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Effects of Health Promotion Programs on Reducing Muscle Pain among Electronic Waste Workers

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Abstract

Background: E-waste workers have a high prevalence of work-related musculoskeletal disorders (WMSDs). This study examined the effects of health promotion programs on reducing muscle pain among electronic waste workers and compared the prevalence between before and after programs.

Materials and Methods: This part of the research was quasi-experimental, with a one-group pre- and post-test design. The researchers selected samples using multi-stage sampling by specifying e-waste recycling shops, a total of 55 shops. The data providers in this study consisted of 159 e-waste workers who participated in the research. The data were collected from the e-waste recycling shops situated in 14 provinces in southern Thailand between January 2021 and October 2021. The details of the program to improve muscle pain are as follows: 1) providing knowledge about work-related muscle aches, and 2) Creating prevention and self-care to protect and reduce muscle aches. A paired t-test and independent t-test were used for comparing between groups. A chi-square test was used for categorical variables where appropriate, and simple linear regression was employed for the analysis.

Results: The result of the prevalence of body muscle aches in 159 e-waste workers, the top 3 common pain symptoms that e-waste workers had body muscle aches including shoulders (42.14%), hips/thighs (37.11%), and upper back (33.96%). The perception levels, behavioral practices, and muscle aches before and after the use of functional improvement programs were significantly different, at $p < 0.001$.

Conclusion: Overall, health promotion programs can be used to reduce impacts of ergonomic risk factors.

Keywords: Health Promotion, Electronic Waste, Recycling.

Introduction

At present, e-waste management is a major problem for the world. It is estimated that the amount of e-waste in Europe will reach in excess of 82 million metric tons by 2030 [1]. This e-waste consists of many materials, mostly metals and other harmful substances that can contaminate the environment [2]. Improper e-waste management processes including collection, transportation, and recycling lead to contamination of the environment and ultimately, affect humans and living organisms [3, 4]. Several studies have reported health effects on those who work in e-waste recycling shops from exposure to heavy metals and chemicals [5–7]. Many studies have also reported health impacts among e-waste workers related to ergonomics. Informal e-waste workers have a high prevalence of work-related musculoskeletal disorders (WMSDs), mostly living in low- and middle-income countries [8–11]. Decharat and Kiddee [12] reported the prevalence of muscle aches among 272 e-waste workers working at e-waste recycling shops in the southern region of Thailand as 188 employees (69.1%) experiencing muscle aches. According to Choobineh et al. [13] and Hosseini et al. [14], improper working conditions, such as poor lighting and vibration, have also been shown to increase the risk of WMSDs and disability in developing countries. Other reported risk factors include the absence of an appropriate work–rest cycle and recovery time, lack of an effective work programme to prevent occupational injuries, as well as the individual's burnout.

The majority of participatory ergonomic intervention techniques, from passive training techniques (such as lectures, showing educational films and producing pamphlets) to performance-based techniques (such as workstation redesign by enlisting employees' help in identifying risk factors and coming up with solutions), have been shown to be effective on reducing the incidence of WMSDs in the workplace [15, 16].

The objectives of this study were to compare ergonomic perception levels and behavioural practices to reduce muscle aches before and after implementing functional improvement programmes to mitigate the effects of muscle aches in employees, and to compare the prevalence of muscle aches before and after the use of functional improvement programmes. The examination was conducted between January and October 2021, focusing on 55 shops in southern Thailand. Details on the following health promotion programs for reducing muscle pain among electronic waste workers are available: first, the researcher organised lectures and video accompanying activities, knowledge of ergonomics, and knowledge of working behaviour guidelines to reduce muscle aches and pains in three zones in the southern region, once per zone for 6 hours. Secondly, an activity was organised for workers to experiment with correct posture, including enhancing work skills in three zones in the southern region, once per zone for 6 hours. Finally, the activities were organized for workers to exchange knowledge and solve problems. Following three months of experimentation and distributing questionnaires to workers employed at e-waste recycling shops, post-test was done to compare performance after attending the staff workshop in the electronic waste recycling workshop.

