Safety and Health at Work 9 (2018) 192–202

Contents lists available at ScienceDirect

Safety and Health at Work

journal homepage: www.e-shaw.org

Original Article

A Cross-sectional Study of Musculoskeletal Symptoms and Risk Factors in Cambodian Fruit Farm Workers in Eastern Region, Thailand

Anamai Thetkathuek*, Parvena Meepradit, Teerayut Sa-ngiamsak

Department of Industrial Hygiene and Safety, Faculty of Public Health, Burapha University, Chonburi 20131, Thailand

ARTICLE INFO

Article history:
Received 12 January 2017
Received in revised form
20 June 2017
Accepted 21 June 2017
Available online 30 June 2017

Keywords:
agriculture
Cambodian workers
eastern Thailand
migrant
musculoskeletal disorder

ABSTRACT

Background: Work-related musculoskeletal disorders are accumulative disorders that are most frequently found in agricultural farmers. The purpose of this study was to investigate factors that affect symptoms resulting from work-related musculoskeletal disorders among Cambodian farm workers working in fruit plantations in the eastern region of Thailand.

Methods: The Nordic Musculoskeletal Questionnaire, Rapid Upper Limb Assessment, and Hazard Zone Jobs Checklist techniques were used to interview 861 farmers who participated in the study.

Results: The data showed that men who had been working for >10 years were more at risk of neck pain than those working for <1 year with adjusted odds ratio (aOR) 1.66, 95% confidence interval (CI) (1.90, 14.5). Among women those who had been working for >10 years experienced lower back pain with aOR 8.13, 95% CI (1.04, 63.74), compared with those who had been working for <1 year. Men whose tasks required raising the arms above shoulder height had a risk factor contributing to neck pain of aOR 1.68, 95% CI (1.08, 2.61) when compared with those who did not work with this posture, and women had aOR 1.82, 95% CI (1.07, 3.12) when compared with those who did not work with this posture.

Conclusion: Based on the results of this study, it is recommended that work-related health conditions are monitored in migrant plantation workers to reduce the risks of musculoskeletal disorders.

1. Introduction

Thailand is an agricultural country with a population of 65.7 million people [1]. Approximately 14.88 million people, or about 38.7%, work in the agricultural sector [2]. Over the past decades, the number of Thai agricultural workers has decreased gradually, which in turn has forced plantation employers to seek migrant workers to combat this critical lack of manpower [3]. Consequently, the number of migrant workers has been increasing continuously. According to the Thailand Bureau of Labor, the number of migrant workers in Thailand had increased from 1,248,064 in 2011 to 1,437,716 in 2016 [4]. Cambodian migrant workers became popular employees in fruit plantations across the eastern region because of its proximity to the Cambodian border, which can easily be crossed into the area. Cambodian migrant workers were considered the largest population of migrant workers in the sector of fruit farms in the eastern part of Thailand [5]. Moreover, according to researchers' observation, these workers were notably exposed to the risks related to ergonomics in this work environment, as it is an occupation requiring various types of heavy workloads, repetitive work, standing tasks, etc.

The World Health Organization has stated that work-related musculoskeletal disorders (WMSDs) constitute a major occupational problem globally [6]. This was in accordance with musculoskeletal symptom risk studies of working activities and postures of migrant workers, in which they performed their work through various activities consisting of fruit tree care taking by applying fertilizers, mixing and spraying pesticides, harvesting, goods packaging, manually carrying packages, etc. In addition, their work postures comprise awkward body bending, heavy manual lifting, repetitive movement, daily prolonged working [7], and awkward neck bending. In addition, many lack the knowledge of safety and healthy working conditions such as the risk from vibrations [6,8]. All these are considered more significant risk factors for musculoskeletal symptoms than others [9–11].

Musculoskeletal symptoms generally contribute to poor quality of life, and illness results in costly treatment. It is anticipated that by the year 2020, numerous people will be suffering from severe

* Corresponding author. Department of Industrial Hygiene and Safety, Faculty of Public Health, Burapha University, Muang, Chonburi 20131, Thailand.
E-mail address: anamai@buu.ac.th (A. Thetkathuek).

2093-7911/$ – see front matter
http://dx.doi.org/10.1016/j.shaw.2017.06.009

health-related problems [12–14]. Recently, many studies investigating the prevalence of WMSDs among agricultural occupation in Thailand have been conducted; for instance, a study in sugarcane plantations found that sugarcane farm workers suffered physical illness symptoms, including back pain, muscle cramps, lumbar pain, and shoulder pain [15]. Another study on a rubber plantation conducted by Plykaew and Kaewthummanukul [16] demonstrated that the prevalence of musculoskeletal symptoms in the 12 months and 7 days prior to the study was 87.7% and 65.11%, respectively.

Many factors contribute to musculoskeletal symptoms [11,17,18], which can be categorized as personal factors [13], such as gender, age, etc.; working conditions involving repetitive movement, exertive force, and prolonged work for mostly 9–12 hours [19]; and awkward postures such as body bending, kneeling, body or arm twisting, and raising hands above the head [7,20,21]. Moreover, inappropriate working conditions and environment factors such as vibrations, combined with prolonged work hours, may also lead to musculoskeletal symptoms [8].

Most WMSDs are accumulative disorders [22]. Musculoskeletal disorders (MSDs) are most frequently found in arms and the back as a result of injuries and disorders across various parts of the body [23]. A variety of methods are widely used to diagnose MSDs, such as ultrasound imaging and medical/symptom examination methods [22]. One of the first signs of an increased risk of MSDs is muscle fatigue, which can eventually lead to decreased strength, reduced task performance, impaired exercise capacity, and/or less ability to exert force, and diminished power output [24,25].

Additionally, there are many methods for measuring the signs of muscle fatigue, including biomechanical manifestation via intracellular pH change, blood samples, and electromyography signals via invasive (needle electromyography) or noninvasive (surface electromyography) techniques [6,22,26–28]. However, for initial field assessment, Rapid Upper Limb Assessment (RULA) and the Hazard Zone Jobs Checklist, which requires basic and quick evaluation procedures, are still extensively used to evaluate the risks of work posture and lifting tasks, which contribute to MSDs affecting an upper body limb, and to evaluate lifting tasks, respectively [29–31].

Many studies relevant to ergonomic-related risk identification among Thai farm workers have been found in related literature reviews. These studies include the study by Swangnetr et al. [32] and others that studied ergonomic-related risk identification and pain analysis for farm workers involved in rice field preparation; Chanprasit and Kaewthummanukul [33] studied corn plantation farm workers and found that most of their working postures did not adhere to ergonomic recommendations such as the prevalence of body bending (9.2%), prolonged standing (97.7%), and manual heavy lifting (90%) [33]. In addition to those described above, studies were also conducted for sugarcane, rice, and rubber tree plantation workers [15,16].

Nevertheless, none of the identified studies included migrant farm workers, such as Cambodians working in Thailand. This study, therefore, focuses on musculoskeletal symptoms among Cambodian migrant workers in the region of eastern Thailand, where most of them were present. All information from this study may therefore help inform the provision of better future health monitoring practice guidance among farm workers in Thailand. The objectives of this research are to study the factors contributing to MSDs among Cambodian migrant farm workers in eastern Thailand.

2. Materials and methods

2.1. Population

The research participants were male and female migrant farm workers, who crossed the Cambodian border seeking employment in fruit plantations in the eastern provinces of Thailand. Working processes of fruit farming require different consecutive tasks, including fruit tree care taking by applying fertilizers, mixing and spraying pesticides, sprinkling water, harvesting, goods packaging, and manually carrying packages. However, only the processes of mixing, spraying pesticides, and harvesting fruits were selected for the study of musculoskeletal symptom risks, which involve working activities and postures of migrant workers.

Backpacks, cars, and stationary pesticide tanks were used as sprayer equipment. Backpack pesticide sprayers are used to apply insecticides directly over relatively small areas. Typically, migrant fruit farm workers used backpack pesticide sprayers by holding insecticide mixed with water. The volume of fully loaded sprayers varies from 8 L to over 22 L. When spraying insecticide using a car, insecticide mixed with water is poured in a large 1,000-L tank positioned on a car. Pesticide spraying usually involves a team of two to three people including a car driver, a sprayer, and an assistant. Farm workers usually spray insecticides along the distance of the area within the larger orchard. The method of using a stationary pesticide tank to spray follows the same pattern as the method of spraying insecticide using a car, except for the location of the large tank, which is placed on the ground. The insecticide team usually consists of two people, a sprayer and an assistant.

