

Ergonomics Investigation of Catering Services in Ice and Snow Industry in Northeast China

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ABSTRACT

Ergonomic survey and questionnaire were conducted for 865 employees working for catering service in the ice and snow industry in northeast China. The purpose was to research the current working conditions of the employees and to assess the risk factors for Work-related Musculoskeletal Disorders (WMSDs) for the ice and snow industry in northeast China. The collected data include general background information of the staff and their main work contents, work postures and working movements. More than 20 biological factors, psychological factors and social factors were assessed. Multivariate logistic regression analysis was used to identify the potential risk for WMSDs. The analysis shows that catering employees in the ice and snow industry generally lacked enough rest and exercise after work and, therefore, had a high potential risk of musculoskeletal injury. Results show that catering staff had higher prevalence of Low Back Pain (LBP) caused by lumbar muscle strains and sprains. Prolonged periods of standing, frequent bending and twisting of waists, holding heads in one position for long time, physical activity and working environment factors, such as workplace temperature changes, are found to be positively correlated with LBP. Prevention of LBP is also proposed in the paper.

Keywords: Work-related musculoskeletal disorders; Low back pain; Catering services; Occupational injuries; Ergonomics investigation; Risk factors; Logistic regression; Prevention

INTRODUCTION

Work-related Musculoskeletal Disorders (WMSDs) are one of the major causes of disabilities among workers across all employment sectors [1]. According to the statistics of the bureau of labor statistics in 1995, occupational injuries caused by repetitive or cumulative injuries represented 65% of all occupational injuries in the United States [2]. WMSDs not only cause mental and physical discomfort of employees, but also result in financial loss. According to the study of the U.S. department of occupational safety and health, WMSDs cost about \$1.4 billion every year [3]. WMSDs have become the most frequently researched occupational injuries in both advanced industrial and commercial countries in Europe and the United States and developing countries [4].

WMSDs commonly occur as a result of a combination and interaction among many factors including, for example, individual factors, such as gender, weight, disease and even dietary habits [5], physical factors, human factors, working environments, social-psychological factors and ergonomic factors [6,7]. Among them, poor posture, repetitive movements, heavy body load and other

ergonomic factors present the main risk factors for developing WMSDs especially in the head and upper limbs [8].

Catering service is the business of providing food service. The main tasks of the service include cooking, baking, frying, boiling, packing, supplying and other handling and repetitive physical work. According to a recent study, the prevalence of WMSDs reported by catering staff in the ice and snow industry in northeast China ranges from 21.5% (thigh) to 58.9% (shoulder). Low/Lower Back Pain (LBP) is common (around 54.7%). Shoulder pain is associated with frequent and prolonged moving of heavy objects and bending while moving and lifting heavy objects; and finger/wrist pain is associated with continuous twisting and vigorous actions among catering workers [9]. The purpose of this study is to examine the risk factors and the prevalence of LBP among the kitchen workers at catering services in ice and snow industry in northeast China. To establish preventative measures for LBP, the perceived work-related risks, such as working hours, the use of equipment and tools, body movement and postures, and work-related LBP are examined using logistic regression.

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METHODS

Data and questionnaires

This study was conducted during October to December in 2018 using structured questionnaires and personal interviews for 24 ice industry services in northeast China. The questionnaire was based on epidemiologically cross-sectional and retrospective design to investigate personal status, occupational status, working postures, workplace environment, and WMSDs etc. A total of 865 catering service personnel agreed to have interviews and to fill in self-administrated questionnaires. A total of 865 questionnaires were issued, out of which 852 were recovered and 15 copies of invalid questionnaires were eliminated. The questionnaires contained demographic characteristics (gender, age, Body Mass Index (BMI)), job description (the main work content such as tasks required to perform everyday, service duration, type of work, daily activities, working conditions, common work postures and movements, as well as frequency of postures and movements), social-psychological factors in the workplace (overtime work, resting time, work intensity, job demand and control, repetitive tasks, working postures, working rhythm, and work pressure), social-psychological factors and organizational factors (levels of social support, work satisfaction from supervisors and co-workers, salary level, promotion system and adequate pre-job training), workplace environmental factors (air temperature change and workspace atmosphere) and ergonomic factors (working postures, such as long standing, bent wrist, forcible activities of the fingers and thumb that carried items, shoulder postures, bending and turning of neck and back for heavy items, lifting or holding heavy items, etc). The questionnaire was pre-tested and revised twice by three experts before its formal release. The pre-testing design was conduct for six employees working at a restaurant in Jilin University. The reliability of the test before and after three weeks was 0.92. The questionnaire provided instructions to subjects one month prior to fill in the questions.