Materials and Methods

This quasi-experimental study among electronic waste workers in southern Thailand. The programme involved participants among e-waste workers in the training programme using and talking about devices, observing their use of devices, and internal feedback on work behaviour. The researchers selected samples using multi-stage sampling by cluster sampling in e-waste recycling shops located in urban areas (refers to the urban district of each province) of 14 provinces in southern Thailand. There were a total of 212 stores located in the southern region and the urban area of each province. Then, Crazy and Morgan samples were calculated [17] at a 95% confidence level or 5% discrepancy, for a total of 136 shops. According to proportional sampling, as a result, there would be 38 e-waste shops in the upper south, 44 in the central south, and 54 in the lower south. The following characteristics were chosen from 136 recycling shops: (1) Operating and having two or more workers; (2) There were e-waste disassembly activities; and (3) Being an e-waste recycling shop located in the southern region and in the urban area of each province. The e-waste recycling stores in Southern Thailand were 136 sites to determine the sample size by using the 40% of the e-waste recycling shops. Thus, purposive sampling was used to obtain a sample of 55 shops that agreed to participate in the research project. From among leaders/or volunteer workers working in e-waste recycling shops, 2–3 representatives from 55 shops totalling 159 employees attended the meeting. Inclusion criteria for the e-waste workers were as follows: 20–60 years old and being in occupational contact with electronic waste recycling stores for at least one year.

This part of the research was quasi-experimental, with a one group pre-and post-test design. The population and sample came from an e-waste recycling shop located in the southern region, Thailand. The investigation would take place between January and October 2021.

The study questionnaire was given to the 159 e-waste workers participating in this study, and all 159 completed and returned it, giving a response rate of 100%. The data collected were checked by researchers. The questionnaire on the parts of ergonomic perception, behavioural guidelines, and work behaviour were tested for internal consistency where had a very high Cronbach's α value of 0.935. 0.897, and 0.955, respectively. Meanwhile, Kuder-Richardson Formula 20 (KR-20) was used to analyze the internal consistency of the questionnaire assessing symptoms of the skeletal and musculoskeletal system. High levels of internal consistency were observed in the questionnaire assessing symptoms of the skeletal and musculoskeletal system, KR-20 = 0.985.

The instrument used in this research was a questionnaire comprising five parts: 1) A general survey of the sample consisting of 12 questions; 2) Ergonomic perception questionnaire (20 items); 3) Behavioural guidelines for reducing muscle aches (20 items); 4) Work behaviour questionnaire (20 items); and 5) Symptoms of skeletal and musculoskeletal system disorders. The perception levels concerning ergonomics and working behaviour guidelines to reduce muscle aches (right = 1, wrong = 0) were measured with the results categorised into three levels interpreted as low (less than 60%), moderate (60–79.99%) and high (80% or more) by using averages and standard deviations. The level of operational behaviour that reduced muscle pain of e-waste workers was also measured. A five-level rating scale was applied as follows: practiced regularly meant doing every day of the week = 4 points; practiced frequently meant doing

5–6 times in a week = 3 points; practiced sometimes meant doing 3–4 times in a week = 2 points; practiced less meant doing 1–2 times in a week = 1 point, and if never practiced in a week = 0 points. To interpret the value of behavior scores based on the overall, there are levels of measurement in scale ranges. This research was divided into three levels including low (average score 1.00–2.33), moderate (average score 2.34–3.66), and high (average score 3.67–5.00), respectively.

Questionnaires concerning the prevalence of skeletal and musculoskeletal disorders related to work were used to survey the symptoms of musculoskeletal and skeletal system problems within the last three months. The survey used a closed question with the following criteria: the ratings below show that there are no anomalies in all positions.

As mentioned, the research collected data on the workers using questionnaires to measure their perceptions of ergonomics and work behaviour guidelines to reduce muscle aches. During the pre- and post-test, we tried a health education program to alleviate muscle pain in e-waste workers who operate e-waste recycling shops. The subjects took three trials as follows.

First, the researcher organised lectures and video accompanying activities, knowledge of ergonomics, and knowledge of working behaviour guidelines to reduce muscle aches and pains. These included: 1) Raising awareness about work-related muscle aches and pains, providing knowledge about work-related muscle aches by conducting group discussions, projecting still images, motion pictures, sharing experiences of work-related pain, analysing problems and finding solutions to problems; 2) Creating prevention and self-care for surveillance and prevention of diseases. Demonstrations of improved ergonomic sitting postures and working correctly were conducted by researchers. Demonstrations and practice of muscle exercises for before and after work, which took about 10-15 minutes were also performed. The total time spent was approximately eight hours.