Inclusion criteria were that the participant was an immigrant of Cambodian nationality, was employed in a fruit plantation in the eastern region of Thailand as a permanent employee, and had been employed for at least 1 year. Those participating in this research did so on a voluntary basis, and permission from the employer was obtained beforehand.

2.2. Sample size

The sample size for this study was determined by the number needed to perform simple logistic regression [34].

$$n = \frac{4P(1-P)\left(Z_{1-\alpha/2} + Z_{1-\beta}\right)^2}{(P_1 - P_2)^2}$$

Here n is the required sample size and P the rate of use of health care services at a Thai hospital or medical facility. According to the study conducted by Lekcharoen et al. [34], regular exposure to a low temperature for more than 3 hours is equivalent to 61.4 ($p = 0.614$) and $p1 - p2$, respectively. The difference in incidence between the groups that had a physical risk and those that did not have the risk was small (0.15).

When the calculation and error approximation are put in place, α will be equal to 5% (=1.96). The formula for hypothesis testing is $(1 - \beta)$ and is equal to 80% (=0.84). The calculation of the sample size indicates that 495.48 informants are required. However, there are variables in this study. Thus, the sample size has been adjusted [35]; np is the adjusted sample size and $n1$ the calculated sample size for simple logistic regression. R is the correlation analysis of multiple logistic regression, which has been set as 35% ($R^2 = 0.35$) for this study. Based on this formula, the total size of the sample is 762 informants.

This study was conducted among workers in fruit orchards and was carried out in three eastern provinces (Chonburi, Rayong, and Chanthaburi) where there were many workers in a relatively small geographic area; this allowed data to be obtained from 861 participants.

2.3. Research ethics

All participants were permitted to decline or withdraw at any time from the study without penalty. Those who agreed to participate signed an informed consent form. The Institutional Review

Board of Burapha University provided ethical approval for the study protocol.

2.4. Tools and data collection

An interview questionnaire in the Khmer language was used to collect data. Interviews of groups of three to seven workers were conducted by five researchers and two translators. Prior to starting the interviews, a formal letter was conveyed to the farm owner or manager and an appointment was arranged by telephone. Both the translator and the Thai interviewer were educated before data collection. The groups of Cambodian migrant farm workers were interviewed by both a Khmer-speaking interpreter and a Thai researcher at the end of a work shift. Interviews had an average duration of 10–15 minutes and were carried out at their local subdistrict health promoting hospital. Data were collected using the interview questionnaire, RULA Assessment Word sheet for evaluating posture at work, and the Hazard Zone Jobs Checklist for evaluating the lifting tasks. Details are as follows.

2.4.1. Interview questionnaire

This questionnaire was divided into four parts. The first part contained demographic characteristics such as gender, age, educational level, marital status, monthly income, and smoking and alcohol consumption history. The second part included work history with the duration of work (years), total plantation space (acres), frequency of spraying (time/wk), duration of insecticide spraying (hours), and the insecticide spraying method. All questions were either multiple-choice type or open ended. The third part, on conditions in the work environment and ergonomic work, included questions about the physical work environment: temperature, vibration from engine, or mechanic and ergonomic work environment (specifically heavy workload, repeated work, standing work, twisting, reaching, bent posture, heavy lifting tasks, kneeling and squatting, and raising arms above shoulder height). The fourth part included questions on the health effects of musculoskeletal symptoms: neck pain, shoulder pain, elbow pain, wrist and hand pain, upper and lower back pain, hip and thigh pain, and pain in the knees and ankles. This ergonomic assessment was adapted from the Nordic Musculoskeletal Questionnaire that evaluated the postural stress of potters and sculptors [36–38]. The score was categorized into two levels: 0 when no symptoms were found and 1 when a symptom was found.

2.4.2. Risk assessment methods for work posture

The posture of the Cambodian farm workers showing their movement while mixing insecticide, spraying mangosteens and rambutans, obtaining durians, and trimming grapes was video recorded. The footage was cropped to produce snapshots for an analysis of postures of the farm workers. Snapshots of six workers were obtained, and the snapshots were analyzed to complete the RULA score sheets; the lifting task was assessed using the Hazard Zone Jobs Checklist.

Migrant farm workers were assessed by RULA because the upper limbs of the arm and wrist were primarily used. The RULA exposure scores were divided into four exposure categories: 0, 1, 2, and 3, indicating negligible, low, medium, and high exposures, respectively. Scores from the position of the upper arm (shoulder posture), lower arm (elbow posture), and wrist were adjusted because of more extreme postures. The following specific decisions were made: (1) determine if the workers worked mostly with their hand/forearm in neutral position or with the palm of the hand facing up or down—if neutral, the wrist twist was scored as mainly of midrange, and if facing up/down, the wrist twist was scored as being at or near the end of twisting range; (2) determine the muscle use score by deciding if the upper limb postures were already scored as mainly static, or if they were repeated four or more times a minute; (3) determine the score of force/load by considering the amount of force or load that was placed on or exerted by the upper limb as part A. Part B scores the posture of the neck, trunk, and legs, and was adjusted for more extreme neck and trunk postures.

The Hazard Zone Jobs Checklist of the Department of Labor and Industries, Washington State, USA, was used for lifting tasks to determine the ergonomic risk among farm workers executing lifting tasks [39]. The calculator for analyzing lifting operations can be explained in six steps: (1) record the weight of the object lifted; (2) select the number on the rectangle below that corresponds to the position of the person's hands when they begin to lift or lower the objects above shoulder height, from waist to shoulder height, from knee to waist height, and below the knee; (3) select the number that corresponds to the number of times a person lifts objects per minute and the total number of hours per day spent lifting; (4) select 0.85 if the person twists $\geq 45^{\circ}$ while lifting, and if not, use 1.0; (5) multiply the numbers that have been selected in Steps 2, 3, and 4 for the lifting limit; and finally (6) compare the weight lifted (1) with the lifting limit (5).

2.5. Data analysis

The accuracy of the information was verified and encoded in a computer. Statistical data analysis was performed by SPSS/PC version 22 software. The statistical data analysis consisted of three parts: (1) analysis of participant characteristics including work history, proportion of exposure to hazards, proportion of self-reporting of subjective symptoms that were classified by genders and analyzed using descriptive statistics including tabulated frequency, percentage, mean, standard deviation, median, minimum, and maximum values; (2) chi-square tests to explore comparisons of independent and dependent variables (musculoskeletal symptoms: neck, shoulder, elbow, wrist, upper and lower back, hip, knee, and foot pain) between men and women (significance level: $p = 0.05$); And (3) multiple logistic regression analysis, preceded by bivariate logistic analysis, to analyze the association between each independent variable and the symptoms of MSDs. Significant variables, including age, duration of work, plantation space, standing work, and arms raised above shoulder height, were used to identify the significant variables contributing to the symptoms of MSDs for the farm workers.

3. Results

3.1. Social demographic data

In this study involving a population of 861 Cambodian farm workers, there were more men than women. The mean age of men and women were 30.7 [standard deviation (SD) 8.4] and 29.8 (SD 8.7) years, respectively. The participants' age ranged mostly between 20 years and 29 years (39.1% of men and 42.2% of women). A comparative analysis found that the mean age of men and women showed no difference and that 69.3% of men were married, compared with 70.6% of women. It was found that 55.5 of men and 57.5% of women were uneducated. Monthly income for men (42.9%) and women (50%) ranged from USD142 to USD200; men had a mean income of USD217 (SD 61), which was higher than that of women (USD205, SD 60; see Table 1).

