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ORIGINAL ARTICLE

Prevalence and risk factors of musculoskeletal symptoms among municipal solid waste workers in Phayao Province, Northern Thailand

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Abstract

Background: Solid waste management needs to be performed worldwide. In developing countries, municipal solid waste is collected manually, requiring heavy physical labor outdoors, which may contribute to the development of work-related musculoskeletal disorders (MSDs). Purpose: To determine the prevalence and risk factors of musculoskeletal symptoms among municipal solid waste workers in local administrative organizations in Phayao Province, Northern Thailand. Methods: A cross-sectional analytic study using sociodemographic, work profile and environment workplace exposure data was conducted. The Standard Nordic Questionnaires among municipal solid waste workers (MSWWs) were used to interview 135 employees who participated in the study. Results: The highest prevalence of musculoskeletal symptoms among MSWWs was shoulder pain (55.56%), followed by low back pain (42.96%), wrist/hand pain (42.22%) and ankle pain (30.37%). There was one risk factor that was significantly associated with musculoskeletal symptoms: a frequency of lifting of ≥150 times/day [adjusted odds ratio (aOR) 4.46; 95% confidence interval (CI), 1.28–15.48]. Additionally, regarding body parts, a frequency of lifting of ≥150 times /day was shown to be a risk factor for wrist/hand pain [aOR 3.06; 95% CI, 1.11–8.44] and knee pain [aOR 4.00; 95% CI, 1.05–15.20]. Lifting heavy objects above the knees was associated with a risk of shoulder pain [aOR 3.80; 95% CI, 1.56–9.26], and workers who lifted objects continuously were at risk of knee pain [aOR 4.97; 95% CI, 1.02–24.31]. Conclusion: These findings demonstrate that the frequency of lifting, lifting continuously and lifting objects above the knees are risk factors for musculoskeletal symptoms, and it is recommended that MSWWs' posture and workplace environment are monitored.

Keywords: Musculoskeletal symptoms, Municipal solid waste workers, Prevalence, Risk factors

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1. Introduction

Due to rapid growth in the population, urbanization and human activities, there are currently major environmental problems causing a drastic increase in municipal solid waste generation, and the various types of waste have been shown to be a threat to human health [1-3]. Solid waste management is a serious challenge, and in developing countries, solid waste management requires predominantly manual handling tasks[4, 5]. Municipal solid waste workers' (MSWs') roles are significant to the reduce, reuse, and recycling movements, which are regarded as sustainable within the waste management hierarchy[6]. In Thailand, manual municipal solid waste collection is the most common occupation requiring physical labor outdoors, including separating, handling, transporting, storing, and disposing of waste, and it is performed by the municipality's local administrative organizations (LAOs). The collection of solid waste is hard work and can affect occupational health. The workers use vehicles that are driven through traffic and collect waste from the rear of the trucks during the collection window daily[7-9]. MSWWs worldwide have the highest risk for work-related disorders, injuries, illnesses, and exposure to various work-related hazards[10-12]. Work-related musculoskeletal disorders (WMSDs) are widely known to be causes of occupational problems in people worldwide[13]. However, MSWWs are frequently exposed to significant occupational hazards[14]. Previous studies have shown that MSWWs have a higher probability of developing MSDs than the general population due to the nature of their work[15]. An individual's working environment may be associated with risk factors for musculoskeletal symptoms, and there are also a large number of past reports on musculoskeletal problems, especially among waste collectors[16, 17]. Moreover, the work-related illnesses that occur among household waste collectors are mostly musculoskeletal disorders due to their poor posture during work[18].

Nonetheless, the identified studies provided little information, and several risk factors were unclear, such as municipal solid waste collection. Occupational epidemiological analytical studies are needed to identify the causes of these health hazards to prevent occupational health problems when solid waste collection systems are implemented and new employees are hired[16]. However, employees are exposed to such health hazards associated with musculoskeletal symptoms because the municipality's local government organization in Phayao Province does not yet have information on health hazards in the work environments of solid waste collection workers.

Thus, the main objective of this study was to determine the prevalence and risk factors of musculoskeletal symptoms among municipal solid waste workers in the municipalities of local administrative organizations in Phayao Province, Northern Thailand and to use the information as a guideline to assess, monitor and prevent health risks associated with the work of solid waste collection workers in the local government organization.

2. Materials and methods

2.1 Study design

A cross-sectional analysis was conducted to determine the prevalence and risk factors of musculoskeletal symptoms among municipal

solid waste workers in Phayao Province, Northern Thailand.

2.2 The population and sample size

The study was conducted among MSWW workers in 21 municipalities of local administrative organizations in Phayao Province, Northern Thailand. Because the population is small, 143 workers who were at least 20 years old were included in the study to represent the entire population, including all employees in the municipalities. The inclusion criteria were permanent or temporary employment and employment for at least one year. The exclusion criteria were a history of surgery for injuries not related to work and an underlying disease causing musculoskeletal symptoms, such as rheumatoid arthritis, gout, and accidental injuries. The workers fulfilled the eligibility criteria, and 135 (94.0%) of them participated in the study.

2.3 Ethical approval

The research study was approved by the Human Ethics Committee at the University of Phayao. The ethical clearance certificate number was Project No. 2/117/61 (February 18, 2019).

