

## ORIGINAL ARTICLE

# Prevalence of musculoskeletal discomfort among female cabin crew in Taiwan

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**Abstract**

**Objectives:** This study investigated the prevalence of musculoskeletal discomfort among female cabin crew through cabin tasks and demographic factors, including age and seniority.

**Methods:** This study conducted an online questionnaire survey targeted at female cabin crew in Taiwan and ensured that the sample size was with a statistical power of 0.95. This study evaluated the work intensity by ranking six common cabin tasks and examined musculoskeletal discomfort with Cornell Musculoskeletal Discomfort Questionnaire. Descriptive statistics were used to learn the work intensity and discomfort conditions. In addition, the Chi-square test of independence and multivariate adjustment were applied to clarify the impact of age and occupation on musculoskeletal discomfort in the neck, shoulders, and lower back.

**Results:** This study enrolled 88 female cabin crew members. Handling carry-on baggage was voted as the highest intensity cabin task (40%), which was also ranked as the strongest intensity on shoulders. Meanwhile, the upper trunk was more prevalent in musculoskeletal discomfort. Moreover, after multivariate adjustment with controlling the effect of age, this study found a marginal significant association ( $p = .09$ ) between seniority and right shoulder discomfort for younger staff.

**Conclusion:** This study found that handling carry-on baggage was associated with musculoskeletal complaints in the shoulders. Therefore, this study suggested that shoulders, especially for the right side might be related to the occupational injury, which was prevalent along with seniority among the younger crew. Overall, this study provided the preliminary findings to improve occupational training for preventive health.

**KEYWORDS**

cabin crew, ergonomics, musculoskeletal discomfort, occupational health, physical work

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## 1 | INTRODUCTION

The aircraft cabin is an extreme environment where the cabin crew suffers from physical and mental pressures. Low barometric pressure, relative humidity, and high concentrations of ozone and carbon dioxide could have detrimental effects on human health, such as dizziness and sore throat.<sup>1</sup> Additionally, irregular work hours and emotional stress could cause mental problems and physical discomfort.<sup>2,3</sup>

Prior studies investigated the connection between health problems and job characteristics of the cabin crew. Disruption of the circadian cycle is common and leads to adverse outcomes for humans. For example, long-term circadian rhythm disorders cause stress and a loss of life control, which results in low work efficiency.<sup>4–6</sup> In addition, clinical evidence suggests that circadian disruptions influence both physical and mental health.<sup>7–9</sup> Anxiety and depression resulting from the lack of sleep could be associated with musculoskeletal discomfort in the neck, shoulders, and lower back.<sup>9–11</sup> Although cabin crew can rest to relieve fatigue and jetlag during flights, they are forced to maintain poor postures in the tiny rest areas, increasing their musculoskeletal pain and aches.<sup>12</sup>

Musculoskeletal discomfort is highly associated with the occupation of being a cabin crew. According to a survey of Saudi Airlines, neck pain was revealed as a chronic health problem among cabin crew. Their analysis further reported a positive correlation between occupation and neck pain.<sup>13</sup> In addition, a study that investigated work-related musculoskeletal symptoms (WMS) of the cabin crew after long-haul flights revealed that lower back pain was the most severe, and lower limb discomfort interfered with their work.<sup>14</sup> Schaub et al. (2007) further linked musculoskeletal discomfort to cabin tasks and specified that pushing or pulling trolleys burden led to a higher burden on the trunk.<sup>15</sup> Apart from that, cabin tasks that require the crew to work above shoulder height, such as using the overhead bins, also increase the physical burden on the lower back and shoulders.<sup>16</sup>

Women constitute a large proportion of cabin crew in Asian airlines because most Asian cultures believe that high service quality could be attributed to gentleness, caring, humility, and good looks, which are regarded as feminine virtues.<sup>17</sup> Some companies have developed marketing strategies with feminine impressions to show kindness, respect, and empathy for passengers.<sup>18,19</sup> However, as female emotional laborers, their mental loads come from both their workplace and social environments, including stereotypes and work-family conflicts.<sup>6</sup> Compared to acute pain and aches, mental and emotional pressures could result in chronic and gradual musculoskeletal discomfort, especially in the lower back.<sup>11</sup>