3.2. Smoking and alcohol intake

Most male and female farm workers (39.3% and 5.8%, respectively) were smokers at the time of the study; 23% of men and 4.2% of women had been smoking for 1–5 years. Their consumption of

Table 1
Participant characteristics

Participant characteristics	Men ($n = 501$) n (%)	Women ($n = 360$) n (%)	Total ($n = 861$) n (%)	χ^2 value	p
Age (y)				7.129	0.129
< 20	37 (7.4)	40 (11.1)	77 (8.9)		
20–29	196 (39.1)	152 (42.2)	348 (40.4)		
30–39	190 (37.9)	119 (33.1)	309 (35.9)		
40–49	63 (12.6)	35 (9.7)	98 (11.4)		
>50	15 (3)	14 (3.9)	29 (3.4)		
M (SD)	30.74 (8.44)	29.85 (8.72)	30.37 (8.57)		
Range	30.00 (18, 61)	29.00 (18, 62)	30 (18, 62)		
Education				4.87	0.088
No education	278 (55.5)	207 (57.5)	485 (56.3)		
Primary level	197 (39.3)	145 (40.3)	342 (39.7)		
High school or above	26 (5.2)	8 (2.2)	34 (3.9)		
Income (USD)					
M (SD)	217 (61)	205 (60)	211 (61)		
Range	200 (86, 514)	200 (86, 514)	200 (86–514)		
Current smoker				124.238	<0.001*
No	304 (60.7)	339 (94.2)	643 (74.7)		
Yes	197 (39.3)	21 (5.8)	218 (25.3)		
Smoking duration (y)				2.19	0.335
1–5	115 (23.0)	15 (4.2)	130 (5.1)		
5–10	46 (9.2)	3 (0.8)	49 (5.7)		
>10	37 (7.4)	2 (0.6)	39 (4.5)		
M (SD)	3.09 (6.02)	0.36 (2.4)	7.77 (7.42)		
Range	0 (0, 40)	0 (0, 30)	5 (1, 40)		
Current drinking habit				138.78	<0.001*
Never drank alcohol	244 (48.7)	315 (87.5)	559 (64.9)		
Former drinker	15 (3)	4 (1.1)	19 (2.2)		
Current drinker	242 (48.3)	41 (11.4)	283 (32.9)		

* Significant at <0.05.
M, mean; SD, standard deviation.

alcoholic drinks indicated that 48.3% of men and 11.4% of women were drinkers. A comparative analysis found that current smoking habits and alcohol consumption among men and women were significantly different: $\chi^2 = 124.238$ ($p < 0.001$) and $\chi^2 = 138.78$ ($p < 0.001$), respectively, as shown in Table 1.

3.3. Work history

This study shows that most of the men (58.9%) and women (59.4%) working on farms had been working for 2–5 years; the mean number of years spent working was 4.4 (SD 3.5) years for men and 4.1 (SD 4.2) years for women.

Men (49.9%) and women (54.7%) worked in an area approximately as big as 19 acres, which could separate in men (58.8, SD 121.18) acres and women (68.83, SD 137.93) acres in average.

Men working on farms mostly sprayed pesticides twice a week (45.1%), while women sprayed once a week (47.2%); 10.2% of men and 5.8% of women sprayed pesticides more than three times a week.

It was found that pesticide spraying sessions lasted 4–5 hours for 42.7% of men and 40.8% women. Cars and motorcycles were used by 43.1% of men and 50.6% of women to spray insecticides, while 25.9% of men and 20.3% of women used backpacks to spray pesticides, and stationary pesticide tanks were used by 30.1% of men and 26.9% of women. These results indicate that the duration of work between men and women demonstrated a significant difference ($\chi^2 = 6.08$, $p = 0.048$), as shown in Table 2.

3.4. Working conditions and working environments

It was found that most farm workers (49.1% of men and 47.2% of women) performed their tasks in settings where the temperature was too hot, and that they were affected by the vibration of machines and tools (men, 13.8%; women, 10.3%). With regard to ergonomics, it was found that most tasks conducted by men (64.3%) and women (64.2%) required bending, squeezing, and reaching gestures, and were followed by tasks performed in a standing position (65.7% of men and 55.8% of women) and by lifting hands above shoulder height (55.1% of men and 53.6% of women). By comparison, these results showed that the current heavy workload and work performed while standing showed significant differences between men and women: $\chi^2 = 4.04$ ($p = 0.044$) and $\chi^2 = 8.56$ ($p = 0.003$), respectively, as shown in Table 3.

3.5. Risk assessment for work posture

With respect to the risk assessment for work posture, it was found that mixing, insecticide spraying of rambutans and mangosteens, obtaining durians, and trimming grapes all had a very high risk score of 7.

The risk for lifting tasks (using the basket and placing it on the floor or in the car) was assessed by the Hazard Zone Jobs Checklist and classified into six steps: (1) the object weight was 57.2 lbs; (2) the position of the worker's hands when he/she began to lift the object were around knees to waist, but when lowering the object the position was waist to shoulder height, so the lifting limit was 40 lbs for both origin and destination; (3) the frequency per minute was nine lifts every minute and the total number of hours per day was >2 hours, so the multiplier was 0.15; (4) the worker performed twists of ≥45° while lifting, so the multiplier was 0.85; (5) the final lifting limit with those conditions was $40 \times 0.15 \times 0.85$, and it was shown to be 51 lbs; and (6) the results found that the weight lifted was higher than the lifting limit, indicating that the lifting operation was hazardous.

3.6. Health effects in MSDs

It was found that most men (38.9%) and women (44.7%) working on farms had developed pain over several body portions, including lower back area, followed by the upper back (28.3% of men and 28.1% of women) and neck (23.8% of men and 24.2% women) areas. This study showed that women were more exposed to ergonomic

Table 2
Work history

Work history	Men ($n = 501$) n (%)	Women ($n = 360$) n (%)	Total ($n = 861$) n (%)	Chi-square value	p
Duration of work (y)				8.856	0.031*
≤1	85 (17)	78 (21.7)	163 (18.9)		
2–5	295 (58.9)	214 (59.4)	509 (59.1)		
>5	121 (24.2)	68 (18.9)	189 (22.0)		
M (SD)	4.44 (3.45)	4.09 (4.18)	4.30 (3.77)		
Range	4 (0.5, 30)	3 (0.33, 31)	3 (0.33, 31)		
The total space of plantation (acres)				3.099	0.212
≤19	250 (49.9)	197 (54.7)	447 (51.9)		
20–40	173 (34.50)	104 (28.9)	277 (32.2)		
>40	78 (15.6)	59 (16.4)	137 (15.9)		
M (SD)	58.81 (121.18)	68.83 (137.93)	59.49 (129.04)		
Range	23.71 (1.98, 988.14)	19.76 (0.39, 988.14)	19.76 (0.39, 988.14)		
Frequency of spraying [time(s)/wk]				5.258	0.154
1	221 (44.1)	170 (47.2)	391 (45.4)		
2	208 (45.1)	154 (42.8)	362 (42.0)		
3	21 (4.2)	15 (4.2)	36 (4.2)		
>3	51 (10.2)	21 (5.8)	72 (8.4)		
Duration of insecticide spraying (h)				0.709	0.871
1–3	176 (35.1)	135 (37.5)	311 (36.5)		
4–5	214 (42.7)	147 (40.8)	361 (42.4)		
6–8	62 (12.4)	44 (12.2)	106 (12.4)		
>8	45 (9)	29 (8.1)	74 (8.7)		
Insecticide spraying method				6.080	0.048*
Backpack	130 (25.9)	73 (20.3)	203 (23.9)		
Car	216 (43.1)	182 (50.6)	398 (46.9)		
Stationary pesticide tank while spraying	151 (30.1)	97 (26.9)	248 (29.2)		

* Significance <0.05.
M, mean; SD, standard deviation.

risk factors (heavy workloads/raising arms above shoulder height) than men: $\chi^2 = 4.401$ ($p = 0.036$) and $\chi^2 = 11.59$ ($p = 0.001$), respectively, as shown in Table 4.

3.7. Factors contributing to the MSD symptoms among Cambodian migrant workers

Concerning bivariate logistic analysis between gender and MSDs, with respect to risk factors contributing to hip and thigh pain as well as wrist and hand pain, it was found that women were at risk of hip and thigh pain as well as wrist and hand pain when compared with men, with an adjusted odds ratio (aOR) equal to 1.85, 95% confidence interval (CI) (1.29, 2.64), and aOR 1.56, 95% CI (1.03, 2.36), as shown in Table 5.

Multiple logistic regression analysis and significant variables, including age, duration of work (years), plantation space (acres), standing work, and raising arms above shoulder height, were used to identify the significant variables contributing to musculoskeletal symptoms for the Cambodian migrant farm workers. For multivariate logistic analysis in men, this study showed that for men age between 40 years and 49 years and an age of >50 years were risk factors for increased knee pain, with aOR 8.78, 95% CI (1.04, 74.18), and aOR 7.63, 95% CI (7.59, 98.78), respectively, when compared with those aged <20 years, as shown in Table 6. However, for women age between 40 years and 49 years and an age of >50 years were not risk factors for increased knee pain more frequently.