Secondly, an activity was organised for workers to experiment with correct posture, including increasing work skills that can reduce muscle pain, and providing social support through visiting activities, listening to opinions, acknowledging problems in practice and giving advice on how to solve problems. The total time spent was approximately 16 hours (2 days).

Next, the activities were organised for workers to exchange knowledge and solve problems. Obstacles to performing correct posture as well as increasing work skills were addressed. The researcher provided social support through visits, listening to opinions, acknowledging problems in practice and giving advice on how to solve them. The total time spent was approximately eight hours.

The workshop participants adopted a model of practice/project/activity that promoted the implementation of e-waste management, operating in their own e-waste recycling shops or the area of workers' responsibility. Investigators visited the area to observe work behaviour. Following three months of experimentation and distributing questionnaires among workers employed at e-waste recycling shops, post-test was done to compare performance after attending the staff workshop in the electronic waste recycling workshop.

Statistical analysis

Descriptive statistical analyses were performed to obtain demographics and baseline characteristics of e-waste workers. Results were described as means (standard deviations) for continuous variables and as frequency counts (percentages) for categorical variables. A paired t-test and independent t-test were used for comparing between groups. A chi-square test for categorical variables was utilized where appropriate. The simple linear regression was used to analyze the univariate and interaction effects of average perception and work behaviour scores to lower employee muscle pain. A p-value of less than 0.05 was considered statistically significant.

Results

General information concerning e-waste workers in e-waste recycling shops: Based on the interview results of 159 e-waste workers who worked in e-waste recycling shops, there were 150 males (94.30%) and more than half (56.60%) had less education than junior high school. Of the e-waste workers, 89.30% had eight hours of work per day, 87.40% had six working days a week and 86.80% had less than or equal to 17 years of work, respectively (Table 1).

The prevalence of musculoskeletal symptoms: According to the results, workers over the age of 35 years experienced more muscle aches and pains such as neck, upper back, lower back, shoulders, hands/wrists and hips/thighs than those younger than 35 years, with a statistically significant difference of 0.05.

For body mass index (BMI) variables, it was found that e-waste workers with a BMI greater than 22.90 experienced muscle aches such as neck, upper back, shoulders, hands/wrists, hips/thighs, and ankles/feet more than employees with a BMI of less than 18.50 and 18.50–22.90, with a statistically significant difference of 0.05. For variable working hours per day and days worked per week, it was found that e-waste workers who worked more than eight hours per day and six days per week experienced muscle aches and pains, including neck, upper back, lower back, shoulders, elbows, hands/wrists, hips/thighs and ankles/feet more than the group of workers who worked less than or equal to eight hours a day and more than six days a week, with a statistically significant difference of 0.05. Concerning working years, it was found that workers with more than 17 years experienced muscle aches and pains, including neck, upper back, lower back, shoulders, hands/wrists, and hips/thighs more than those employed less than or equal to 17 years, with a statistically significant difference of 0.05 (Table 2).

Table 1. General information of e-waste workers working in e-waste recycling shops in the southern region, Thailand, 3 months in the part (n=159)

Variables		n=159	%
Sex	Male	150	94.34
	Female	9	5.66
Education levels	Less than junior high school	90	56.60
	More than junior high school	69	43.40
Aged	≤ 35 years	78	49.06
	>35 years	81	50.94
Average (SD) = 35.14 (12.50) years			
BMI	<18.50	14	8.81
	18.50 - 22.90	64	40.25
	>22.90	81	50.94
Hours worked per day (n, %)	≤8 hrs./day	142	89.31
	>8 hrs./day	17	10.69
Days worked per week (n, %)	≤6 days per week	139	87.42
	>6 days per week	20	12.58
Duration of work (yrs) (n, %)	>17 years	89	55.97
	≤17 years	70	44.03

Table 2. Prevalence of musculoskeletal symptoms classified by personal information and the position on the body of e-waste workers who working in e-waste recycling shops in the southern region, Thailand, assess symptoms experienced over the past 3 months (n=159).