According to the report of the Ministry of Labor in Taiwan in 2017, around 80% of staff aboard aircraft are women aged from 22 to 45.<sup>20</sup> Although cabin crew work is socially accepted and many younger women in Taiwan aspire to work on aircraft, a high health-related turnover rate among younger crews is common in Asian airlines. Their mental and physical problems increase operating costs and medical expenses for companies and society. In research conducted by the Institute of Labor, Occupational Safety and Health, Ministry of Labor in Taiwan, musculoskeletal discomfort accounted for 46.8% of occupational diseases with more than 70 million USD of labor insurance expenditures (0.67% of GDP).<sup>21</sup>

The cabin crew is exposed to irregular work hours and stays in the cabin for a long time. Meanwhile, they have to engage in many physical and emotional challenges during work. Previous studies have focused on the prevalence of musculoskeletal disorders and mental concerns. Few studies have thoroughly investigated the association of pain and aches with cabin tasks and personal conditions. This study argues that both factors could greatly impact musculoskeletal discomfort. Therefore, this study aims to examine the intensity of cabin tasks and musculoskeletal discomfort among female cabin crew. In addition, personal conditions were investigated along with demographic factors, including age and seniority, to determine the influences of age-related degeneration and occupation on musculoskeletal discomfort.

## 2 | METHODS

### 2.1 | Questionnaire design

A cross-sectional study was conducted to understand working conditions and the level of discomfort of the female cabin crew. This study applied six cabin tasks: handling carry-on baggage, handling carts, galley work, services (beverage, meal, and duty-free), safety checks, and other tasks (standing or walking for long duration), to understand the physical intensity while working aboard aircraft.<sup>22</sup> Although some tasks might slightly differ from aircraft types, Lee et al. (2012) ensured that these six tasks could cover major aircraft types by self-reported measurement and focus groups of the senior cabin crew.<sup>22</sup> Musculoskeletal discomfort in 20 body parts was investigated by the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ).<sup>23</sup>

The questionnaire included four sections. The first section collected information on demographics, physical conditions, regulations, and training experiences.

The second section assessed the work intensity of WMS-related job tasks. The third section evaluated discomfort for 20 body parts from three aspects: frequency, level, and influence on work. The fourth section was designed to link job tasks and discomfort in critical body parts, that is, the neck, shoulders, and lower back.

Although several studies have tested the validity and cultural adaptation of CMDQ,<sup>24–27</sup> the Chinese version was lack. This study kept the quality of the survey questionnaire based on previous studies and ensured validity by translating the original version from English to Chinese. Four native Chinese speakers were invited, including three researchers in ergonomics and one senior cabin crew (working over twenty years), to make sure all the questionnaire descriptions meeting content validity.

With regard to the response quality, researchers ensured the length of the questionnaire should be a short version, that respondents could finish within 15–30 min.<sup>28</sup> According to the pilot study, the studied questionnaire took participants approximately 15 min to complete. Meanwhile, this study offered a lottery for each valid response as an incentive.<sup>28</sup>

## 2.2 | Participants

This study estimated the sample size with G\*Power 3.1.9.6 (Faul et al., Germany) before the questionnaire survey.<sup>29</sup> A priori power analysis of G\*Power was applied to calculate a statistically significant with a statistical power of 0.95. The result indicated that the total sample size should be no less than 82.

According to the annual report of the Civil Aeronautics Administration in 2018, the number of cabin crew registered in Taiwan was 8307, and the total target population estimated was 7060 after excluding foreign members.<sup>30,31</sup> This study recruited participants by distributing flyers from November 5th, 2017 to July 5th, 2018 in Taoyuan International Airport, the largest and busiest airport in Taiwan, to approach the most Taiwanese cabin crew. All of them were on duty for either departure from or arrival to TPE (IATA airport code of Taoyuan International Airport).