It was found that men who had been working for >10 years had a higher risk of neck pain when compared with men who had been

Table 3
Proportion of exposure to hazards

Working environment	Men ($n = 501$) n (%)	Women ($n = 360$) n (%)	Total ($n = 861$) n (%)	Chi-square value	p
Physical work environment					
Too high temperature	246 (49.1)	170 (47.2)	416 (48.3)	0.296	0.586
Vibration from engine or mechanic	69 (13.8)	37 (10.3)	106 (12.3)	2.737	0.124
Ergonomic work environment					
Heavy workload	242 (48.3)	149 (41.4)	391 (45.4)	4.040	0.044*
Repeated work	281 (56.1)	180 (50)	461 (53.5)	3.121	0.077
Standing work	329 (65.7)	201 (55.8)	530 (61.6)	8.563	0.003*
Twisting, reaching, bending posture at work	322 (64.3)	231 (64.2)	553 (64.2)	0.001	0.925
Heavy lifting task	240 (47.9)	165 (45.8)	405 (47.0)	0.361	0.548
Job applications requiring to kneel and squat	168 (33.5)	116 (32.2)	284 (33.0)	0.163	0.687
Raising arms above shoulder	276 (55.1)	193 (53.6)	469 (54.5)	0.185	0.667

* Significant at <0.05.

Table 4
Proportion of subjective symptoms reporting

Musculoskeletal disorder in the past 12 mo ($n = 861$)	Men ($n = 501$) n (%)	Women ($n = 360$) n (%)	Total ($n = 861$) n (%)	Chi-square value	p
Neck pain	119 (23.8)	87 (24.2)	206 (23.9)	0.020	0.888
Shoulder pain	98 (19.6)	88 (24.4)	186 (21.6)	2.950	0.086
Right shoulder	8 (1.6)	2 (0.6)	10 (1.2)	1.978	0.160
Left shoulder	1 (0.2)	3 (0.8)	4 (0.5)	1.819	0.177
Both shoulders	91 (18.2)	84 (23.3)	175 (20.3)	3.457	0.063
Elbow pain	21 (4.2)	17 (4.7)	38 (4.4)	0.140	0.708
Right elbow	4 (0.8)	5 (1.4)	9 (1.0)	0.706	0.401
Left elbow	1 (0.2)	0 (0)	1 (0.1)	0.719	0.396
Both elbows	16 (3.2)	13 (3.6)	29 (3.4)	0.112	0.738
Wrist and hand pain	49 (9.8)	52 (14.4)	101 (11.7)	4.401	0.036*
Right wrist and hand	12 (204)	8 (2.2)	20 (2.3)	0.028	0.868
Left wrist and hand	4 (0.8)	3 (0.8)	7 (0.8)	0.003	0.955
Both wrist and hand	33 (6.6)	41 (11.39)	74 (8.6)	6.149	0.013*
Upper back pain	142 (28.3)	101 (28.1)	243 (28.2)	0.009	0.926
Lower back pain	195 (38.9)	161 (44.7)	356 (41.3)	2.906	0.088
Hip and thigh pain	67 (13.4)	80 (22.2)	147 (17.1)	11.585	0.001*
Knee pain	58 (11.6)	58 (16.1)	116 (13.5)	3.694	0.055
Ankle pain	52 (10.4)	44 (12.2)	96 (11.1)	0.718	0.397

* Significant at <0.05.

Table 5
Factors affecting symptoms of musculoskeletal disorders in all participants

Factor	Number ($n = 861$)	Neck pain	Shoulder pain	Elbow pain	Wrist and hand pain	Upper back pain	Low back pain	Hip and thigh pain	Knee pain	Foot pain
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	aOR (95% CI)
Gender										
Male	501 (58.2)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Female	360 (41.8)	1.02 (0.75, 1.4)	1.33 (0.96, 1.84)	1.13 (0.59, 2.18)	1.56 (1.03, 2.36)	0.99 (0.73, 1.33)	1.27 (0.97, 1.67)	1.85 (1.29, 2.64)	1.41 (0.99, 2.17)	1.20 (0.79, 1.84)

Data presented as aOR (95% CI). Reference group for each factor: gender: male (Ref.).
Bivariate: male and female.
aOR, adjusted odds ratio; CI, confidence interval; OR, odds ratio; Ref., reference.

working for <1 year, with aOR 1.66, 95% CI (1.90, 14.5). However, this study found that women who had been working for >10 years did not have a risk of increased neck pain, when compared with those who had been working for <1 year.

Men who worked in a plantation area of >39 acres in total had an increased risk of pain in the neck, wrist, upper and lower back, knee, and ankle, when compared with those who had worked in a plantation area of fewer than 20 acres, as shown in Table 6. Men whose tasks required raising the arms above shoulder height had a risk factor contributing to neck pain, with aOR 1.68, 95% CI (1.08, 2.61), as shown in Table 6.

Among women, it was found that working durations of 6–10 years and >10 years when compared with a working duration of <1 year were risk factors affecting pain in the lower back, with aOR 5.92, 95% CI (1.02, 34.3) and aOR 8.13, 95% CI (1.04, 63.74), respectively. However, it was found that men who had been working for 6–10 years and >10 years were not at a risk of lower back pain compared with those who had worked for <1 year.

Women who worked in a plantation area of >39 acres in total had an increased risk of pain in the neck, elbow, wrist, upper and lower back, knee, and ankle when compared with those who worked in a plantation area of fewer than 20 acres, as shown in Table 7. Women whose tasks required raising the arms above shoulder height had a risk factor contributing to neck pain, with aOR 1.82, 95% CI (1.07, 3.12), when compared with those who did not work in this position, as shown in Table 7.

4. Discussion

4.1. Overall prevalence

The result of the study indicated that the prevalence of musculoskeletal symptoms measured by at least one symptom among Cambodian farm workers who worked in the orchards in the eastern region was 692 (80.40%). When comparing the proportion of subjective symptoms reported by men and women, it was found that wrist and hand pain and hip and thigh pain significantly differed: $\chi^2 = 4.40$ ($p = 0.036$) and $\chi^2 = 11.59$ ($p = 0.001$) for men and women, respectively. For the nine body parts, the highest prevalence of musculoskeletal symptoms were reported for complaints in the lower back (38.9% of men and 44.7% of women), followed by upper back (28.3% of men and 28.1% of women) and neck (23.8% of men and 24.2% of women), which corresponds to the study conducted by Meyers et al. [11]; they indicated that musculoskeletal symptoms were caused by disorders of the muscles, tendons, joints, nerves, and tissues throughout the body. Most organs that developed a disorder, such as the lower back, neck, and shoulders, are usually used in agriculture work. This is consistent with the study by McMillan et al. [40], who examined musculoskeletal symptoms in 1,212 farm workers in Saskatchewan, Canada, and found that most participants (85.6%) reported having musculoskeletal pain in at least one body part over the past year.

The current study reports that lower back pain did not differ between men and women. The highest prevalence of musculoskeletal symptoms found in this study was in the lower back, which was high compared with corresponding rates from other studies, although it is difficult to compare directly because of different modified measurement tools, the Standard Nordic Questionnaire used, and a broadly different study population. The study of Ng et al. [41] indicated that the prevalence of lower back pain, measured using a modified Standard Nordic Questionnaire (Indonesian version), was 24.5% among Indonesian oil palm plantation farm workers. However, the prevalence of lower back pain is lower than that reported in the study conducted by Keawduangdee et al. [42], who indicated a prevalence rate of lower back pain of 83.1% among Thai farm workers during the rice transplanting process. They also used a modified Standard Nordic Questionnaire (Thai version), which was also used in a study among pluckers in a tea plantation in Tamil Nadu, India. Vasanth et al. [43] reported that the prevalence of lower back pain was 52.8% using a modified Standard Nordic Questionnaire (Indian version).

4.2. Work conditions

Tasks performed by the Cambodian farm workers in the orchard require heavy physical strength, for instance, lifting fruit baskets. By comparing the ergonomic work environment between men and women, it was found that the amount of heavy workloads and standing work significantly differed. From this study, the result of the lifting work assessment, measured using the techniques of the Hazard Zone Jobs Checklist, found that the fruit container lifting task is a high-risk task, as the container's weight is 57.2 lbs, which exceeds the weight (51 lbs) recommended by the Department of Labor and Industries [39]. In addition, Cambodian farm workers are also exposed to other risk factors such as unhealthy working gestures, repeated exposure, repeated working gestures such as pesticide mixing and spraying, and collection of fruits such as grapes, durians, and rambutans.