2.4 Tools and data collection

In this study, the data were collected by using structural questionnaires and face-to-face interviews. The questionnaires were divided into three parts. The first part consisted of general sociodemographic characteristics, including the participant's age (years), gender, height (cm), body weight (kg), marital status, education level, and monthly income (USD); the number of household members; his or her work history; any underlying diseases; alcohol consumption; cigarette smoking; and an annual health report. The second part corresponded to a work profile and individuals' physical and working environments, such as their position, job-related tasks, employment duration (years), working duration (hours/day), and frequency at which they lift objects (times/day); the weight of the containers or bags lifted (kg); the range of working hours; whole-body vibrations from vehicles and machines; continuous lifting tasks; and holding on vehicles and lifting heaving objects above the knees. All questions were either multiple-choice and fixed-choice or open-ended. The third part was constructed based on musculoskeletal symptoms by body region using the Standardized Nordic Questionnaire (SNQ)[19] and translated into the Thai language. Cronbach's alpha coefficient was used to evaluate the reliability of the questionnaire, and the internal consistency value was 0.89 for the severity of pain. The interview duration was approximately 15-20 minutes per person, and the interview was administered by a researcher during August – October 2019.

2.5 Data analysis

The data analyses were conducted using STATA version 14 (Stata Corp LP., Texas, USA 2015). Descriptive statistical analyses were performed to describe the sociodemographic and health data, work profiles, frequencies and proportions of tasks performed in the workplace, and prevalence of musculoskeletal symptoms; the data are expressed as the frequency, percentage, mean, standard deviation [*SD*], median, maximum and minimum. The outcome variable was analyzed using a univariable analysis of each independent variable. Any variable whose univariable test result showed a *p-value* of less than 0.25 was included in the first multivariable model, and the likelihood ratio was assessed by the chi-squared test. Then,

a multivariable model containing all covariates identified was used to assess the importance of each covariate using the *p-value* of its Wald statistic by the backward elimination technique[20], which accounts for confounding factors and other important factors that need further analysis, and to determine the odds ratio (OR) of various risk factors at a 95% confident interval. The significance level (*p-value*) was set to be below 0.05.

3. Results

3.1 MSWWs' sociodemographic and health data

All 135 MSWWs were men, with a mean age of 42.7 (*SD* 9.77) years. Most of the workers had ages between 40 and 49 years (40.0%) and less than 40 years (34.1%). Most (64.4%) of the workers were married. It found that 54.8% of the workers had a high school education. The monthly income (77.0%) was approximately USD 297.03 and USD 495.02 for most workers, and the median income was USD 297.03 (min.-max., USD 231.02-692.61). The mean number of household members was 3.96 (*SD* 1.59), and for 65.9% of the workers, this number was greater than or equal to four (≥4 persons). Furthermore, most of these employees were cigarette smokers (63.0%), and 67.4% of them consumed alcohol. Most of the MSWWs had a body mass index (kg/m^2) of 48.9%, which was considered normal (18.5–22.99 kg/m^2), followed by 47.4%, which was considered obese. The median body mass index was 22.8 (min.-max., 15.9-36.1 kg/m^2). Majority of the workers (84.4%) did not have an underlying disease, and 54.81% did not undergo annual health examinations. Almost all MSWWs (80.0%) had been employed previously, as shown in **Table 1.**

Table 1 Sociodemographic of the MSWWs (n=135)

Characteristics	Frequency (%)
Gender	
Male	135 (100.00)
Age (Years)	
< 40	46 (34.07)
40-49	54 (40.00)
≥ 50	35 (25.93)
Mean (*SD*)	42.73 (9.77)
Min-Max	20, 64
Marital status	
Single	43 (31.85)
Married	87 (64.44)
Widower	5 (3.71)
Education level	
Primary School	51 (37.78)
High school	74 (54.81)
Diploma or above	10 (7.41)
Income (USD)*	
< 297.03	30 (22.22)
297.03-495.02	104 (77.04)
≥ 495.05	1 (0.74)
Mean (*SD*)	314.27 (65.51)
Median	297.03
P^{25th}-P^{75th}	297.03, 330.03
Min-Max	231.02, 692.61
Number of household members	
< 4	46 (34.07)
≥ 4	89 (65.93)
Mean (*SD*)	3.96 (1.59)
Min-Max	1, 9

Table 1 Sociodemographic of the MSWWs (n=135) (cont.)

Characteristics	Frequency (%)
Alcohol consumption	
No drank	44 (32.59)
Current drinker	91 (67.41)
Cigarette smoke	
No smoking	50 (37.04)
Current smoker	85 (62.96)
BMI (kg/m^2)	
< 18.50	5 (3.70)
18.5-22.99	66 (48.89)
≥ 23.00	64 (47.41)
Mean (*SD*)	23.56 (3.66)
Median	22.77
P^{25th}-P^{75th}	20.82, 26.04
Min-Max	15.92, 36.11
Previous work	
Yes	108 (80.00)
No	27 (20.00)
Underlying disease	
Yes	21 (15.56)
No	114 (84.44)
Annual medical checkups	
Yes	61 (45.19)
No	74 (54.81)

Presented in frequency and percentage

* 1 USD was approximately = 30.30 THB

3.2 Work profile and working environment among municipal solid waste workers

The vast majority of 88.2% among MSWWs workers were temporary employed position and government/permanent position (11.8%). It was reported that there was a fifth work-related task; most of these workers were workers who lifted containers or bags/separators in the rear of the trucks (51.85%), followed by vehicle drivers (22.22%) and workers who lifted containers or bags (19.26%). It was found that the smallest proportion of workers were separators in the rear of the trucks (5.19%) and sewage workers (1.48%). Most of these workers had employment durations of five or more years (52.6%), and the median duration was 5.0 years (min.-max., 1 – 34 years).