Statistical analysis

Descriptive statistics was used to summarize demographic characteristics of different catering staff including on-site senior chef, chef, kitchen staff, cleaner, off-site manager, foreman, and service personnel regarding age, BMI, working duration etc. Cross-tabulation analysis was performed for the percentage frequency distribution of the used movements and postures by workers during their work. Male workers comprised 55.0% and female 45.0%. The average age of the respondents was 33.27 years old (SD=11.32 years old), among them the majority staff were 20-29 years old (42.7%), followed by 30-39 years old (22.5%). The average height and weight were 165.07 cm (SD=7.62 cm) and 61.26 cm (SD=11.06 kg), respectively. The average service duration was less than 5 years (34.2%) (Table 1).

RESULTS

Work-related Musculoskeletal Disorders in catering staff

The prevalence of WMSDs in catering staff in ice and snow industry in northeast China is shown in Table 2. Table 2 demonstrates a high rate of WMSD occurrence. WMSD is the leading cause of occupational injury and disability among carting workers.

Table 2 shows differences in the prevalence of musculoskeletal symptoms. Most studies report higher prevalence among women. However, prevalence of LBP symptoms has been reported to be higher for men in some studies [3-7].

Hand/Wrist and LBP had the highest prevalence and there was inter-occupational difference in the prevalence. Neck and shoulder were not commonly affected regions by WMSDs and there was no statistically significant difference in terms of inter-occupations. Chefs were at the highest risk of having WMSD with low back and wrist as the two most affected regions. High incidence rate of WMSD was also found in employed kitchen assistants or kitchen workers, waiters, off-site foremen, and off-site managers.

Table 1: Demographic characteristics of the catering staff.

| Staff position | Number | Age (age, $\bar{x} \pm 2s$) | BMI (kg/m^2 , $\bar{x} \pm 2s$) | Average service duration (year) |
|------------------------|--------|------------------------------|---|---------------------------------|
| Chef | 97 | 35.6 \pm 13.0 | 26.6 \pm 7.2 | 4.3 |
| Assistant chef | 249 | 34.2 \pm 12.9 | 24.2 \pm 5.8 | 2.5 |
| Cleaner | 61 | 34.9 \pm 13.3 | 24.4 \pm 6.7 | 2.3 |
| Off-site manager | 41 | 30.7 \pm 12.2 | 25.0 \pm 8.6 | 4.9 |
| Off-site foreman | 125 | 25.3 \pm 7.2 | 19.6 \pm 5.1 | 2.5 |
| Off-site service staff | 264 | 23.5 \pm 6.8 | 19.3 \pm 5.9 | 2.7 |
| Total | 837 | 34.2 \pm 13.1 | 24.4 \pm 6.3 | 3.1 |

Table 2: Frequency distribution of reported Work-related Musculoskeletal Disorders (WMSDs) by catering staff.

| | Number | Regions of WMSDs | | | |
|------------------------|--------|------------------|-----------|------------|----------------|
| | | Neck | Shoulder | Hand/Wrist | Low back/Waist |
| Chef | 249 | 82 (37.6) | 75 (34.4) | 85 (39.0) | 154 (70.6) |
| Assistant chef | 61 | 30 (35.3) | 25 (29.4) | 21 (24.7) | 47 (55.3) |
| Cleaner | 41 | 10 (25.6) | 8 (20.5) | 6 (15.4) | 10 (25.6) |
| Off-site manager | 68 | 24 (58.5) | 16 (39.0) | 23 (56.1) | 29 (70.7) |
| Off-site foreman | 125 | 24 (58.5) | 16 (39.0) | 23 (56.1) | 29 (70.7) |
| Off-site service staff | 264 | 30 (35.3) | 25 (29.4) | 21 (24.7) | 47 (55.3) |
| <i>p</i> -value | | 0.017 | 0.252 | <0.001 | <0.001 |

Risk factors of low back pain

Table 2 demonstrates a high incidence rate of LBP. It is, therefore, important to identify risk factors associated with LBP. Based on our critical literature review, 24 risk factors were selected and evaluated using univariate logistic regression analyses. Table 3 shows the analysis results.