Musculoskeletal symptoms		**Trunk**			**Arms**			**Lower body**	
(n, %)		Neck (18, 11 .32)	Upper back (54, 33.96)	Lower back (24, 15.09)	Shoulders (67, 42.14)	Elbows (12, 7.55)	Hands/wrists (42, 26.42)	Hips/thighs (59, 37.11)	Ankles/feet (32, 20.13)
Age	≤ 35 years (n=78)	6 (7.69)	15(19.23)	6 (7.69)	14(17.95)	5(6.41)	19(24.36)	18 (23.08)	15 (19.23)
	>35 years (n=81)	12(14.81)	39(48.15)	18(22.22)	53(65.43)	7(8.64)	23 (28.40)	41 (50.62)	17 (20.99)
P-value		<0.001*	<0.001*	0.085	<0.001*	0.058	<0.001*	<0.001*	0.014*
BMI	<18.50 (n=14)	1(7.14)	3 (21.43)	2 (14.29)	2 (14.29)	1 (7.14)	2 (14.29)	1 (7.14)	1 (7.14)
	18.50-22.90 (n=64)	3 (4.69)	16 (25.00)	10 (15.63)	7(10.94)	4(6.25)	11 (17.19)	15 (23.44)	12 (18.75)
	>22.90 (n=81)	14(17.28)	35(43.21)	12(14.81)	58(71.60)	7(8.64)	29(35.80)	43 (53.09)	19(23.46)
P-value		<0.001*	<0.001*	0.085	<0.001*	0.058	<0.001*	<0.001*	0.014*
Hours worked per day (n, %)	≤8 (n = 142)	7 (4.93)	38(26.76)	9 (6.34)	52 (36.62)	4 (2.82)	27 (19.01)	43 (30.28)	17 (11.97)
	>8 (n = 17)	11 (64.71)	16 (94.12)	15 (88.24)	15 (88.24)	8 (47.06)	15 (88.24)	16 (94.12)	15 (88.24)
P-value		<0.001*	0<.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
Days worked per week (n, %)	≤6(n = 139)	3 (2.16)	36(25.90)	10 (7.19)	48 (34.53)	2 (1.44)	25 (17.99)	41 (29.50)	18 (12.95)
	>6(n = 20)	15(75.00)	18(90.00)	14(70.00)	19(95.00)	10(50.00)	17 (85.00)	18 (90.00)	14 (70.00)
P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
Duration of work (yrs) (n, %)	≤17 (n = 89)	6(6.74)	23(25.84)	9(10.11)	24(26.97)	8 (8.99)	18 (20.22)	20 (22.47)	18 (20.22)
	>17 (n = 70)	12(17.14)	31(44.29)	15(21.43)	43(61.43)	6 (8.57)	24 (34.29)	39 (55.71)	14 (20.00)
P-value		<0.001*	<0.001*	<0.001*	<0.001*	0.087	<0.001*	<0.001*	0.095

Chi-squared test, *Significant at $p < 0.05$.

Compared ergonomic perception levels, behavioural approaches, and pains of workers before–after the workshop: Based on the results of the ergonomic perception level before the participatory workshop among e-waste workers in this study, it was found that education levels were significantly different, at $p < 0.05$. E-waste workers who had education levels less than junior high school had significantly lower ergonomic perception levels than those who had education above junior high school ($p < 0.001$). In addition, after the participatory workshop among e-waste workers, it was found that age and education levels were significantly different, at $p < 0.001$. E-waste workers aged > 35 years and who had education levels below junior high school had significantly lower ergonomic perception levels on worked behaviour guidelines than those aged ≤ 35 years and with education above junior high school ($p < 0.001$). Comparing the levels of ergonomic perception before and after the participatory workshop among e-waste workers, these were significantly different at $p < 0.001$ (average score (SD) before; 57.90 (11.76), average score (SD) after; 65.86 (11.93)). The results indicated that the ratings of ergonomic perception levels before and after the program which were compared between groups were statistically significant ($p < 0.001$).