Risk assessment using the RULA technique [36–38] found that those tasks are associated with very high risk. As a result, they may lead to injury and inflammation of muscles, tendons, and other organs, which corresponds to the findings of the study conducted by Basher et al. [44], who indicated that almost half (42%) of the sample group responded that they had experienced pain symptoms in multiple organs at least once while performing these tasks in the plantation or orchard.

4.3. Factors affecting MSDs

Musculoskeletal symptoms among Cambodian farm workers who work in the orchard may be caused by various risk factors. According to this study, risk factors contributing to musculoskeletal symptoms are age, working duration, plantation area, and unhealthy working gestures.

Table 6
Factors affecting symptoms of musculoskeletal disorders among men

Factor	Number ($n = 501$)	Neck pain	Shoulder pain	Elbow pain	Wrist and hand pain	Upper back pain	Low back pain	Hip and thigh pain	Knee pain	Foot pain
		aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
Age (y)										
<20	33 (7.4)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
20–29	196 (39.1)	0.60 (0.27, 1.33)	1.31 (0.50, 3.40)	1.23 (0.15, 10.92)	1.99 (0.43, 9.19)	1.78 (0.76, 4.21)	1.13 (0.54, 2.39)	5.43 (0.71, 41.63)	4.01 (0.51, 31.73)	1.37 (0.29, 6.53)
30–39	190 (37.9)	0.68 (0.31, 1.51)	1.316 (0.50, 3.46)	1.42 (0.17, 12.11)	2.09 (0.45, 9.78)	1.35 (0.56, 3.24)	0.94 (0.44, 2.01)	6.90 (0.90, 52.93)	7.05 (0.89, 55.45)	2.60 (0.56, 12.13)
40–49	63 (12.6)	0.867 (0.35, 2.17)	1.074 (0.35, 3.33)	1.936 (0.19, 19.45)	2.697 (0.51, 14.22)	1.909 (0.72, 5.05)	1.44 (0.61, 3.42)	8.151 (0.99, 67.35)	8.777 (1.04, 74.18)	3.585 (0.69, 18.54)
>50	15 (3)	1.980 (0.54, 7.32)	1.371 (0.28, 6.77)	6.334 (0.50, 80.37)	6.116 (0.84, 44.56)	1.340 (0.32, 5.69)	0.85 (0.22, 3.23)	9.089 (0.82, 100.40)	7.634 (7.59, 98.78)	6.185 (0.83, 46.14)
Period of insecticide use (y)										
<5	12 (2.4)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
1–5	368 (73.5)	2.13 (0.45, 10.16)	1.01 (0.26, 3.94)	0.47 (0.05, 4.22)	1.86 (0.22, 15.60)	1.70 (0.43, 6.72)	2.97 (0.74, 11.93)	2.22 (0.27, 18.17)	0.32 (0.08, 1.23)	0.44 (0.10, 1.86)
6–10	112 (22.4)	0.97 (1.90, 4.94)	0.77 (0.18, 3.22)	0.50 (0.05, 5.03)	1.179 (0.13, 10.77)	1.19 (0.29, 4.93)	2.55 (0.61, 10.67)	1.09 (0.12, 9.72)	0.24 (0.06, 1.00)	0.43 (0.09, 2.01)
>10	9 (1.8)	1.66 (1.90, 14.51)	1.06 (0.12, 8.90)	0.000 (0)	0.000 (0)	0.91 (0.11, 7.85)	0.95 (0.11, 8.25)	2.99 (0.21, 42.36)	0.00 (0)	0.000 (0)
Total area of plantation (acres)										
<20	250 (49.9)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
20–39	173 (34.5)	1.46 (0.90, 2.36)	0.48 (0.27, 0.84)	0.67 (0.22, 2.05)	1.07 (0.51, 2.24)	1.09 (0.70, 1.73)	1.17 (0.77, 1.76)	0.75 (0.41, 1.38)	0.89 (0.45, 1.77)	0.73 (0.34, 1.58)
>39	78 (15.6)	2.45 (1.35, 4.45)	1.55 (0.86, 2.78)	1.83 (0.62, 5.37)	3.57 (1.68, 7.59)	2.50 (1.44, 4.33)	3.53 (2.03, 6.11)	1.37 (0.66, 2.81)	2.96 (1.44, 6.0)	3.94 (1.92, 8.09)
Standing work										
No	179 (35.7)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	322 (64.3)	0.83 (0.48, 1.45)	0.90 (0.50, 1.62)	2.22 (0.53, 9.27)	1.22 (0.55, 2.73)	1.19 (0.71, 2.03)	1.16 (0.71, 1.89)	0.58 (0.29, 1.13)	0.53 (0.26, 1.08)	0.77 (0.34, 1.58)
Trunk flexion, neck flexion, and twist										
No	179 (35.7)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	
Yes	322 (64.31)	0.93 (0.54, 1.62)	0.89 (0.49, 1.58)	2.16 (0.52, 8.91)	0.91 (0.42, 1.98)	1.27 (0.75, 2.13)	1.53 (0.94, 2.79)	1.38 (0.70, 2.74)	1.09 (0.53, 2.27)	0.96 (0.45, 2.07)
Elevated shoulders/arms										
No	225 (49.9)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	276 (55.1)	1.68 (1.08, 2.61)	1.39 (0.87, 2.20)	0.94 (0.38, 2.35)	1.57 (0.83, 2.97)	1.52 (1.01, 2.95)	1.08 (0.74, 1.57)	0.90 (0.53, 1.53)	1.46 (0.81, 2.63)	1.34 (0.72, 2.50)

Data presented as aOR (95% CI). Reference group for each factor: age: <20 years (Ref.); period of insecticide use: ≤1 year (Ref.); total plantation area: ≤20 acres (Ref.); standing work: no (Ref.); trunk flexion, neck flexion, and twist: no (Ref.); elevated shoulders/arms: no (Ref.).
Covariates adjusted: age, period of insecticide use, total plantation area, standing work, trunk and neck flexion, twist; elevated shoulders/arms.
aOR, adjusted odds ratio; CI, confidence interval; OR, odds ratio; Ref., reference.