Workplace temperature change refers to outdoor temperature fluctuations during working period which could reach 10°C daily.

Physical exercise is defined as body movement that requires energy expenditure. The interviewed workers normally had 20 minutes of vigorous-intensity activity of body movement at least three times per month. Backbend is defined as a stretch-up that the back is bended continuously for at least five minutes. Labor intensity is classified as continuous work for at least two hours (high), one hour (medium), and 30 minutes (low).

Other risk factors include subjective working posture comfort, space size of work environment, control of work progress, staff

shortage, satisfaction of salary level, satisfaction of promotion system, satisfaction of work and other psychological factors that can help alleviate burnout. Some subjective feelings for LBP symptoms that presented minor negative correlation factors were also considered. Uncontrollable factors, such as frequent shift-replacement by colleagues, satisfaction of salary level, etc., were not included in the final multivariate ergonomic analysis.

Multivariate ergonomic analysis for low back pain

The multivariate logistic regression analysis for LBP was performed on controllable factors only. The results are displayed in Table 4.

Seven factors were identified to strongly related to LBP with multivariate logistic regression analysis: ambient temperature change, repetitive work, bending amplitude of back, prolonged trunk flexion posture, long standing and high labour intensity increased the risk of LBP incidence. However, physical exercise seemed to reduce the risk of LBP.

Table 3: Results from univariate logistic regression.

| Variables | Coefficients | Wald χ^2 | p-value | Odds ratio | 95% CI |
|--|--------------|---------------|---------|------------|----------------|
| Workplace temperature change | 0.356 | 7.311 | 0.007 | 1.428 | 1.103 ~ 1.848 |
| Physical exercise | -0.246 | 6.357 | 0.012 | 0.782 | 0.646 ~ 0.947 |
| Bending amplitude of back | 0.763 | 18.382 | <0.001 | 2.146 | 1.514 ~ 3.042 |
| Lifting of loads | 0.080 | 0.403 | 0.526 | 1.084 | 0.845 ~ 1.389 |
| Trunk flexion | 1.775 | 9.297 | 0.002 | 5.900 | 1.885 ~ 18.465 |
| Long-standing | 1.491 | 17.847 | <0.001 | 4.442 | 2.224 ~ 8.872 |
| Repetitive back or waist movements | 1.024 | 10.728 | 0.001 | 2.786 | 1.509 ~ 5.142 |
| Regularly excessive working hours | -0.261 | 1.454 | 0.228 | 0.770 | 0.504 ~ 1.177 |
| Regular shift | -0.391 | 1.521 | 0.217 | 0.676 | 0.363 ~ 1.259 |
| Rest at the prescribed time | -0.168 | 0.612 | 0.434 | 0.845 | 0.555 ~ 1.288 |
| Labor intensity | 1.140 | 18.303 | <0.001 | 3.128 | 1.855 ~ 5.274 |
| Subjective working posture comfort | -0.349 | 1.376 | 0.241 | 0.706 | 0.394 ~ 1.263 |
| space size of work environment | -0.327 | 2.241 | 0.134 | 0.721 | 0.470 ~ 1.106 |
| Repetitive work | 0.938 | 7.287 | 0.007 | 2.555 | 1.293 ~ 5.049 |
| Sufficient self-control of work progress | -0.261 | 1.485 | 0.221 | 0.770 | 0.507 ~ 1.171 |
| Job stress | 0.682 | 8.460 | 0.004 | 1.978 | 1.249 ~ 3.132 |
| Work rhythm | 0.021 | 0.009 | 0.922 | 1.021 | 0.674 ~ 1.547 |
| Sufficient personnel | -0.597 | 4.829 | 0.028 | 0.551 | 0.323 ~ 0.938 |
| Get alone well with co-workers | 0.286 | 0.586 | 0.444 | 1.331 | 0.640 ~ 2.766 |
| Social responsibility | 0.641 | 2.731 | 0.098 | 1.898 | 0.888 ~ 4.059 |
| Sufficient pre-job training | 0.946 | 4.472 | 0.034 | 2.575 | 1.072 ~ 6.189 |
| Satisfactory of payment | -0.742 | 7.084 | 0.008 | 0.476 | 0.276 ~ 0.822 |
| Satisfactory of promotion system | -0.536 | 6.260 | 0.012 | 0.585 | 0.385 ~ 0.890 |
| Job satisfaction | -0.081 | 0.083 | 0.773 | 0.922 | 0.533 ~ 1.597 |