The results of the worked behaviour guidelines to reduce muscle aches before the participatory workshop among e-waste workers in this study, it was found that education levels, days worked per week, and duration of work were significantly different at $p < 0.05$. E-waste workers who had education levels below junior high school had significantly lower levels of opinion on worked behaviour guidelines than those who had education above junior high school ($p < 0.001$) and e-waste workers who had ≤ 6 days worked per week, and a duration of work ≤ 17 years had significantly high levels of opinion on worked behaviour guidelines than those who had > 6 days worked per week and a duration of work >17 years ($p < 0.001$). Comparing the levels of opinion of worked behaviour guidelines to reduce muscle aches before and after the participatory workshop among e-waste workers, these were significantly different at $p < 0.001$ (average score (SD) before; 1.85 (0.18), average score (SD) after; 2.72 (0.18)). The results indicated that the ratings of behaviour guidelines levels before and after the program were compared between groups were statistically significant ($p < 0.001$).

In addition, the results of the work behaviour score to reduce muscle aches and pains of workers before the participatory workshop among e-waste workers in this study revealed that education levels were significantly different at $p < 0.001$. E-waste workers who had education levels below junior high school had significantly lower work behaviour score levels than those who had education above junior high school ($p < 0.001$). In addition, after the participatory workshop among e-waste workers, it was found that education levels and days worked per week were significantly different at $p < 0.001$ (average score (SD) before; 1.85 (0.17), mean score (SD) after; 3.63 (0.18)). E-waste workers who had education levels above junior high school had significantly higher work behaviour score levels than those who had education below junior high school ($p < 0.001$). E-waste workers who had > 6 days worked per week had significantly higher work behaviour score levels than those who had worked ≤ 6 days per week. The levels of work behaviour before and after the participatory workshop among e-waste workers were significantly different at $p < 0.001$ (average score (SD) before; 1.85 (0.17), mean score (SD) after; 3.63 (0.18)). The results indicated that the ratings of work behavior levels before and after the program which were compared between groups were statistically significant ($p < 0.001$).

The results of study on the prevalence of muscle pain among e-waste workers showed that, after the training programme, the prevalence of muscle pain diminished statistically significantly at 0.05. However, it was found that the top three areas of pain were the upper back (17.61%), shoulders (14.47%) and ankles/feet aches (11.95%), respectively. The prevalence of muscle pain among e-waste workers before and after the participatory workshop was significantly different at $p < 0.001$ (Table 3).

The results of the analysis with simple linear regression statistics (Table 4) indicated that the positive influence of increasing perceptions affected the performance scores, when comparing the scores of workers who had a high average preception score with those of workers with a lower average preception score. It was found that those with a higher average showed better average scores for working habits to reduce muscle aches and pains.

Table 3. Comparison of levels of ergonomic perception, work behavior and work behavior guidelines to reduce employee muscle aches, and the prevalence of musculoskeletal symptoms before and after participatory workshops (n=159)