Participants could access the online questionnaire on SurveyMonkey via the QR code shared on the flyer. They had to read an informed consent form and instructions before starting the questionnaire. Besides, every participant was required to claim gender and birthplace to meet the requirement of this study, that is, female and Taiwanese cabin crew. This study confirmed that all participation was voluntary and anonymous. Additionally, this study was

of ethics approval through the Department of Industrial Engineering, Tsinghua University.

## 2.3 | Statistical methods

This study analyzed the results with descriptive statistics to understand the conditions of the perceived cabin task intensity and musculoskeletal discomfort (frequency, discomfort level, and interference with work). Then, this study focused on the neck, shoulders, and lower back, respectively, to link the discomfort to cabin tasks.

The Chi-square test of independence was applied to find out the effects of age and seniority on musculoskeletal discomfort in the neck, shoulders, and lower back, which body parts were pointed out several times in previous studies. The reason for investigating demographic factors was to look into whether the discomfort was associated with the occupation or the age-related degeneration, which could further provide precise suggestions for occupational preventative health. The analysis ought to use the maximum likelihood ratio Chi-square test if the statistical assumption (less than eighty percent of the cells should be no less than five) is violated. Otherwise, the Pearson Chi-square test is suggested.<sup>32</sup>

Moreover, this study controlled the confounding effect of age and seniority to figure out their separate effect from the results of the Chi-square test of independence. The statistical analyses were conducted with Minitab 17 Statistical Software (Minitab, LLC.).

## 3 | RESULTS

### 3.1 | Participants

There were 90 submitted responses, and 88 of them were valid. Two submissions were eliminated because their answers did not meet the legal age of working in Taiwan. No missing data were detected since researchers had set questions as mandatory, whose function was provided by the online platform.

The work experience of the cabin crew covered the majority of commercial aircraft. Among all responses, nearly all participants (96.6%) were working on B777, and three-quarters of them were working on A330. Participants enrolled in this study could reveal the current situation of the cabin crew in Taiwan, since their working experiences were of the main commercial aircraft in both Taiwan airline companies, Eva Air and China Airlines.

Overall, all participants were female and Table 1 presents the characteristics of study participants. Most

	Mean	SD	Percentage
Height (cm)	164.27	3.17	
Weight (kg)	53.20	5.14	
Flight Hours (last month)	72.24	17.51	
Flight Hours (last week, excluded those who were not on duty last week, 6 of 88)	21.38	9.53	
Age			
22–25 years old			29 (33%)
26–30 years old			40 (46%)
31–35 years old			2 (2%)
Over 35 years old			17 (19%)
Seniority			
<1 year			7 (8%)
1–3 years			45 (51%)
4–6 years			14 (16%)
>7 years			22 (25%)
Have regular training			72 (82%)
Have ergonomic training			15 (17%)
Have handling carry-on baggage training			3 (3%)