The employees' working hours ranged from 3 – 12 hours/day. Most MSWWs (68.9%) reported that they spend six or more hours/day at the workplace. Only 31.1% reported spending less than six hours/day at their workplace. Most MSWWs (54.1%) had a lifting frequency greater than or equal to 150 times/day, and 45.9% of the workers had a frequency of less than 150 times/day. The MSWWs' median frequency of lifting was 150 times/day, and the range of the minimum and maximum frequency was 0 – 500 times/day. Most MSWWs (52.6%) lifted containers or bags weighing more than or equal to 30 kg, and 47.4% of the workers lifted containers weighing less than 30 kg each day. The median weight of the containers or bag lifted was 30 kg (min.-max., 0 – 150 kg). Regarding the daily shifts, most MSWWs (60.7%) work from 7 am to 4 pm, 25.2% work from 5 am to 12 pm, and 14.1% work from 12 am to 10 am, as shown in **Table 2.**

Most of the respondents (65.9%) were exposed to whole-body vibrations in vehicles or machines while working. Additionally, a large proportion of the workers (75.6%) reported lifting containers or materials and lifting objects above the knees. Most respondents (76.3%) reported holding objects every day in vehicles for their job, as shown in **Table 2.**

Table 2 Work profile and working environment of the MSWWs (n = 135)

Work profile	Frequency (%)
Positions	
Government/permanent position	16 (11.85)
Temporary employed position	119 (88.15)
Job tasks	
Lifting containers or bags	26 (19.26)
Separators in the rear of the trucks	7 (5.19)
Lifting containers or bags/separators in the rear of the trucks	70 (51.85)
Vehicle drivers	30 (22.22)
Sewage workers	2 (1.48)
Employment duration (in years)	
< 5	64 (47.41)
≤ 5	71 (52.59)
Mean (*SD*)	7.63 (7.61)
Median	5.00
P^{25th}-P^{75th}	3,10
Min-Max	1, 34
Daily working hours (hours/day)	
< 6	42 (31.11)
≥ 6	93 (68.89)
Mean (*SD*)	6.12 (1.69)
Median	6.00
P^{25th}-P^{75th}	4, 8
Min-Max	3, 12
Frequency of lifting (times/day)	
< 150	62 (45.93)
≥ 150	73 (54.07)

Table 2 Work profile and working environment of the MSWWs (n = 135) (cont.)

Work profile	Frequency (%)
Mean (*SD*)	156.24 (130.49)
Median	150.00
P^{25th}-P^{75th}	10, 250
Min-Max	0, 500
Weight of container or bags lifting (kg)	
< 30	64 (47.41)
≥ 30	71 (52.59)
Mean (*SD*)	44.74 (69.38)
Median	30.00
P^{25th}-P^{75th}	10, 60
Min-Max	0, 150
Rang in working time	
07 am-4 pm	82 (60.74)
12 am -10 am	19 (14.07)
5 am- 12 pm	34 (25.19)
Physical and working environments	
Whole-body vibrations in vehicles or machines while working	
Yes	89 (65.93)
No	46 (34.07)
Lifting continuously	
Yes	102 (75.56)
No	33 (24.44)
Holding with vehicle	
Every day	103 (76.30)
Sometimes	32 (23.70)
Lifting containers or materials and lifting objects above the knees	
Yes	102 (75.56)
No	33 (24.44)

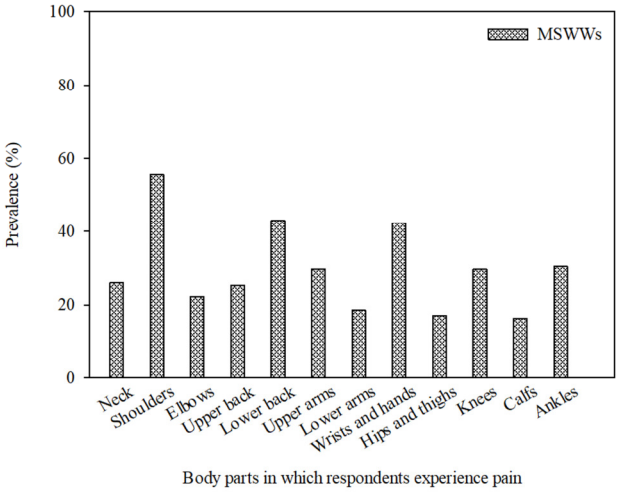

Figure 1 Prevalence of musculoskeletal symptoms in 12 body parts among MSWWs.

Figure 1 demonstrates the prevalence of musculoskeletal symptoms in 12 defined body parts of MSWWs over the last 12 months. The majority (84.4%) of these workers had musculoskeletal symptoms. Shoulder pain was found to be the most common (55.6%), followed by low back pain, wrist/hand pain and ankle pain (43.0%, 42.2%, and 30.4%, respectively).