Variables			E-waste recycling shop employees				P-value *[a]
			Before programme		After programme		
			Score/average (SD), number (%)	Interpret the results	Score/average(SD), number (%)	Interpret the results	
Ergonomic perception level (20 items)	Age	≤ 35 years(n=78)	59.20 (10.05)	low	70.52 (12.52)	moderate	<0.001*[a]
		>35 years (n=81)	57.01 (12.04)	low	62.85 (11.72)	moderate	<0.001*[a]
		p-value*[b]	0.265		<0.001*		
	Education	Less than junior high school (n=90)	55.20 (11.25)	low	62.41 (11.84)	moderate	<0.001*[a]
		More than junior high school (n=69)	62.84 (13.01)	moderate	72.52 (11.62)	moderate	<0.001*[a]
		p-value*[b]	<0.001*		<0.001*		
	BMI	<18.50 (n=14)	57.25 (11.52)	low	61.58 (11.32)	moderate	<0.001*[a]
		18.50 - 22.90 (n=64)	58.50 (12.20)	low	63.85 (12.47)	moderate	<0.001*[a]
		>22.90(n=81)	57.21 (10.41)	low	64.01 (12.58)	moderate	<0.001*[a]
		p-value*[b]	0.204		0.520		
	Hours worked per day (n,%)	≤8 hrs./day (n=142)	55.85 (11.02)	low	64.52 (11.41)	moderate	<0.001*[a]
		>8 hrs./day (n=17)	57.02 (12.20)	low	65.05 (13.02)	moderate	<0.001*[a]
		p-value*[b]	0.320		0.210		
	Days worked per week (n,%)	≤6 days per week (n=139)	57.89 (13.11)	low	66.85 (13.20)	moderate	<0.001*[a]
		>6 days per week (n=20)	58.25 (12.58)	low	67.52 (12.07)	moderate	<0.001*[a]
		p-value*[b]	0.318		0.301	0.225	
	Duration of work (yrs) (n,%)	≤17 (n = 89)	58.50 (11.41)	low	67.58 (11.05)	moderate	<0.001*[a]
		>17 (n = 70)	57.92 (12.08)	low	66.92 (10.30)	moderate	<0.001*[a]
		p-value*[b]	0.304		0.358		
	Average (SD)		57.90 (11.76)	low	65.86 (11.93)	moderate	<0.001*[a]
Awareness of work behavior guidelines to reduce muscle aches (20 items)	Age	≤ 35 years(n=78)	1.82 (0.21)	low	2.79 (0.15)	moderate	<0.001*
		>35 years (n=81)	1.75 (0.15)	low	2.40 (0.18)	moderate	<0.001*[a]
		p-value*[b]	0.224		<0.001*		
	Education	Less than junior high school (n=90)	1.78 (0.18)	low	2.42 (0.19)	moderate	<0.001*[a]
		More than junior high school (n=69)	1.96 (0.20)	low	2.89 (0.20)	moderate	<0.001*[a]
		p-value*[b]	<0.001*		<0.001*		
	BMI	<18.50 (n=14)	1.91 (0.17)	low	2.75 (0.18)	moderate	<0.001*[a]
		18.50 - 22.90 (n=64)	1.82 (0.21)	low	2.84 (0.16)	moderate	<0.001*[a]
		>22.90(n=81)	1.89 (0.19)	low	2.87 (0.20)	moderate	<0.001*[a]
		p-value*[b]	0.059		0.340		
	Hours worked per day (n, %)	≤8 hrs./day (n=142)	1.86 (0.18)	Low	2.87 (0.19)	moderate	<0.001*[a]
		>8 hrs./day (n=17)	1.98 (0.19)	low	2.60 (0.17)	moderate	<0.001*[a]
		p-value*[b]					
	Days worked per	≤6 days per week (n=139)	1.82 (0.15)	low	2.89 (0.21)	moderate	<0.001*[a]

	week (n, %)	>6 days per week (n=20)	1.89 (0.19)	low	2.40 (0.18)	moderate	<0.001*[a]
		p-value*[b]	0.238		<0.001*		
	Duration of work (yrs) (n,%)	≤17 (n = 89)	1.92 (0.20)	low	2.85 (0.19)	moderates	<0.001*[a]
		>17 (n = 70)	1.71 (0.18)	low	2.79 (0.18)	moderates	<0.001*[a]
		p-value*[b]	<0.001*		0.322		
	Average (SD)		1.85 (0.18)	low	2.72 (0.18)	moderates	<0.001*[a]
Work habits to reduce muscle aches and pains (20 items)	Age	≤ 35 years(n=78)	1.85 (0.18)	low	3.72 (0.14)	high	<0.001*[a]
		>35 years (n=81)	1.87 (0.17)	low	3.68 (0.18)	high	<0.001*[a]
		p-value*[b]	0.381		0.295		
	Education	Less than junior high school (n=90)	1.71 (0.15)	low	3.50 (0.21)	moderate	<0.001*[a]
		More than junior high school (n=69)	1.98 (0.20)	low	3.71 (0.23)	high	<0.001*[a]
		p-value*[b]	<0.001*		<0.001*		
	BMI	<18.50 (n=14)	1.85 (0.16)	Low	3.55 (0.17)	moderate	<0.001*[a]
		18.50 - 22.90 (n=64)	1.82 (0.20)	Low	3.64 (0.15)	moderate	<0.001*[a]
		>22.90(n=81)	1.89 (0.18)	low	3.60 (0.21)	moderate	<0.001*[a]
		p-value*[b]	0.128		0.354		
	Hours worked per day (n, %)	≤8 hrs./day (n=142)	1.84 (0.15)	Low	3.64 (0.19)	moderate	<0.001*[a]
		>8 hrs./day (n=17)	1.90 (0.19)	low	3.60 (0.17)	moderate	<0.001*[a]
		p-value*[b]	0.062		0.059		
	Days worked per week (n, %)	≤6 days per week (n=139)	1.83 (0.14)	low	3.62 (0.19)	moderate	<0.001*[a]
		>6 days per week (n=20)	1.87 (0.18)	low	3.51 (0.17)	moderate	<0.001*[a]
		p-value*[b]	0.229		<0.001*		
	Duration of work (yrs) (n, %)	≤17 (n = 89)	1.82 (0.18)	low	3.85 (0.19)	high	<0.001*[a]
		>17 (n = 70)	1.85 (0.19)	low	3.55 (0.17)	moderates	<0.001*[a]
		p-value*[b]	0.358		<0.001*		
	Average(SD)		1.85 (0.17)	low	3.63 (0.18)	moderates	<0.001*[a]
Musculoskeletal symptoms	**Trunk**	Neck	18 (11.32)		8 (5.03)		<0.01*
		Upper back	54 (33.96)		28 (17.61))		<0.01*
		Lower back	24 (15.09)		11 (6.92)		<0.01*
	Arms	Shoulders	67 (42.14)		23 (14.47)		<0.01*
		Elbows	12 (7.55)		6 (3.77)		<0.01*
		Hands/wrists	42 (26.42)		18 (11.32)		<0.01*
	Lower body	Hips/thighs	59 (37.11)		14 (8.81)		<0.01*
		Ankles/feet	32 (20.13)		19 (11.95)		<0.01*