Table 7
Factors affecting symptoms of musculoskeletal disorders among women

Factor	Number ($n = 360$)	Neck pain	Shoulder pain	Elbow pain	Wrist and hand pain	Upper back pain	Low back pain	Hip and thigh pain	Knee pain	Foot pain
		aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
Age (y)										
<20	40 (11.1)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
20–29	152 (42.2)	0.52 (0.23, 1.19)	1.40 (0.58, 3.39)	2.32 (0.25, 21.58)	0.90 (0.32, 2.55)	1.45 (0.62, 3.39)	1.07 (0.52, 2.22)	1.68 (0.59, 4.76)	0.41 (0.17, 1.02)	0.74 (0.26, 2.12)
30–39	119 (33.1)	0.41 (0.17, 0.98)	1.11 (0.44, 2.77)	2.19 (0.23, 20.92)	1.03 (0.35, 2.99)	1.21 (0.50, 2.93)	0.72 (0.34, 1.54)	2.28 (0.79, 6.55)	0.38 (0.15, 0.99)	1.07 (0.37, 3.07)
40–49	35 (9.7)	1.18 (0.42, 3.29)	1.13 (0.36, 3.54)	2.88 (0.31, 38.63)	0.32 (0.06, 1.87)	0.78 (0.24, 2.48)	0.32 (0.12, 0.90)	0.49 (0.10, 2.31)	0.31 (0.08, 1.18)	0.00 (0)
>50	14 (3.9)	0.74 (0.17, 3.18)	0.94 (0.19, 4.47)	0.00 (0)	1.73 (0.33, 9.22)	1.32 (0.31, 5.59)	0.51 (0.13, 1.94)	1.55 (0.29, 8.17)	1.24 (0.28, 5.5)	0.46 (0.05, 4.58)
Period of insecticide use (y)										
<1	9 (2.5)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
1–5	283 (78.6)	5.40 (0.58, 48.83)	3.20 (0.37, 27.5)	0.46 (0.04, 4.98)	2.93 (0.31, 27.41)	4.83 (0.55, 42.71)	4.53 (0.85, 24.1)	3.06 (0.35, 27.09)	—	0.88 (0.16, 4.86)
6–10	55 (15.3)	3.859 (0.38, 39.11)	2.84 (0.30, 26.55)	0.12 (0.01, 2.53)	0.61 (0.05, 7.63)	2.69 (0.28, 26.03)	5.92 (1.02, 34.33)	3.28 (0.34, 31.48)	—	0.44 (0.06, 3.22)
>10	13 (3.6)	10.75 (0.88, 131.61)	3.91 (0.33, 46.05)	0.57 (0.02, 13.15)	5.84 (0.437, 78.07)	6.76 (0.56, 81.02)	8.13 (1.04, 63.74)	5.54 (0.44, 69.28)	—	2.19 (0.23, 20.46)
Total area of plantation (acres)										
<20	197 (54.7)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
20–39	104 (28.9)	0.46 (0.23, 0.95)	0.58 (0.31, 1.07)	0.00 (0)	0.39 (0.15, 1.0)	0.69 (0.38, 1.24)	0.97 (0.59, 1.6)	1.49 (0.80, 2.77)	1.55 (0.76, 3.15)	0.91 (0.39, 2.15)
>39	59 (16.4)	3.03 (1.58, 5.80)	1.75 (0.92, 3.32)	3.50 (1.20, 10.19)	4.00 (1.93, 8.3)	2.82 (1.50, 5.30)	2.83 (1.50, 5.36)	3.56 (1.82, 6.96)	4.69 (2.21, 9.94)	3.16 (1.44, 6.94)
Standing work										
No	156 (44.2)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	201 (55.8)	0.92 (0.74, 1.80)	0.99 (0.53, 1.84)	0.37 (0.11, 1.28)	1.67 (0.72, 3.86)	1.01 (0.55, 1.85)	1.05 (0.61, 1.80)	0.89 (0.46, 1.72)	1.81 (0.81, 4.04)	0.63 (0.27, 1.46)
Trunk flexion, neck flexion, and twist										
No	129 (35.8)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	231 (64.2)	1.18 (0.59, 2.35)	0.79 (0.42, 1.49)	4.07 (1.02, 16.19)	0.92 (0.39, 2.14)	1.32 (0.70, 2.46)	1.18 (0.67, 2.07)	1.46 (0.73, 2.90)	1.11 (0.48, 2.53)	1.42 (0.59, 3.40)
Elevated shoulders/arms										
No	167 (46.4)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	193 (53.6)	1.82 (1.07, 3.12)	1.27 (0.77, 2.10)	0.853 (0.29, 2.43)	0.657 (0.34, 1.26)	0.71 (0.43, 1.15)	1.04 (0.67, 1.61)	0.63 (0.37, 1.07)	0.88 (0.48, 1.62)	1.03 (0.53, 2.02)

Data presented as aOR (95% CI). Reference group for each factor: age: <20 years (Ref.); period of insecticide use: ≤1 year (Ref.); total plantation area: ≤20 acres (Ref.); standing work: no (Ref.); trunk flexion, neck flexion, and twist: no (Ref.); elevated shoulders/arms: no (Ref.).
Covariates adjusted: age, period of insecticide use, total plantation area, standing work, trunk flexion, neck flexion, twist, and elevated shoulders/arms.
aOR, adjusted odds ratio; CI, confidence interval; OR, odds ratio; Ref., reference.

4.3.1. Age

This study found that men had a slightly higher average age than women (30.74 years vs. 29.85 years). However, the age of men and women was not significantly different. It also revealed that men who were between 40 years and 49 years of age and those >50 years old had a risk of developing knee pain more frequently (8.78 and 7.63 times, respectively) than men who were <20 years old. However, women aged between 40 years and 49 years and those > 50 years old were not at a risk of increased knee pain more frequently. There is some possibility that a group of 40–49-year-old male farm workers might have begun to suffer from MSDs due to tasks performed in the orchard, which required standing work (65.7%) and caused more knee pain. Apparently, this corresponded to the previous study results, indicating that farm workers who were 20–60 years old usually experienced musculoskeletal discomfort, especially those in the 41–60-year age group [44].

In addition, inappropriate working aspect and working posture were found among men who had heavier workload ($p = 0.04$) and standing work, which may cause knee pain, than among women ($p = 0.003$). This corresponds to the study of work-related knee pain symptom and other factors among 1,616 workers. It indicated that 122 people (7.5%) have chronic knee pain. In 243 people (15.0%), significant associations were found between incident chronic knee pain and handling loads of >4 kg [OR 2.1 (1.2–3.6) for men, OR 2.3 (1.1–5.0) for women] [45].

4.3.2. Gender

This study showed that women were more exposed to ergonomic risk factors (heavy workloads and raising arms above shoulder height) than men ($\chi^2 = 4.401$, $p = 0.036$, and $\chi^2 = 11.59$, $p = 0.001$, respectively). Moreover, regarding the data analysis of bivariate logistic regression, it was found that the women participating in the study were more at risk of developing wrist and hand pain as well as hip and thigh pain than men. This may be the result of heavier workloads assigned to female farm workers since women are usually assigned multiple tasks per day, such as watering fruit, dragging pesticide cables, trimming branches, fruit collecting, fruit selection, and fruit packaging. In addition, women are still expected to do difficult housework. The risk can also come from the physical differences between men and women, which correspond to a previous study that indicated that women farm workers experience more muscle discomfort symptoms than men ($p < 0.001$) due to various housework tasks that may increase the level of muscle discomfort [46]. Therefore, task assignment should be conducted in appropriate proportions for each gender. Follow-up on MSDs should be carried out regularly.

Additionally, the increasing body of confirmation that has accumulated in the past 10–15 years continues to show considerable sex differences in clinical and experimental pain responses, and some evidence suggests that pain treatment responses may differ for women versus men [47]. Moreover, physical symptoms in turn were the strongest predictor of illness behavior. Gender difference in physical symptoms disappeared after controlling for positive and negative mood states. Thus, mood states seem to mediate gender differences in symptom reporting [48].

4.3.3. Work duration

The duration of work (in years) between men and women was significantly different ($\chi^2 = 8.86$, $p = 0.031$). It indicated that the mean duration of work among men was 4.44 years (SD 3.45) and in women 4.09 years (SD 4.18). It was found that men who had been working longer than 10 years had a 1.66 times higher risk of neck pain than those who had been working for <1 year. However, this study found that women who had been working for >10 years were not at a risk of increased neck pain, when compared with those who had been working for <1 year. If men have to work for extended periods, the risk of neck pain will increase. If it was possible, men normally worked on muscles around the neck and shoulders rather than women, such as the method of spraying insecticide from a backpack [men (25.9%) vs. women (20.3%)] with a significant difference ($p = 0.048$).

In the case of women, it was found that those who had been working for 6–10 years and >10 years had, respectively, 5.92 and 8.13 times higher risk of lower back pain than those who had worked for <1 year. However, it was found that men who had been working for 6–10 years and >10 years were not at a risk of lower back pain than those who had worked for <1 year. This may be the result of heavier workloads assigned to women because women are normally assigned multiple tasks per day including working in fruit farm and housework.

This factor could be related to pain in the low back pain, which corresponds to the study results reported by Alghadir and Anwer [49], who found an association between the duration of work (years) and pain symptoms occurring in many parts of the body ($p < 0.05$). This corresponds to the study conducted by Ng et al. [50], who mentioned that working duration is an ergonomic risk factor that is related to MSDs.

It also corresponds to a study conducted in Bangladesh, which found that working duration in massive orchards has shown an association with musculoskeletal pain [44]. The risk among Cambodian farm workers may be a result of unhealthy working gestures and heavy lifting tasks. The fruit basket's weight is 57.2 lbs, which exceeds the standard weight of 51 lbs [38]. The longer working duration also imposes more of a risk of development of MSDs [44]. This corresponds to the findings of a study, which indicated that a task of lifting at least 10–20 kg during the working duration of 10–20 years will increase the risk of developing hip pain. After 10 years of working in an orchard, hip pain will start to appear.

4.3.4. Plantation area

The effect of plantation area (acres) did not significantly differ between men and women. However, plantation areas of 20–39 acres and >39 acres impose an increased risk of pain in the neck, elbow, wrist, hand, upper and lower back, hip, thigh, knee, and feet in both men and women compared with those who worked in plantations with fewer than 20 acres. The main cause of MSDs in men and women was usually attributed to overwork rather than ergonomic factors, particularly with regard to pain in the neck, wrist, upper and lower back, knee, or feet. A larger area requires a higher number of tasks, which may cause more MSDs. This corresponds to the study conducted by Hartman et al. [12], which mentions that the risk of back pain for workload has aOR1.54, 95% CI (0.99, 2.38).