3.3 Factors affecting musculoskeletal symptoms among MSWWs

Univariate analysis of the variables, including age, body mass index (kg/m^2), positions, job task, employment duration (years), daily working duration (hours/day), frequency of lifting (times/day), weight of containers or bags lifted (kg), holding in vehicles, whole-body vibrations from vehicles or machines while working, lifting heavy objects above the knees, continuous lifting, alcohol consumption, smoking, previous work, number of household members and underlying diseases, was used to identify the significant variables contributing to musculoskeletal symptoms in the MSWWs. This study showed that a daily working duration of eight or more hours/day (≥8 hours /day) compared with a daily working duration of less than eight hours (<8 hours/day) were risk factors for musculoskeletal symptoms, with OR 4.04, 95% CI [0.90-18.30]. Moreover, a frequency of lifting objects of more than or equal to 150 times/day (≥150 times/day) compared with that of less than 150 times/day (<150 times/day) was a statistically significant risk factor for musculoskeletal symptoms, with OR 2.75, 95% CI [1.03-7.33] (p<0.05), as exhibited in **Table 3.**

Eventually, multiple logistic regression analyses were conducted with significant variables selected at p<0.25 and other factors that have been shown to influence musculoskeletal symptoms with backward elimination, including the daily working duration, frequency of lifting, lifting heavy objects above the knees, weight of the containers or bag lifted and underlying diseases; the regression was adjusted for the covariates (age and duration of employment). The frequency of lifting objects more than or equal to 150 times/day (≥150 times/day) compared with that of less than 150 times/day (<150 times/day) was found to be a statistically significant risk factor for musculoskeletal symptoms, with an adjusted odds ratio (aOR) of 4.46, 95% CI [1.28-15.48] (p < 0.05), as illustrated in **Table 4.**

Table 3 Crude odd ratio (cOR) with 95% confidence interval (95% CI) of musculoskeletal symptoms based on simple logistic regression (n = 135)

Factors	Musculoskeletal symptoms		cOR	95%CI	*p-value*
	Present (n=114)	Absent (n=21)			
Age (Years)					
<40	38 (33.33)	8 (38.10)	Ref		
≥ 40	76 (66.67)	13 (61.90)	1.23	0.47-3.22	0.674
BMI (kg/m^2)					
18.5-22.99 (Normal)	56 (49.12)	10 (47.62)	Ref		
< 18.50 (Underweight)	4 (3.51)	1 (4.76)	1.40	0.14-13.86	0.962
≥ 23.00 (Obese/overweight)	54 (47.37)	10 (47.62)	1.35	0.14-13.37	
Positions					
Government/permanent position	13 (11.40)	3 (14.29)	Ref		
Temporary employed position	101(88.60)	18 (85.71)	1.29	0.34-5.00	0.713
Job tasks					
- Lifting containers or bags	20 (17.54)	6 (28.57)	Ref		
- Separators in the rear of the trucks	6 (5.26)	1 (4.76)	1.80	0.18-18.05	0.335
- Lifting containers or bag/separate in the rear of the trucks	63 (55.26)	7 (33.33)	2.70	0.81-8.97	
- Vehicle drivers	24 (21.05)	6 (28.57)	1.20	0.33-4.31	
- Sewage workers	1 (0.88)	1 (4.76)	0.30	0.02-5.55	
Employment duration (in years)					
< 5	53 (46.49)	11 (52.38)	Ref		
≥ 5	61 (53.51)	10 (47.62)	1.27	0.50-3.22	0.620
Daily working hours (in hours)					
< 8	80 (70.18)	19 (90.48)	Ref		
≥ 8	34 (29.82)	2 (9.52)	4.04	0.90-18.30	0.035*
Frequency of lifting (times/day)					
< 150	48 (42.11)	14 (66.67)	Ref		
≥ 150	66 (57.89)	7 (33.33)	2.75	1.03-7.33	0.037*
Weight of container or bags lifting (kg)					
< 30	54 (47.37)	10 (47.62)	Ref		
≥ 30	60 (52.63)	11 (52.38)	1.01	0.40-2.57	0.983

Table 3 Crude odd ratio (cOR) with 95% confidence interval (95% CI) of musculoskeletal symptoms based on simple logistic regression (n = 135) (**cont.**)

Factors	Musculoskeletal symptoms		cOR	95%CI	*p-value*
	Present (n=114)	Absent (n=21)			
Holding with vehicle					
Sometimes	26 (22.81)	6 (28.57)	Ref		
Every day	88 (77.19)	15 (71.43)	0.74	0.26-2.10	0.575
Vibrations in vehicles or machines					
No	39 (34.21)	7 (33.33)	Ref		
Yes	75 (65.79)	14 (66.67)	0.96	0.36-2.58	0.938
Lifting continuously					
No	26 (22.81)	7 (33.33)	Ref		
Yes	88 (77.19)	14 (66.67)	0.59	0.22-1.62	0.316
Alcohol consumption					
No drank	35 (30.70)	9 (42.86)	Ref		
Current drinker	79 (69.30)	12 (57.14)	1.69	0.65-4.38	0.283
Smoking					
No smoking	40 (35.09)	10 (47.62)	Ref		
Current smoker	74 (64.91)	11 (52.38)	1.68	0.70 - 5.70	0.280
Previous work					
No	23 (20.18)	4 (19.05)	Ref		
Yes	91 (79.82)	17 (80.95)	0.93	0.29-3.03	0.905
Underlying disease					
Yes	19 (16.67)	2 (9.52)	Ref		
No	95 (83.33)	19 (90.48)	1.90	0.41-8.85	0.382
Lifting containers, bags, or materials above knees					
No	25 (21.93)	8 (38.10)	Ref		
Yes	89 (78.07)	13 (61.90)	2.19	0.82-5.87	0.128
Number of household members					
< 4	42 (36.84)	4 (19.05)	Ref		
≥ 4	72 (63.16)	17 (80.95)	0.40	0.13 -1.28	0.100

cOR, Crude odds ratios; Ref, Reference

* Significant at $p<0.05$

Table 4 Adjusted odds ratio (aOR) with 95% confidence interval (95% CI) of musculoskeletal symptoms based on multiple logistic regression (n = 135)