TABLE 1 Study participant characteristics

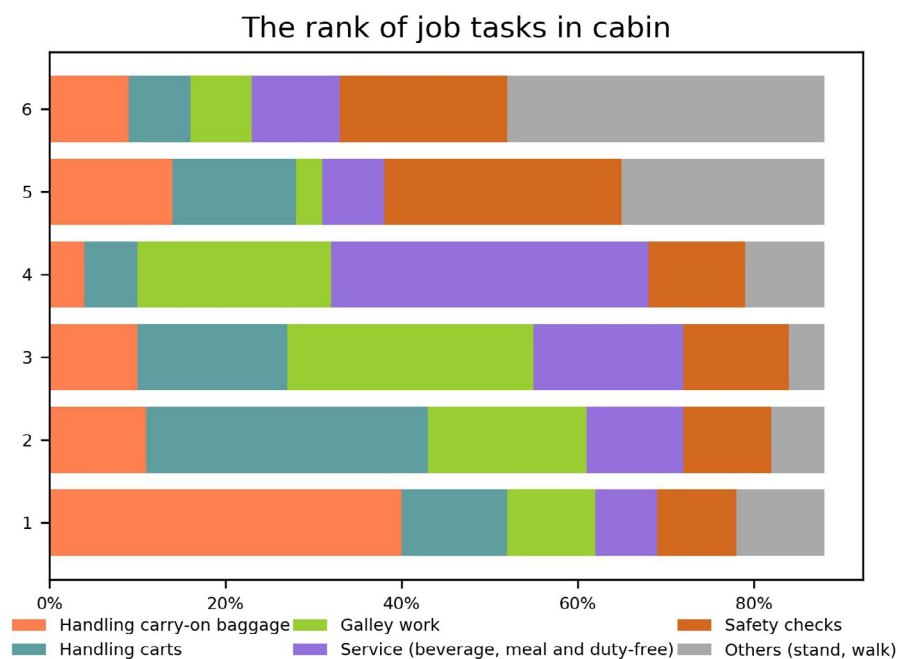


FIGURE 1 The rank of six job tasks in cabin

of them aged from 22 to 30, with nearly 80%. For seniority, just over 40% of participants worked more than four years. Although 82% of them reported that they participated in regular training, less than one-fifth of respondents had ergonomic training and the proportion of handling carry-on baggage training was far less than the above two pieces of occupational training, with only 3%.

### 3.2 | Cabin tasks

Participants ranked six regular tasks by work intensity. The rank one task is with the highest work intensity, meaning that workers are the most likely to experience exhaustion while doing this task. On the other hand, the rank six task is with the lowest work intensity, requiring little physical strength (See Figure 1).

Among six cabin tasks, handling carry-on baggage, handling carts, and galley work were ranked as the top three cabin tasks with higher intensity. More than 40% of participants rated handling carry-on baggage the highest intensity task, and over half of the participants considered it one of the top two highest intensity tasks. Handling carts was ranked second, implying that moving carts in the narrow aisle and the small galley was associated with physical exhaustion. Galley work was the third. Stretching to reach higher goods and bending over to access stuff in lower spaces were required while working in the galley, which should be related to the work intensity. In addition, safety checks and others were selected as the two cabin tasks with the lowest work intensity.

### 3.3 | Discomfort of body parts

Table 2 shows the condition of musculoskeletal discomfort among the investigated cabin crew. Participants were asked to recall their physical pain and aches during the recent workweek and answered the frequency, discomfort level, and interference with work. According to CMDQ, the discomfort frequency was divided into five categories: several times every day, once every day, 3–4 times in that workweek, 1–2 times in that workweek, and never. In addition, the discomfort feeling was described with three levels: very, moderately, and slightly uncomfortable. Moreover, CMDQ evaluated the extent of interference with work in three degrees: substantially, slightly, and not interfered at all.

#### 3.3.1 | Discomfort frequency

Shoulder pain and aches were the most common musculoskeletal discomfort, with nearly 90% of participants suffering from the discomfort during the recent workweek. Besides, more than one-fifth of respondents experienced that discomfort in the shoulders several times in that week. In addition to the shoulders, over 80% of responses reported discomfort in the neck, lower back, right wrist, lower legs, and foot at least once in the last workweek. In contrast, there were differences in the left forearm, hip, thighs, left upper arm, and left knee, being only around 10% of participants complaining of pain and aches every day. Moreover, the results indicated the right body underwent the discomfort frequently than the left side, which might result from the large proportion of right-handed participants while the number of left-handed was only eight.

#### 3.3.2 | Discomfort level

In general, most participants experienced slight discomfort among the majority of body parts, especially for upper arms, left forearm, hip, and thighs, being over three-quarters of respondents. In terms of the severe discomfort level, compared to the left shoulder and lower back, the proportion of extreme discomfort in the right shoulder was relatively fewer. Yet, it was worth noticing that the right shoulder pain and aches accounted for nearly 60% at the extreme and moderate levels, and the proportion was around 50% in the left shoulder and lower back. Additionally, more than one-third of the participants marked the neck, upper back, and right wrist as serious and moderate discomfort. Moreover, the results also opined the obvious discomfort feelings in lower legs and feet, with approximately one-fifth reporting as serious level.