[a] Paired t-test was used to compare between before and after, [b] Independent t-test was used for comparing between the means in two unrelated (independent) groups
* Significant at $p < 0.05$.

Table 4. The relationship between perception and work behavior to reduce employee muscle aches with an average score in an electronic waste recycling store.

Factors	Pearson's R	Adj R^2	B	95% CI for B	P-value
Perception	0.564	0.061	35.987	28.542 – 39.645	0.014*
Working habits to reduce muscle aches and pains	0.598	0.074	34.749	25.158 – 38.747	0.009*
Behavioral* perception	0.613	0.065	0.587	0.457 – 0.539	<0.001*

* Significant at $p < 0.05$.

Discussion

The results of this study demonstrated three common muscle pain symptoms experienced by e-waste workers including shoulders (42.14%), hips/thighs (37.11%) and upper back (33.96%). The results for health effects among e-waste workers support those of Bang Van Nguyen et al. [18], who reported musculoskeletal disorders in at least one body region including the lower back as the most affected site, followed by neck and shoulders. Similarly, the results of a study by Acquah et al. [8] reported that among 82 dismantlers and 21 burners, dismantlers and burners of electronic waste manifested MSD symptoms including the lower back (65%), shoulders (39%), upper arms (27%), and neck (27%). The shoulders were the most prevalent area reported in this research. This has also been reported among e-waste workers in Nigeria where a 14% prevalence of shoulder pain was noted [11]. In this study, differences of age, education, BMI, hours worked per day, day worked per week, and duration worked had a difference of MSD symptoms, which was supported by Augustine A. Acquah [8], who reported that the e-waste job category suggests specific work-related morbidity depending on differences in the prevalence, location and intensity of MSD symptoms. In addition, several studies [19–21] have reported that a task seen as intellectually demanding can cause changes in postural behaviour, musculoskeletal diseases, and pain. This situation can be exacerbated by psychosocial factors including time constraints, as well as the severity and duration of the task demands. The results of this study show that the scores for ergonomic perception (57.90 (11.76)), work behaviour guidelines (1.85 (0.18)), and work behaviour (1.85 (0.17)) among e-waste workers before participatory workshops were at low levels. However, after the participatory workshops, the scores for ergonomic perception (65.86 (11.93)), work behaviour guidelines (2.72 (0.18), and work behaviour (1.85 (0.17)) increased. These results are supported by Eva L. Bergsten et al. [22] who reported that an implementation proved successful among participants in a training programme on using and talking about devices, observing the use of devices among colleagues and internal feedback on work behaviour, which were increased significantly ($p < 0.01$). In this study, the scores for ergonomic perception increased after the programme finished, which supported the findings of van Eerd et al. [23], who reported that a better understanding of the implementation process and factors influencing the process can facilitate successful implementation of interventions. In addition, the implementation process can increase the likelihood that the intervention will lead to the intended result.