Factors	Musculoskeletal symptoms		aOR	95%CI	*p-value*
	Present (n=114)	Absent (n=21)			
Age (Years)					
<40	38 (33.33)	8 (38.10)	Ref		
≥ 40	76 (66.67)	13 (61.90)	1.04	0.34-3.24	0.941
Employment duration (in years)					
< 5	53 (46.49)	11 (52.38)	Ref		
≥ 5	61 (53.51)	10 (47.62)	2.07	0.66-6.47	0.213
Daily working hours (in hours)					
< 8	80 (70.18)	19 (90.48)	Ref		
≥ 8	34 (29.82)	2 (9.52)	3.64	0.75-17.76	0.110
Frequency of lifting (times/day)					
< 150	48 (42.11)	14 (66.67)	Ref		
≥ 150	66 (57.89)	7 (33.33)	4.46	1.28-15.48	0.019*
Weight of container or bags lifting (kg)					
< 30	54 (47.37)	10 (47.62)	Ref		
≥ 30	60 (52.63)	11 (52.38)	0.67	0.21-2.20	0.511
Lifting containers, bags, or materials above knees					
No	25 (21.93)	8 (38.10)	Ref		
Yes	89 (78.07)	13 (61.90)	2.09	0.71-6.16	0.184
Underlying disease					
No	95 (83.33)	19 (90.48)	Ref		
Yes	19 (16.67)	2 (9.52)	2.38	0.44-12.84	0.314
Number of household members					
< 4	42 (36.84)	4 (19.05)	Ref		
≥ 4	72 (63.16)	17 (80.95)	0.34	0.10-1.22	0.098

Adjusted odds ratio: aOR; Ref, Reference

* Significant at $p<0.05$

It was found that MSWWs who had a frequency of lifting of ≥150 times/day was a statistically significant risk factor for wrist/hand pain and knee pain than those with a frequency of lifting of <150 times/day, with an aOR of 3.06 (95% CI [1.11-8.44]) and aOR of 4.00 (95% CI [1.05-15.20]) ($p<0.05$), respectively. The workers who were exposed to whole-body vibrations and machines while working every day was a statistically significant risk factor for knee pain than those who were sometimes exposed to whole-body vibrations and machines, with 71%, aOR 0.29, 95% CI [0.11-0.76] ($p<0.05$). Moreover, the results indicated that workers who had been lifting continuously was a statistically significant risk factor for knee pain, with an aOR of 4.97 and 95% CI of [1.02-24.31] ($p<0.05$). Additionall y,lifting heavy containers or objects above the knees was a statistically significant risk factor for shoulder pain compared with not lifting heaving objects, with an aOR of 3.80 and 95% CI of [1.56-9.26] ($p<0.05$). In addition, we found that the presence of an underlying disease was a statistically significant risk factor for wrist/hand pain and knee pain compared with the absence of an underlying disease, with an aOR of 3.34 (95% CI [1.16-9.67]) and aOR of 3.90 (95% CI [1.29-11.85]) ($p<0.05$), as indicated in **Table 5**.

Table 5 Risk factors for musculoskeletal symptoms in 12 body parts among MSWWs in Phayao Province, Northern Thailand

Factors	(n = 135)	Neck	Shoulders	Upper back	Elbows	Lower back	Upper arms	Lower arms	Wrists and hands	Hips and thighs	Knees	Calfs	Ankles
		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]	aOR [95%CI]	aOR [95%CI]	aOR [95%CI]
Age (yrs.)													
<40	46 (34.07)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
≥40	89 (65.93)	0.84 (0.32, 2.15)	1.22 (0.53, 2.85)	1.23 (0.47, 3.18)	0.51 (0.20, 1.33)	0.45 (0.19, 1.06)	0.91 (0.37, 2.19)	0.57 (0.20, 162)	0.65 (0.28, 1.51)	0.53 (0.18, 1.52)	1.16 (0.44, 3.08)	1.79 (0.55, 5.85)	1.00 (0.41, 2.48)
Employment duration (yrs.)													
<5	64 (47.41)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
≥5	71 (52.59)	0.98 (0.40, 2.40)	1.47 (0.66, 3.26)	1.02 (0.42, 2.47)	1.37 (0.54, 3.48)	1.55 (0.70, 3.48)	1.89 (0.81, 4.39)	0.96 (0.35, 2.68)	0.79 (0.35, 1.74)	1.75 (0.62, 4.96)	1.41 (0.57, 3.51)	0.81 (0.28, 2.37)	1.23 (0.53, 2.87)
Daily working hours (hrs.)													
<8	99 (73.33)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
≥8	36 (26.67)	1.35 (0.55, 3.30)	1.38 (0.59, 3.22)	0.59 (0.22, 1.61)	1.10 (0.42, 2.87)	1.93 (0.83, 4.51)	1.14 (0.47, 2.77)	0.47 (0.14, 1.52)	0.73 (0.31, 1.71)	1.90 (0.69, 5.25)	1.33 (0.53, 3.30)	1.26 (0.43, 3.70)	1.88 (0.80, 4.43)
Frequency of lifting (times/day)													
<150	62 (45.93)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
≥150	73 (54.07)	1.30 (0.42, 4.03)	2.00 (0.75, 5.30)	2.85 (0.81, 0.04)	1.27 (0.42, 3.84)	0.71 (0.26, 1.91)	1.25 (0.45, 3.50)	3.43 (0.83, 4.12)	3.06* (1.11, 8.44), $p<0.030$	2.19 (0.52, 9.14)	4.00* (1.05, 15.20), $p<0.043$	1.43 (0.33, 6.32)	0.81 (0.29, 2.28)
Weight of the containers or bags lifting (kg)													
<30	64 (47.41)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
≥30	71 (52.59)	0.74 (0.27, 2.00)	1.32 (0.55, 3.21)	0.61 (0.22, 1.64)	1.20 (0.43, 3.30)	2.43 (0.96, 6.18)	1.48 (0.57, 3.81)	1.92 (0.58, 6.36)	1.35 (0.56, 3.27)	1.53 (0.45, 5.18)	1.85 (0.62, 5.49)	3.97 (0.80, 19.77)	1.77 (0.66, 4.72)