#### 3.3.3 | Work interference of the discomfort

Around one-fifth of the participants considered that pain and aches in the right wrist, right shoulder, lower back, and right knee substantially affected their work. What is more, the discomfort in the neck, lower legs, and feet was of interferences to a slight and heavy extent for half of the participants. In contrast, the left forearm, hip, and thighs had few influences on their job tasks. Moreover, similar to the findings from discomfort frequency, participants complained less about the left side than the opposite side among 20 body parts. It might also be associated with their handedness and motions.

### 3.4 | The influence of job task on body parts

Previous studies presented that the neck, shoulders, and lower back were associated with the frequent motions of cabin tasks, such as pushing and pulling.<sup>14,15</sup> Therefore, this study conducted a further investigation to identify the perceived intensity in the above three body parts among cabin tasks. Figure 2 illustrates the intensity of six job tasks through the neck, shoulders, and lower back.

Overall, the pattern of the perceived task intensity to three body parts was similar. It was noteworthy that the shoulders received slightly higher intensity while handling carry-on baggage than the other two parts. On the contrary, the intensity of services was lower for shoulders. Additionally, handling carts were of much less intensity for the neck. Moreover, galley works produced comparable intensity in these three parts.

TABLE 2 Musculoskeletal discomfort in 20 body parts (in percentage)

	Frequency			Discomfort level				Interference with work			
	Several times everyday	Once everyday	3–4 times last week	1–2 times last week	Never	Very	Moderate	Slight	Substantially interfered	Slightly interfered	Not at all
Neck	18.18	5.68	18.18	42.05	15.91	17.05	19.32	63.64	12.50	40.91	46.59
Shoulder (right)	22.73	5.68	30.68	30.68	10.23	19.32	37.50	43.18	15.91	47.73	36.36
Shoulder (left)	20.45	5.68	18.18	44.32	11.36	22.73	27.27	50.00	14.77	46.59	38.64
Upper back	14.77	5.68	15.91	43.18	20.45	6.82	27.27	65.91	7.95	36.36	55.68
Upper arm (right)	9.09	1.14	23.86	40.91	25.00	4.55	20.45	75.00	6.82	31.82	61.36
Upper arm (left)	7.95	2.27	13.64	44.32	31.82	5.68	14.77	79.55	4.55	31.82	63.64
Lower back	21.59	7.95	23.86	31.82	14.77	22.73	26.14	51.14	17.05	35.23	47.73
Forearm (right)	7.95	2.27	27.27	36.36	26.14	5.68	20.45	73.86	4.55	30.68	64.77
Forearm (left)	6.82	4.55	13.64	37.50	37.50	4.55	9.09	86.36	2.27	31.82	65.91
Wrist (right)	10.23	5.68	32.95	32.95	18.18	9.09	30.68	60.23	20.45	43.18	36.36
Wrist (left)	5.68	5.68	22.73	36.36	29.55	3.41	22.73	73.86	11.36	34.09	54.55
Hip/buttocks	6.82	5.68	9.09	42.05	36.36	5.68	17.05	77.27	6.82	27.27	65.91
Thigh (right)	7.95	2.27	14.77	38.64	36.36	3.41	14.77	81.82	6.82	21.59	71.59
Thigh (left)	6.82	2.27	17.05	39.77	34.09	4.55	12.50	82.95	5.68	25.00	69.32
Knee (right)	11.36	2.27	17.05	40.91	28.41	9.09	22.73	68.18	15.91	30.68	53.41
Knee (left)	11.36	2.27	15.91	39.77	30.68	7.95	23.86	68.18	14.77	32.95	52.27
Lower leg (right)	19.32	11.36	19.32	31.82	18.18	19.32	27.27	53.41	12.50	37.50	50.00
Lower leg (left)	19.32	12.50	19.32	30.68	18.18	18.18	27.27	54.55	13.64	37.50	48.86
Foot (right)	21.59	13.64	15.91	29.55	19.32	20.45	26.14	53.41	14.77	40.91	44.32
Foot (left)	21.59	13.64	15.91	29.55	19.32	21.59	23.86	54.55	14.77	39.77	45.45