4.3.5. Unhealthy working gestures

It was found that unhealthy working gestures in both men and women during tasks requiring elevation of the arms above shoulder height are a risk factor for neck pain, which is 1.68 times (men) and 1.82 times (women) higher than that in men and women who are not required to undertake tasks of this kind. Data analysis of the bivariate logistic regression found that women participants were not at a higher risk of neck pain when compared with their male counterparts. In particular, the comparison of ergonomic work environment highlighted no significant differences between men and women performing tasks that involve raising the arms above shoulder height. It can be concluded that raising arms above shoulder height was a risk factor for neck pain for all those requested to perform this task. For farm workers, there are various tasks that require lifting hands above shoulder height, such as fruit

harvesting, pesticide spraying, and fruit (grape, rambutan, and durian) picking.

Based on the ergonomic risk assessment using the RULA technique, it was found that the fruit collection and pesticide spraying tasks present a very high risk level. Those tasks require awkward wrist postures, elevated shoulders/arms, trunk flexion, and neck flexion, which correspond to the findings of the study conducted by Kalra et al. [51], who mention that neck and shoulder pain have direct relationships with agricultural activities, such as soil preparation, watering, pest control, fertilization, pesticide spraying, etc. These activities cause neck and shoulder pain symptoms, which correspond to the findings of the study of the National Institute for Occupational Safety and Health [52]. This study indicated that the risk factor of repeated tasks and labor enforcement is the risk factor concerning the force being exerted in' for neck and shoulder disorders. An example of this activity is the continual use of arms and hands, which requires constant moving and the force being exerted in' for neck and shoulder.

4.4. Implications

There is a deficiency in data on risk factors for musculoskeletal symptoms for migrant farm workers. This study shows the different risk factors and their risk levels in certain works. Knowledge of these factors can be utilized to determine and control high-risk tasks before they develop into musculoskeletal symptoms, such as the design of the ladder used to pick fruits from different fruit trees.

4.5. Study strengths and limitations

The strengths of the present study lie in its correspondently large sample size, which was composed of farm workers from eastern Thailand.

The limitations of this study result from ergonomic risk assessment and the assessment of risk factors contributing to musculoskeletal symptoms among Cambodian farm workers in the orchards in the eastern provinces of Thailand only. The ergonomic assessment is conducted by watching the selected video of some farm workers. Therefore, the source of information may be limited, and factors of the disorder may not represent the whole population of Cambodian farm workers. In addition, the assessment is conducted through interviews. There is no medical proof from a physician, and therefore there may be some errors in the data.

The results of this study showed significant differences between men and women, with respect to their current drinking history, duration of work (years), and use of insecticide spraying methods. In addition, the difference in proportion of exposure to hazards between men and women, including heavy work and standing work, was found to be statistically significant. The difference in MSDs, including levels of wrist and hip pain as well as hip and thigh pain, between men and women was found to be statistically significant. The risk factors contributing to MSDs in men included age (>40 years), period of insecticide use (>10 years), total plantation area (>39 acres), and elevated shoulders/arms. Among women, the risk factors contributing to MSDs consisted of the period of insecticide use (>6 years), total plantation area (>39 acres), and unhealthy working gestures (elevated shoulder/arms).

The recommendation of this study is to implement health surveillance for MSDs in at-risk groups based on age, working duration, plantation space, and unhealthy working posture. MSD control should be put in place to follow up farm workers' health, especially for men who are >40 years of age, who have been working for over 6 years, who have been working in plantation areas larger than 39 acres, and whose tasks require elevation of the shoulders/arms, as these factors can increase the risk of MSDs. Similarly, health surveillance should be conducted in women who are in at-risk groups due to factors such as period of insecticide use (>6 years), total plantation area (>39 acres), and unhealthy working gestures (elevated shoulders/arms).

The results of this study can be used to implement a preventive program, such as working posture/working station improvement, to decrease WMSDs among Cambodian farm workers and maintain good health within this population.

Conflicts of interest

All authors declare no conflicts of interest.

Acknowledgments

This work was financially supported by a research grant from Burapha University through the National Research Council of Thailand (grant number 36/2559).

References

[1] National Statistical Office, National Statistical Office of Thailand, Ministry of Information and Communication Technology. Population and housing census year 2016 [Internet]. 2016 [cited 2016 Oct 1]. Available from: http://service.nso.go.th/nso/web/statseries/statseries01.html.
[2] National Statistical Office. The direction of labor Thailand [Internet]. 2016 [cited 2016 Nov 1]. Available from: http://service.nso.go.th/nso/web/article/article_36.html.
[3] Samneang C. The situation of migrant workers in Thailand. Institute for Public Policy Studies Chiang Mai University [Internet]. 2013 [cited 2016 Aug 28]. Available from: http://www.siamintelligence.com/thai-labor-migration-status/.
[4] Office of Foreign Workers Administration. Number of foreigners allowed to work across the country [Internet]. March 2017 [cited 2017 Jun 13]. Available from: https://www.doe.go.th/prd/assets/upload/files/alien_th/a8b24dbc15d4e304a9db2c2d013fe808.pdf.
[5] International Labor Organization. Agriculture [Internet]. 2013 [cited 2016 Nov 28]. Available from: http://www.oit.org/public/english//region/asro/bangkok/child/trafficking/downloads/vol2-agriculture-thai.pdf.
[6] Sauter S, Hales T, Bernard B, Fine L, Petersen M, Putz-Anderson V, Schleiffer L, Ochs T. Summary of two NIOSH field studies of musculoskeletal disorders and VDT work among telecommunications and newspaper workers. In: Luczak H, Cakir A, Cakir G, editors. Work with display units. (The Netherlands): Elsevier Science; 1993. p. 229–39.
[7] Fathallah FA. Musculoskeletal disorders in labor-intensive agriculture. Appl Ergon 2010;41:738–43. http://dx.doi.org/10.1016/j.apergo.2010.03.003. Epub 2010 Apr 15.
[8] Solecki L. Low back pain among farmers exposed to whole body vibration: a literature review. Med Pr 2011;62:187–202.
[9] McCurdy SA, Samuels SJ, Carroll DJ, Beaumont JJ, Morrin LA. Agricultural injury in California migrant Hispanic farm workers. Am J Ind Med 2003;44:225–35.
[10] Von Essen SG, McCurdy SA. Health and safety risks in production agriculture. West J Med 1998;169:214–20.
[11] Meyers JM, Miles JA, Faucett J, Janowitz I, Tejeda TG, Kabashima JN. Ergonomics in agriculture: workplace priority setting in the nursery industry. Am Ind Hyg Assoc 1997;58:121–6.
[12] Hartmana E, Huub HE, Vrielinkb O, Metzb JHM, Huirnea RBM. Exposure to physical risk factors in Dutch agriculture: effect on sick leave due to musculoskeletal disorders. Int J Ind Ergon 2005;35:1031–45.
[13] Udon C, Janwantanakul P, Kanlayanaphotporn R. The prevalence of low back pain and its associated factors in Thai rubber farmers. J Occup Health 2016;58(6):534–42.
[14] Murray CJ, Lopez AD. The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries and risk factors in 1990 and projected to 2020. In: Global burden of disease and injury series, vol. II. Cambridge (MA): Harvard School of Public Health; 1996. p. 27–8.
[15] Sriwong N, Inmuong U. Health impacts from sugarcane growing on sugarcane farmers in Nongkungkeao Sub-district, Sriboonrung District, Nongbualamphu Province. J Public Health Res 2013;6:14–22.
[16] Plykaew R, Kaewthummanukul T. Working posture and musculoskeletal disorders among rubber plantation workers. Nurs J 2013;40:1–10.
[17] Meyers JM, Miles JA, Faucett J, Janowitz I, Tejeda DG, Duraj V, Kabashima J, Smith R, Weber E. High risk tasks for musculoskeletal disorders in agricultural