Table 5 Risk factors for musculoskeletal symptoms in 12 body parts among MSWWs in Phayao Province, Northern Thailand (**cont.**)

Factors	(n = 135)	Neck	Shoulders	Upper back	Elbows	Lower back	Upper arms	Lower arms	Wrists and hands	Hips and thighs	Knees	Calfs	Ankles
		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]	aOR [95%CI]	aOR [95%CI]	aOR [95%CI]
Whole-body vibrations in vehicles or machines while working													
No	46 (34.07)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	89 (65.93)	0.41 (0.16, 1.03)	0.84 (0.35, 2.02)	0.91 (0.34, 2.41)	0.50 (0.19, 1.34)	0.69 (0.30, 1.62)	1.52 (0.60, 3.89)	0.87 (0.29, 2.61)	1.06 (0.43, 2.60)	1.13 (0.37, 3.42)	0.29* (0.11, 0.76), p<0.012	0.45 (0.14, 1.41)	0.59 (0.24, 1.46)
Lifting continuously													
No	33 (24.44)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	102(75.56)	1.21 (0.30, 4.83)	1.79 (0.51, 6.24)	2.06 (0.46, 9.17)	0.46 (0.09, 2.31)	1.85 (0.51, 6.54)	1.01 (0.26, 13.73)	1.94 (0.28, 13.73)	1.24 (0.30, 5.87)	2.47 (0.40, 15.35)	4.97* (1.02, 24.31), p<0.048	5.18 (0.68, 39.38)	0.96 (0.25, 3.73)
Lifting containers or materials and lifting objects above the knees													
No	33 (24.44)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	102(75.56)	0.94 (0.35, 2.54)	3.80* (1.56, 9.26), p<0.003	2.50 (0.84, 7.47)	1.32 (0.42, 4.11)	2.02 (0.78, 5.23)	0.90 (0.36, 2.23)	2.25 (0.59, 8.60)	0.70 (0.29, 1.71)	1.65 (0.47, 5.75)	1.48 (0.52, 4.24)	1.14 (0.36, 3.62)	0.97 (0.38, 2.49)
Underlying disease													
No	114(84.44)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	21 (15.56)	1.97 (0.68, 5.70)	0.77 (0.27, 2.14)	0.53 (0.34, 3.76)	1.13 (0.60, 0.27)	0.85 (0.30, 2.40)	1.21 (0.42, 3.49)	1.55 (0.41, 5.87)	3.34* (1.16, 9.67), p<0.026	1.77 (0.52, 6.05)	3.90* (1.29, 11.85), p<0.016	0.76 (0.19, 3.08)	2.05 (0.74, 5.66)

Note: Data presented as aOR [95% CI]. The reference group for each factor: age: <40 years (Ref.); employment duration <5 years (Ref.); working time <8 h/day (Ref.); frequency of lifting < 150 times/day (Ref.); weight of container or bags lifting <30 kg (Ref.); whole-body vibrations in vehicles or machines while working: no (Ref.); lifting continuously: no (Ref.); lifting containers or materials and lifting objects above the knees: no (Ref.) and underlying disease: no (Ref.).

Covariates adjusted: age, employment duration, working time, frequency of lifting, weight of container or bags lifting, whole-body vibrations in vehicles or machines while working, lifting continuously, lifting containers or materials and lifting objects above the knees and underlying disease.

aOR, adjusted odds ratio; CI, confidence interval; Ref., reference

* Significant at p<0.05.

4. Discussion

4.1 Sociodemographic and health data

The age of the MSWWs was found to exhibit a lower odds ratio for the presence of musculoskeletal symptoms (aOR = 1.04). There was no relation between the presence of musculoskeletal symptoms and the age of the workers. In contrast, Chaiklieng and Juntratep[21], in a previous study, indicated that solid waste collectors employed for ≥ 40 years in LAOs in Northeast Thailand, were at risk of musculoskeletal symptoms , with an aOR of 5.35 (95% CI [1.09-26.19]), and Reddy and Yasobant[22] suggested that workers who were >45 years old were at risk for musculoskeletal symptoms , with an aOR of 7.56 (95% CI [2.18-26.18]). However, being aged ≥40 years is not related to the presence of low back pain in solid waste collectors (SWCs)[23]. Similarly, a study conducted in India showed that habits such as cigarette smoking and alcohol consumption do not influence MSD pain severity[22]. Conversely, Chaiklieng and Juntratep[21] showed that smoking every day was significantly associated with musculoskeletal symptoms in SWC workers, with an aOR of 7.27 and 95% CI of (1.14-46.27). Furthermore, this study showed that the body mass index (kg/m^2) was not associated with musculoskeletal symptoms among MSWs. In this study, as in the previous studies, the results show that solid waste collectors are predominantly aged ≥40 years. However, most of them are men who are smokers (62.96%) and alcohol drinkers (67.41%), which increases their risk for accidents or injuries while working.