## Relationship between tasks and three body parts



FIGURE 2 The relationship between tasks and three body parts

TABLE 3 Chi-square values based on the Chi-square test of independence

	Discomfort frequency	Discomfort level	Work interference
Age			
Neck	14.34 <sup>a,*</sup>	12.44 <sup>**</sup>	16.28 <sup>**</sup>
Shoulder (right)	7.28 <sup>a</sup>	5.62	5.36
Shoulder (left)	9.24 <sup>a</sup>	5.07	6.53
Lower back	6.25 <sup>a</sup>	9.32 <sup>*</sup>	6.35
Seniority			
Neck	13.31 <sup>a</sup>	6.71 <sup>a</sup>	11.64 <sup>**</sup>
Shoulder (right)	13.76 <sup>a</sup>	3.97 <sup>a</sup>	11.25 <sup>a,*</sup>
Shoulder (left)	11.76 <sup>a</sup>	6.53 <sup>a</sup>	9.93 <sup>a</sup>
Lower back	4.37 <sup>a</sup>	8.15 <sup>a</sup>	8.27 <sup>a</sup>

<sup>a</sup>The maximum likelihood ratio chi-square test.

\* $p < .1$ ; \*\* $p < .05$ .

### 3.5 | Demographic factors

This study examined the impact of age and seniority, on the discomfort conditions (frequency, level, and work interference) in four body parts (neck, right/left shoulder, and lower back), which complained the most in the previous and present study. This study divided participants into three age groups (22 to 25, 26 to 30, and more than 30) and four seniority groups (<1, 1–3, 4–6, and >7 years) and

examined musculoskeletal discomfort from three aspects in four body parts.

Table 3 shows the results of the Chi-square test of independence. Age significantly influenced discomfort level and work interference in the neck. Besides, the frequency of the neck discomfort and the discomfort level of the lower back were marginally significant. According to multivariate adjustment for seniority, age remained a relevant variable to understand the discomfort conditions of the

neck ( $p_{frequency} = 0.09$ ,  $p_{level} = 0.03$ ,  $p_{interference} = 0.09$ ) and lower back ( $p_{level} = 0.09$ ) for younger employees, seniority less than three years. With respect to seniority, the Chi-square test result of work interference presented significant and marginally significant in terms of the neck and right shoulder, respectively. After controlling age, seniority still had the main association with the right shoulder discomfort on work interference among the younger crew ( $p_{interference} = 0.09$ ), aged from 22 to 25.

The results clarified that aches in the neck and lower back might result from physical deterioration in younger staff. On the contrary, pain in the right shoulder could be related to the occupational injury for them.

## 4 | DISCUSSION

The upper trunk had a higher discomfort level than the lower trunk and this considerably interfered with work. This result is consistent with prior literature about musculoskeletal discomfort when pushing and pulling,<sup>15,16</sup> postures frequently used by cabin crew while handling carts, trolleys, and overhead compartments. Reviews of homemakers and cleaners indicate musculoskeletal discomfort in the neck, shoulders, and lower back is due to work-related exposures.<sup>33,34</sup> This reflects the work-related musculoskeletal discomfort of cabin crew because homemakers and cleaners share many similar activities, such as lifting heavy objects reaching up into over-shoulder positions and using their hands repetitively for security preparation and in-flight service. Additionally, the limited cabin requires many twisted postures, such as bending and squatting, which can increase the cabin crew's physical burdens, not only on the lower trunk but also on the upper trunk, specifically the lower back.<sup>35,36</sup>

This study specified that handling carry-on baggage was highly influenced by pain and aches in the shoulders because of the prolonged extension of the arms to complete overhead jobs, which is also a sensitive and vulnerable body part for women.<sup>37</sup> Meanwhile, this task was of the highest intensity among six common cabin tasks since the crew had to move or lift carry-on baggage to meet the regulations to avoid in-flight accidents. In an investigation of Korean female farmers, Min et al. (2016) reported that orchard (i.e., apple, peach) farmers engaged in prolonged standing and lifting farming work and experienced the most significant musculoskeletal discomfort in their shoulders compared to other farming modes, including rice, greenhouses (i.e., tomato, cucumber), and dry fields (i.e., corn, potato).<sup>37</sup> Therefore, in this study, the association between seniority and the right shoulder revealed that musculoskeletal discomfort could be attributed to the workplace, and handling carry-on baggage was critical.