field work. In: Proceedings of the IEA 2000/HFES 2000 Congress, San Diego, CA 2000.
[18] Meyers JM, Miles JA, Faucett J, Janowitz I, Tejeda DG, Weber E, Smith R, Garcia L. Priority risk factors for back injury in agricultural Field work: vineyard ergonomics. J Agromed 2004;9:433–48.
[19] National Statistical Office, National Statistical Office of Thailand, Ministry of Information and Communication Technology. Population and housing census year 2010 [Internet]. 2010 [cited 2014 Oct 1]. Available from: http://popcensus.nso.go.th/en/.
[20] Zeng X, Kociolek AM, Khan MI, Milosavljevic S, Bath B, Trask C. Whole body vibration exposure patterns in Canadian Prairie farmers. Ergonomics 2017;60(8):1064–73.
[21] Havrda JB. Imaging of farm-related injuries. Radiol Technol 2013;85:163–83.
[22] Sa-ngiamsak T, Vila-Chã C, Baptista J, Torres Costa J. Assessment of muscle fatigue in work related musculoskeletal disorders by high-density surface electromyography [Internet]. Doctoral degree Dissertation. University of Porto. 2016 [cited 2016 Nov 17]. Available from: https://repositorio-aberto.up.pt/bitstream/10216/83623/2/129665.pdf.
[23] Occupational Safety and Health Administration. Ergonomics [Internet]. 2016 [cited 2000 Nov 17]. Available from: https://www.osha.gov/Publications/osha3125.pdf.
[24] Troiano A, Naddeo F, Sosso E, Camarota G, Merletti R, Mesin L. Assessment of force and fatigue in isometric contractions of the upper trapezius muscle by surface EMG signal and perceived exertion scale. Gait Posture 2008;28:179–86. http://dx.doi.org/10.1016/j.gaitpost.2008.04.002. Epub 2008 May 19.
[25] Davis Mellar P, Walsh Declan. Mechanisms of fatigue. J Support Oncol 2010;8:164–74.
[26] Merletti R. Basic concepts and applications of multichannel surface EMG. Slovenian–Italian workshop on quantitative needle and high resolution surface EMG. University Medical Centre Ljubljana, Division of Neurology [Internet]. 2013 [cited 2016 Aug 28]. Available from: http://www2.kclj.si/ikn/DEJA/SIIT/2.pdf.
[27] Merlett R, Holobar A, Farina D. Analysis of motor units with high-density surface electromyography. J Electr Kinesiol 2008;18:879–90. http://dx.doi.org/10.1016/j.jelekin.2008.09.002. Epub 2008 Nov 11.
[28] Madeleine P, Leclerc F, Arendt-Nielsen L, Ravier P, Farina D. Experimental muscle pain changes the spatial distribution of upper trapezius muscle activity during sustained contraction. Clin Neurophysiol 2006;117:2436–45.
[29] Yoo IG, Lee J, Jung MY, Yang NY. Neck and shoulder muscle activation in farm workers performing simulated orchard work with and without neck support. Work 2011;40:385–91. http://dx.doi.org/10.3233/WOR-2011-1250.
[30] Highnett S, McAtamney L. Rapid entire body assessment (REBA). Appl Ergon 2000;31:201–5.
[31] Kong YK, Lee SJ, Lee KS, Kim GR, Kim DM. Development of an ergonomics checklist for investigation of work-related whole-body disorders in farming—AWBA: agricultural whole-body assessment. J Agric Saf Health 2015;21:207–15.
[32] Swangnetr M, Kaber D, Phimphasak C, Namkorn P, Saenlee K, Zhu B, Puntumetakul R. The influence of rice plow handles design and whole-body posture on grip force and upper-extremity muscle activation. Ergonomics 2014;57:1526–35. http://dx.doi.org/10.1080/00140139.2014.934301.
[33] Chanprasit C, Kaewthummanukul T. Occupational health hazards, work-related illness and injury, work behaviors among informal workforce: case study in baby corn planting group. Public Health J Burapha Univ 2010;5:40–50.
[34] Lekcharoen N, Thetkathuek A, Rudtanasudjatum K. Factors influencing occupational risk behaviors among Thai and migrant fishery workers in Kohperit, Leamsing, Chantaburi province. Public Health J Burapha Univ 2011;6:41–52.
[35] Hsieh FY, Bloch DA, Larsen MD. A simple method of sample size calculation for linear and logistic regression. Stat Med 1998;17:1623–34.
[36] Vazquez-Cabrera FJ. Ergonomic evaluation, with the RULA method, of greenhouse tasks of trellising crops. Work 2016;54:517–31. http://dx.doi.org/10.3233/WOR-162314.
[37] McAtamney L, Nigel Corlett E. RULA: a survey method for the investigation of world-related upper limb disorders. Appl Ergon 1993;24:91–9.
[38] Ergonomics Plus Inc. A step-by-step guide Rapid Upper Limb Assessment (RULA) [Internet]. 2015 [cited 2016 Nov 17]. Available from: http://ergo-plus.com/resources/ergo-tools/.
[39] Department of Labor and Industries. Washington state hazard zone checklist [Internet]. 2012 [cited 2016 Nov 17]. Available from: http://www.lni.wa.gov/Safety/Topics/Ergonomics/Services Resources/Tools/default.asp.
[40] McMillan M, Trask C, Dosman J, Hagel L, Pickett W., Saskatchewan Farm Injury Cohort Study Team. Prevalence of musculoskeletal disorders among Saskatchewan farmers. J Agromed 2015;20:292–301. http://dx.doi.org/10.1080/1059924X.2015.1042611.
[41] Ng YG, Mohd Tamrin SB, Mohd Yusoff IS, Hashim Z, Deros BM, Abu Bakar S, How V. Risk factors of musculoskeletal disorders among oil palm fruit harvesters during early harvesting stage. Ann Agric Environ Med 2015;22:286–92. http://dx.doi.org/10.5604/12321966.1152101.
[42] Keawduangdee P, Puntumetakul R, Swangnetr M, Laohasiriwong W, Settheetham D, Yamauchi J, Boucaut R. Prevalence of low back pain and associated factors among farmers during the rice transplanting process. J Phys Ther Sci 2015;27:2239–45. http://dx.doi.org/10.1589/jpts.27.2239. Epub 2015 Jul 22.
[43] Vasanth D, Ramesh N, Fathima FN, Fernandez R, Jennifer S, Joseph B. Prevalence, pattern, and factors associated with work-related musculoskeletal disorders among pluckers in a tea plantation in Tamil Nadu, India. Indian J Occup Environ Med 2015;19:167–70. http://dx.doi.org/10.4103/0019-5278.173992.
[44] Basher A, Nath P, Siddique ZS, Rahman MH, Rubel MA, Sayed MS, Ahmad SA, Mondol GD, Bhuiyan MR. Musculoskeletal disorder (MSD) among agricultural workers. Mymensingh Med J 2015;24:1–8.
[45] Herquelot E, Bodin J, Petit A, Ha C, Leclerc A, Goldberg M, Zins M, Roquelaure Y, Descatha A. Incidence of chronic and other knee pain in relation to occupational risk factors in a large working population. Ann Occup Hyg 2015;59:797–811.
[46] Das B. Gender differences in prevalence of musculoskeletal disorders among the rice farmers of West Bengal, India. Work 2015;50:229–40. http://dx.doi.org/10.3233/WOR-131694.
[47] Fillingim RB, King CD, Ribeiro-Dasilva MC, Rahim-Williams B, Riley 3rd JL. Sex, gender, and pain: a review of recent clinical and experimental findings. J Pain 2009;10:447–85.
[48] Gijsbers van Wijk CMT, Kolk AM. Sex differences in physical symptoms: the contribution of symptom perception theory. Soc Sci Med 1997;45:231–46.
[49] Alghadir A, Anwer S. Prevalence of musculoskeletal pain in construction workers in Saudi Arabia. Sci World J 2015;2015:529873. http://dx.doi.org/10.1155/2015/529873. Epub 2015 Feb 25.
[50] Ng YG, Shamsul Bahri MT, Irwan Syah MY, Mori I, Hashim Z. Ergonomics observation: harvesting tasks at oil palm plantation. J Occup Health 2013;55:405–14.
[51] Kalra S, Arora B, Pawaria S. Cross sectional survey of work related musculoskeletal disorders and associated risk factors among female farmers in rural areas of Haryana, India. Indian J Physiother Occup Ther 2016;10:149–54.
[52] National Institute for Occupational Safety and Health. In: Bernard BP, editor. Musculoskeletal disorders and workplace factors. Cincinnati (OH) 1997.