grzywacz JG, Chen H, Arcury TA, Schulz MR, Blocker JN, *et al*. Prevalence of epicondylitis, rotator cuff syndrome, and low back pain in latino poultry workers and manual laborers. Am J Ind Med. 2013; 56(2): 226-34. doi: 10.1002/ajim.22127.

[14] Sundstrup E, Jakobsen MD, Brandt M, Jay K, Aagaard P, Andersen LL. Associations between biopsychosocial factors and chronic upper limb pain among slaughterhouse workers: cross sectional study. BMC Musculoskelet Disord. 2016; 17: 104. doi: 10.1186/s12891-016-0953-7.

[15] Andersen LL, Fallentin N, Thorsen SV, Holtermann A. Physical workload and risk of long-term sickness absence in the general working population and among blue-collar workers: prospective cohort study with register follow-up. Occup Environ Med. 2016; 73(4): 246-53. doi: 10.1136/oemed-2015-103314.

[16] World Health Organization. Preventing disease through a healthier and safer workspace. 2018 [cited 2023 Jan 9]. Available from: https://www.who.int/publications/i/item/preventing-disease-through-a-healthier-and-safer-workspace.

[17] Yoshimoto T, Oka H, Fujii T, Nagata T, Matsudaira K. The economic burden of lost productivity due to presenteeism caused by health conditions among workers in Japan. J Occup Environ Med. 2020; 62(10): 883-8. doi: 10.1097/jom.0000000000002001.

[18] Young AE, Viikari-Juntura E, Boot CR, Chan C, Gimeno Ruiz de Porras D, Linton SJ. Workplace outcomes in work-disability prevention research: a review with recommendations for future research. J Occup Rehabil. 2016; 26(4): 434-47. doi:10.1007/s10926-016-9675-9.

[19] Health and Safety Executive (HSE). Managing risks and risk assessment at work. 2024. [cited 2024 May 10]. Available from: https://www.hse.gov.uk/simple-health-safety/risk/index.htm?utm_source=hse.gov.uk&utm_medium=referral&utm_campaign=guidance-push&utm_term=risk&utm_content=home-page-popular.

[20] Oliver M, Rodham K, Taylor J, McIver C. Understanding the psychological and social influences on office workers taking breaks; a thematic analysis. Psychol Health. 2021; 36(3): 351-66. doi: 10.1080/08870446. 2020.1764954.

[21] The National Chicken Council (NCC). Worker safety. 2022 [cited 2023 Aug 10]. Available from: https://www.nationalchickencouncil.org/policy/worker-safety/.

[22] van Oostrom SH, Driessen MT, de Vet HC, Franche RL, Schonstein E, Loisel P, et al. Workplace interventions for preventing work disability. Cochrane Database Syst Rev. 2009; 2: Cd006955. doi: 10.1002/14651858. CD006955.pub2.

[23] van Vilsteren M, van Oostrom SH, de Vet HC, Franche RL, Boot CR, Anema JR. Workplace interventions to prevent work disability in workers on sick leave. Cochrane Database Syst Rev. 2015; 10: Cd006955. https://doi:10.1002/14651858.CD006955.pub3.

[24] Vogel N, Schandelmaier S, Zumbrunn T, Ebrahim S, de Boer WE, Busse JW, et al. Return-to-work coordination programmes for improving return to work in workers on sick leave. Cochrane Database Syst Rev. 2017; 3(3): CD011618. doi: 10.1002/14651858. CD011618.pub2.

[25] World Health Organization. The Asia-Pacific perspective: redefining obesity and its treatment. 2000 [cited 2021 Sep 8]. Available from: https://apps.who.int/iris/bitstream/handle/10665/206936/0957708211_eng.pdf.

[26] Pugh JD, Gelder L, Williams AM, Twigg DE, Wilkinson AM, Blazevich AJ. Validity and reliability of an online extended version of the Nordic Musculoskeletal Questionnaire (NMQ-E2) to measure nurses' fitness. J Clin Nurs. 2015; 24(23-24): 3550-63. doi: 10.1111/jocn.12971.

[27] Kee D. An empirical comparison of OWAS, RULA and REBA based on self-reported discomfort. Int J Occup Saf Ergon. 2020; 26(2): 285-95. doi: 10.1016/j.ergon. 2021.103140.

[28] Krejcie RV, Morgan DW. Determining sample size for research activities. Educ Psychol Meas. 1970; 30(3): 607-10. doi: 10.1177/001316447003000308.

[29] Arcury TA, Cartwright MS, Chen H, Rosenbaum DA, Walker FO, Mora DC, et al. Musculoskeletal and neurological injuries associated with work organization among immigrant Latino women manual workers in North Carolina. Am J Ind Med. 2014; 57(4): 468-75. doi: 10.1002/ajim.22298.

[30] Norheim KL, Samani A, Bonlokke JH, Omland O, Madeleine P. The effects of age and musculoskeletal pain on force variability among manual workers. Hum Mov Sci. 2019; 64: 19-27. doi: 10.1016/j.humov. 2018.12.006.

[31] Tudorascu I, Sfredel V, Riza AL, Danciulescu Miulescu R, Ianosi SL, Danoiu S. Motor unit changes in normal aging: a brief review. Rom J Morphol Embryol. 2014; 55(4): 1295-301. PMID: 25611259.

[32] Tirloni AS, Reis DCD, dos Santos JB, Reis PF, Barbosa A, Moro ARP. Body discomfort in poultry slaughter-house workers. Work. 2012; 41(Suppl 1): 2420-5. doi: 10.3233/ WOR-2012-0651-2420.

[33] Kee D, Na S, Chung MK. Comparison of the Ovako Working Posture Analysis System, Rapid Upper Limb Assessment, and Rapid Entire Body Assessment based on the maximum holding times. Int J Occup Saf Ergon. 2020; 77(4): 102943. doi: 10.1016/j.ergon. 2020.102943.

[34] Nordin M, Pope MH, Andersson G. Musculoskeletal disorders in the workplace: principles and practice. 2nd Ed. Philadelphia: Mosby Elsevier; 2007.

[35] Sanders MJ. Ergonomics and the management of musculoskeletal disorders. 2nd Ed. Saint Louis: Butterworth- Heinemann; 2004.

[36] Oakman J, Chan S. Risk management: where should we target strategies to reduce work-related musculoskeletal disorders?. Saf Sci. 2015; 73: 99-105. doi: 10.1016/j.ssci.2014.11.026.

[37] Sundstrup E, Seeberg KGV, Bengtsen E, Andersen LL. A systematic review of workplace interventions to rehabilitate musculoskeletal disorders among employees with physical demanding work. J Occup Rehabil. 2020; 30(4): 588-612. doi: 10.1007/s10926-020-09879-x.

[38] Carolan S, Harris PR, Cavanagh K. Improving employee well-being and effectiveness: systematic review and meta-analysis of web-based psychological interventions delivered in the workplace. J Med Internet Res. 2017; 19(7): e271. doi: 10.2196/jmir.7583.

[39] Tarro L, Llauradó E, Ulldemolins G, Hermoso P, Solà R. Effectiveness of workplace interventions for improving absenteeism, productivity, and work ability of employees: a systematic review and meta-analysis of randomized controlled trials. Int J Environ Res Public Health 2020; 17(6): 1901. doi: 10.3390/ijerph 17061901.