4.2 Working environment

The results of this study showed that most workers were temporary workers (88.6%) and most MSWWs had >5 years of employment experience, which involved lifting loads of ≥30 kg/day for ≥8 hours/day (29.8%). In contrast, Chaiklieng and Juntratep[21], in a previous study conducted in Nong Bua Lam Phu, Northeastern Thailand, indicated that MSWWs were at a significantly increased risk of musculoskeletal symptoms, especially those in the ≥ 4 years of employment group, with an aOR of 4.95 and 95% CI of [1.02-23.94]. In contrast, a study conducted in India showed that workers with employment durations of >5 years were not associated with MSDs[22]. In addition, it was found that lifting containers or bags weighing ≥30 kg showed no relation with musculoskeletal symptoms. Moreover, the most prevalent tasks among MSWWs were holding on the vehicles with their arms and hands (76%), as shown in Figure 2, lifting continuously (76%), lifting containers, bags, or other waste materials above the knees (76%), and whole-body vibrations from vehicles and machines (65.9%).

It is obvious that MSWWs are exposed to occupational health hazards in working environments. Although these factors have no association with musculoskeletal symptoms, they contribute to workplace hazards[24]. It has been reported in Chiang Mai, Thailand by Narisara et al.[25] that the most significant ergonomic hazards include lifting trash bags/bins (86.92%), followed by a forward-bending body position, a twisting position, and repetitive tasks (86.5%, 85.0%, and 80.0%, respectively). Additionally, literature reviews on handling solid waste in informal and organized manners showed that MSDs are a direct result of repeatedly moving and lifting heavy objects, such as containers, filled bags, and other materials filled

with solid waste, as well as long days, leading to acute chronic pain and discomfort[26]. However, this study found that workers were handling segregation in the rear of the vehicle during waste collection (5.19%), as shown in Figure 3. These issues may lead to muscle pain, fatigue, back pain, sprains and wrist/hand pain[26]. As a result, in 66 MSWWs (57.9%), significant associations were found between a frequency of lifting of ≥150 times/day and musculoskeletal symptoms, with a high aOR of 4.46, 95% CI of [1.28-15.48], and *p*=0.019.

The results of this study are similar to those of previous studies conducted among solid waste workers showing they are at a high risk of MSDs[27, 28]. Likewise, in Brazil, a study demonstrated that MSWWs are commonly exposed to vibrations, awkward postures, and repetitive movements[29].

4.3 Overall prevalence of musculoskeletal symptoms

The majority of municipal solid waste workers in Phayao Province, Northern Thailand, which was 114 workers (84.4%), had musculoskeletal symptoms. Similarly, previous studies have shown that the prevalence of MSDs in MSWWs in India and Tehran, Iran were 70.0%[22] and 65.0%[30], respectively. In addition, our study showed that shoulder pain was the most common MSD, followed by low back pain and wrist/hand pain, affecting 55.56%, 42.96%, and 42.22% of workers, respectively. In addition, Abd El-Wahab et al.[31] reported low back/sciatic pain (OR = 3.5, 95% CI = 1.8 – 7.0) among municipality workers in Alexandria, Egypt. Likewise, musculoskeletal pain in MSWWs in India was found in the knees (84.5%), shoulders (74.5%), and lower back (50.9%)[22]. According to Mehrdad et al.[30], the prevalence of symptoms in the low back, knees, shoulders, upper back and neck was 45.0%, 29.0%, 24.0%, 23.0%, and 22.0%, respectively. Asante et al.[32] reported that the prevalence of low back pain (LBP) lasting 12 months was 32% to 74% among waste collection workers, although none of the included studies quantified the relationships between the risk factors and LBP. In Thailand, municipal solid waste workers (MSWWs) in municipality authorities are involved in various types of waste handling activities, such as waste collection, transportation, sorting, processing and disposal. Hence, solid waste management procedures in Thailand are associated with occupational-related hazards such as musculoskeletal disorders.

4.4 Risk factors associated with musculoskeletal symptoms among MSWWs

The results of this study showed that an age ≥40 years was not associated with pain in any of the body parts. However, in contrast to the finding of this study in MSWWs in Northeastern Thailand aged ≥40 years, Juntratep and Sunisa reported that musculoskeletal symptoms were significantly associated with musculoskeletal symptoms (aOR 5.35, [95% CI, 1.09-26.19])[21]. However, being aged ≥40 years is not related to LBP among solid waste collectors[23]. However, a study in Finland showed that male workers performing manual labor had a higher risk of joint pain than did female workers (OR 1.65, [95% CI, 1.33-2.05] and aOR 2.60, [95% CI, 1.9-3.6]). It was obvious that the elbows, neck, low back, and wrist/hands were body parts at risk of joint pain, with an aOR of 2.76 [95% CI, 1.95-3.92], and it was found that the age group 50-64 years was at risk of joint pain, with an aOR of 3.12 [95% CI, 2.24-4.34][33, 34]. However, age and the presence of