On the other hand, pain in other body parts of the upper trunk, namely, the neck and lower back, was more likely to be frequent and severe and associated with age rather than the length of seniority. This finding has added to the current literature about musculoskeletal discomfort in female cabin crew since previous studies mainly explored musculoskeletal discomfort in general.<sup>14,22</sup> Although some have pointed out the upper trunk as the relevant body part,<sup>13,14</sup> the association between pain in the specific part and job activities needs further discussion.

Moreover, focusing on female workers, they face dilemmas in balancing careers, family life, and social expectations in most occupations, including cabin crew and nurses, leading to emotional exhaustion.<sup>8,38</sup> Regardless of pressures from work, female workers are also likely to experience depressive symptoms in daily life, causing chronic musculoskeletal discomfort and interfering with their life quality.<sup>11</sup> Especially for those with childcare, they can be very stressful, and caring for children is a significant risk factor for musculoskeletal problems in the neck and shoulders.<sup>6,33</sup> Accordingly, mental and physical factors are contributing risk factors for developing musculoskeletal discomfort, but different factors might cause pain in different body parts.<sup>33</sup> Combined with the findings of this study, the present study suggested that shoulder protection is important to women. Specifically, mothers, who are doing the job requiring prolonged standing and stretching postures, are at higher risk of musculoskeletal discomfort.

Nevertheless, adequate management of worktime and job arrangements to overcome fatigue could be a form of social support for creating a working environment of both mentally and physically friendly.<sup>6</sup> Some interventions that combined biopsychosocial treatment and cognitive behavioral principles with electromyography effectively improved occupational performance and alleviated musculoskeletal pain.<sup>39,40</sup> Therefore, companies and safety groups can offer a personal caring approach and prevent occupational injury in cabin crew.

### 4.1 | Limitations and future research

A few factors limited this study. First, this study was limited by its small sample size, which lacks the generalization to a larger number of the cabin crew. Second, the questionnaire survey was conducted among cabin crew based in Taiwan. Although the cultural backgrounds are similar in Asia, more representative samples would make the present results and findings more convincing and reliable. Third, in addition to the above selection biases, this study asked participants to recall past experiences, which resulted in information biases in the current work.



Future research could focus on the following three aspects. First, enlarging the sample size and comparing the impacts of cultural backgrounds on the occupational health of female staff could enhance the reliability of public health studies. Second, following the findings regarding demographic factors, further investigation of both mental and physical issues could help clarify the association between shoulder discomfort and crew work and provide preventative measures to protect workers from injury. Third, considering family and childcare factors for musculoskeletal discomfort could help understand female workers' lives, and these factors might be important for cabin crew due to their abnormal working hours and the lack of management of family relationships.

## 5 | CONCLUSION

Most participants considered handling carry-on baggage as the most intense task. In addition, the investigation with the neck, shoulders, and lower back revealed the association between right shoulder aches and seniority among the younger cabin crew, being related to the higher intensity and interference while discharging cabin baggage placement. In contrast, the neck and lower back discomfort was caused by age-related physical degeneration, especially for those who just started their career.

This study could contribute to developing better training programs, such as monitoring muscle activities, during training courses to enhance safety in the workplace. Meanwhile, results might benefit the cabin ergonomic design, such as overhead bins.

### DISCLOSURE

*Ethical approval:* This study was approved by the Department of Industrial Engineering, Tsinghua University. *Informed consent:* The informed consent was presented before the main body of the questionnaire. *Registry and the registration No. of the study/trial:* N/A. *Animal studies:* N/A. *Conflict of interest:* Authors declare no conflict of interests for this article.

### AUTHOR CONTRIBUTION

Conception and design of the work: X. L., L. D., and P.-L. P. R.; Questionnaire design and data acquisition: X. L. and P.-H. C.; Data analysis and interpretation: P.-H. C.; Manuscript: P.-H. C.; Validation and supervised this study: P.-L. P. R. All authors read and approved the final manuscript.


### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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