Similarly, Limerick [24] reported that as the employer receives more knowledge, they can possibly help achieve the best results from employees. In addition, these results reported that the use of participative ergonomic techniques to derive solutions is believed to develop more effective solutions as well as resulting in greater 'ownership' by those affected, leading to greater commitment to the changes being implemented. After three months of participating in the programme and monitoring by researchers, it was found that the work behaviour concerning ergonomics among e-waste workers was more appropriate.

Similarly, the studies of Kim and Lee [25] and Robertson et al. [26] demonstrated that an educational intervention can potentially alter behaviours, reduce symptoms, and improve performance through training combined with a sitting workstation, which has an impact on the prevention of discomfort among office employees. In this study, the researcher transfer of training into practice included e-waste workers and shop owners. They were motivated to learn by training, and the perceived utility of training to facilitate use of knowledge and skills was high among all participants. These results are supported by Grossman and Salas [27], who reported that motivation before, during and after training is a crucial prerequisite for the effective transfer of trained skills to the worksite. In this study, the participants were concerned about work behaviour guidelines increasing after the implementation process. Thus, the participants shared their opinions in order to produce an appropriate workflow to reduce ergonomic impacts by presenting a workstation, management guidelines for workflow, how to work and how to provide a conducive work environment for ergonomic effects. Lin S et al. [28] studied the impact of participatory ergonomic interventions on musculoskeletal disorders (MSDs) among young dental professionals in China. The results showed that participants in the ergonomic intervention group experienced significant reductions in MSDs, with improvements in the neck (OR = 2.93, 95% CI: 1.25, 4.03) and wrists/hands (OR = 2.33, 95% CI: 1.08, 4.21).

Additionally, their work ability index scores slightly increased by 0.53 (95% CI: −0.02, 1.56) as a result of the interventions. These results are supported by Ehsanollah Habibi and Shiva Soury [29] who reported that there was a decline in musculoskeletal symptoms among a trained group of participants after they received the training and the results revealed a lower rate of pain in the low back, neck, knee and wrist, which was significant ($P < 0.05$). The analysis using simple linear regression statistics revealed those with a higher average and average scores of working habits that were effective in reducing muscle aches and pains. These results are supported by many studies [30-32], which report that ergonomic interventions had positive effects on study outcomes. Several ergonomic interventions to prevent MSDs among dental professionals were found to exert a positive effect on the prevalence of MSDs or working posture. According to Vazquez-Cabrera [33] administrative measures can be proposed such as worker training programs to prevent inappropriate working postures among agricultural workers. In this study, following the training programme, the prevalence of muscle pain dropped statistically significantly at 0.05. However, it was found the top three prevalences of pain included upper back aches, shoulder aches, and ankles/feet aches. This may be due to the fact that some workers still have a long working period each day and are responsible for many duties. In addition, some neglected the stretching exercises that the programme suggested. Therefore, organizing appropriate work periods along with scheduled time for rest or muscle relaxation, as per the designed program, can help reduce work-related injuries.

Conclusion

Functional improvement programmes to reduce ergonomic impacts on e-waste recycling shop employees are appropriate to be used for work pattern improvement to reduce muscle injuries. However, success can only be achieved by allowing those involved to acknowledge and understand the importance and impact on health. In addition, encouraging participation will allow the programme to be implemented voluntarily and sustainably. This study examined a sample of multiple southern regions that posed challenges for evaluation. As a result, the program's success will grow if recycling shop operators use it to promote the health of their staff or form collaborations other retailers in similar locations. In addition, Government agencies, such as local government organizations and public health authorities, play a critical role in improving worker health by establishing regulations and standards for occupational safety, providing training and education on injury prevention, supporting health and welfare initiatives such as annual health check-ups, and facilitating the creation of safe and healthy work environments. Furthermore, governments have the opportunity to collaborate with the private sector to foster optimal working conditions, thereby contributing to the reduction of workplace accidents.

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Conflict of interest

None declared.

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Ethical Considerations

Cooperative letters and informed verbal consent were obtained from all study participants.

Code of Ethics

The Ethics Committee of the Institute of Research and Development, Thaksin University, approved this research (COA No. TSU 2021-037 REC No.0019).

Authors' Contributions

Somsiri Decharat: Conceptualization, Methodology, Investigation, Writing-Original draft Preparation, Writing-Review & Editing, Supervision, Project administration, Funding acquisition, Data curation and Formal analysis. Peeranart Kiddee: Validation, co-investigation.

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