an underlying disease were not significantly associated with low back pain (LBP). Likewise, a study conducted by Sunisa et al.[23] showed that age and the presence of an underlying disease were not associated with LBP among SWCs in Nong Bua Lam Phu, Northeastern Thailand. However, it was found that an employment duration of ≥5 years was a risk factor of low back pain, with an aOR of 2.32, [95% CI, 0.97-5.50], (p<0.05), which is consistent with the results in a study by Sunisa et al.[23]. Workers with an employment duration of ≥4 years showed a relationship with low back pain, with an aOR of 3.37, [95% CI, 1.11-10.07], and this relationship was statistically significant at p<0.031, which is consistent with the results shown by Salve et al.[15] A study conducted in India showed an odds ratio for LBP and working experience of ≥10 years among municipal waste loaders in Mumbai, with an OR of 3.14 [1.30-7.59, p<0.01]. However, it was found that lifting containers or bags weighing ≥30 kg was not related to LBP. Consistent with the study results reported by Sunisa et al.[23], no association was found lifting containers or bags weighing >50 kg among SWCs. Moreover, the MSWWs who had a frequency of lifting ≥150 times/day were at risk of wrist/hand pain and knees, with an aOR of 2.93, [95% CI, 1.06-8.14], (p < 0.039) and an aOR of 3.73, [95% CI, 0.98-14.30], (p < 0.05), respectively. It was found that of these workers, whole-body exposure to whole-body vibrations and machines while working every day increased the risk of knee pain by 71% (aOR 0.29, [95% CI, 0.11-0.76]) (p < 0.012). In addition, lifting heavy containers or materials above the knees was a risk factor for shoulder pain, with an aOR of 3.80, [95% CI, 1.56-9.26], (p < 0.003). Since lifting was the most frequent cause of injury among SWCs in the private (28%) and public sectors (37%)[12], heavy lifting also leads to a higher rate of back and shoulder pain[31]. Risk factors are considered to be modifiable or non-modifiable variables related to an increased risk of disorders or ergonomic hazards[35]. Additionally, we found that the presence of an underlying disease was a statistically significant risk factor for wrist/hand pain and knees pain compared with the absence of an underlying disease, with an aOR of 3.34, [95% CI, 1.16-9.67], (p < 0.026) and an aOR of 3.90, [95% CI, 1.29-11.85], (p < 0.016), respectively.

The prevalence of musculoskeletal symptoms has also been shown to be high, even in many developing countries, such as Thailand. MSWWs collect solid waste manually, and household solid waste collectors have many job-related responsibilities. Hence, heavy physical labor performed outdoors, such as heavy lifting, loading, lifting/carrying, pulling/pushing, handling, and segregation, has been shown to induce pain in the hips/thighs, shoulders, wrists/hands, elbows, and knees, irrespective of the load carried[36-39]. Furthermore, the study has shown a higher prevalence of MSDs in the hips/thighs than those reported in other studies, suggesting that musculoskeletal problems are common among waste collectors[10]. This result may have occurred because waste workers repetitively engage in lifting heavy community dustbins throughout the workday. Similarly, past studies conducted with solid waste workers in developing countries such as Taiwan[7], Egypt[11], India[15], and Nigeria[40] have reported a high prevalence of MSDs, particularly in the low back, shoulders, wrist/hands, upper back, neck, and knee[11].

Implications

There are few studies on risk factors for musculoskeletal symptoms among municipal solid waste workers in Thailand. This study shows some risk factors of musculoskeletal symptoms related to this type of work. Knowledge of these factors can be utilized to identify and modify high-risk job-related tasks before workers develop musculoskeletal symptoms, such as the design of mechanical support in a working environment.

Study limitations

The limitations of the present study include the small sample size by study area, which was composed of municipal solid waste workers from local administrative organizations (LAOs) in Phayao Province, Northern Thailand.

The study's limitations result from the inclusion of an ergonomics risk assessment. Consequently, the data retrieved and risk factors of musculoskeletal symptoms identified may not be representative of the whole population of MSWWs. Additionally, the assessment being conducted through interviews may lead to recall bias in the reports of musculoskeletal symptoms experienced over the previous year. There were no medical diagnoses from a physician, and therefore, there may be some errors in the data.

Conclusions

The study indicates that the prevalence of musculoskeletal symptoms was high among municipal solid waste workers over the last 12 months in Phayao Province, Northern Thailand. The structural questionnaire interview revealed that all 135 employees were men, most of whom were 40-49 years of age. Most MSWWs reported experiencing pain in the shoulder, low back, wrist/hands, and ankles, and a frequency of lifting of ≥150 times/day was significantly associated with musculoskeletal symptoms among MSWWs. In addition, the difference in exposure to a wide variety of factors in the physical work environment including lifting in awkward postures, lifting loads that are hard to hold and having too few mechanicals support on during work. The risk factors contributing to musculoskeletal symptoms among MSWWs were as follows: a frequency of lifting of ≥150 times/day was a risk factor of wrist/hand pain and knee pain, lifting continuously was a risk factor for knee pain, and whole-body exposure to vibrations and machines while working every day was a risk factor for knee pain. Moreover, these workers lifted heavy containers or materials above the knees, which was a risk factor for shoulder pain. Consequently, frequent lifting work needs to be minimized to reduce the incidence of musculoskeletal symptoms. The information provided in this study may be used to develop new approaches to prevent musculoskeletal symptoms in workers. To that end, MSWWs need to be evaluated, their health needs to be monitored, and assistive tools for lifting or preventive measures need to be implemented though training; annual medical checkups for all workers, particularly those working as solid waste collection employees, should be provided. Additional studies should be conducted to further assess the risk factors for musculoskeletal symptoms among MSWWs in the workplace to prevent musculoskeletal symptoms.

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