Table 4: Results from multivariate logistic regression.

| Variables | Coefficients | Wald χ^2 | p-value | Odds ratio (OR) | 95% CI |
|------------------------------------|--------------|---------------|---------|-----------------|----------------|
| Workplace temperature change | 0.530 | 12.284 | <0.001 | 1.699 | 1.263 ~ 2.286 |
| Physical exercise | -0.272 | 6.559 | 0.01 | 0.762 | 0.618 ~ 0.938 |
| Repetitive back or waist movements | 1.069 | 10.126 | 0.001 | 2.689 | 1.468 ~ 4.531 |
| Bending amplitude of back | 0.540 | 7.784 | 0.005 | 1.716 | 1.74 ~ 2.507 |
| Long-standing | 2.112 | 6.620 | 0.010 | 8.267 | 1.654 ~ 41.318 |
| Trunk flexion | 1.293 | 10.314 | 0.001 | 3.645 | 1.655 ~ 8.025 |
| Trunk flexion | 0.919 | 9.933 | 0.002 | 2.508 | 1.416 ~ 4.441 |

DISCUSSION

Although the content of work differed significantly from the main tools used in the work, catering service work required standing for long period of time or working hours. Back, shoulder and the wrist moves were commonly used during their work, for example, caring heavy objects above shoulder level, performing lifts with a semi-squatting position, turning and bending of back and waist to pick up objects, and bending the back forward to perform work. Poor posture at work is a major cause of LBP for employees in the ice and snow industry in China.

Although the types of food and beverage services provided by catering staff differed, the overall labour intensity was high. From the perspective of traditional Chinese medicine, static work maintaining the same posture for a long period with high intensity can cause structural deterioration of bone tissue and defects in the innate immune system, leading to bone fragility and an increased risk of fractures of the hip, spine, and wrist. Long-standing means continuous standing for more than one and a half hours at a time. According to modern preventive medicine, long-standing is similar to a sedentary lifestyle and has a negative cumulative effect on the overall functioning of the body. For people whose work involves lifting, carrying or performing similar, vertebrae and intervertebral disc are subjected to compression. Poor posture can result in spinal and joint dysfunction and result in pain or damage. It is recommended to take sitting positions to alternate between sitting and standing for long-standing posture, which can provide appropriate support to better maintain proper body position. A good work posture should be alternative posture and movement, such as a short walk after a standing or a short break.

The results of this study show that 15.3% participants worked more than ten hours a day on average, and 2.5% had to work up to seven days per week. About 30.6% workers had no any break during the day and 60.8% had no regular exercise during the past three months. These data indicate that the ice and snow catering staff in northeast China worked overtime without rest and physical exercise. In general, repetitive tasks, although in allowable limit, biomechanical load is accumulated which could be transmitted through the biomechanics of the limbs and body to LBP. Therefore the proper rest is important and necessary, and suitable work-rest schedule for workers should be planned according to the workload [10]. It is advisable to take ergonomic intervention, such as different work break schedules and a break at least 30 minutes after work, to increase the strength of spines. Instruction and regulations on proper work practices and the use of rest breaks are needed.

Research has pointed that workplace rest and exercises are effective in reducing of WMSDs [11]. Hence this study indicates that WMSDs are a significant issue for food and beverage service professionals in northeast region of China if intervention is not conducted. The WMSD issue could be intensified in the future. Therefore, physical exercise intervention can be applied to reduce WMSDs and both beneficial short-term and long-effect effects could be achieved.

Repetitive or prolonged trunk flexion posture was a common posture among catering service staff, especially among kitchen cleaners and kitchen porters who were involved in food preparation. Standing for a long time trunk flexion posture, human muscle wall isometrically construct and lead to fatigue if time duration is long. The dynamic balance of musculoskeletal system can be lost which causes musculoskeletal disorders. This study indicates that

the incidence of LBP was common in catering service staff, typical young employees. Hence LBP may worsen pain in the long run [12,13].

Temperature variation in the working environment was another factor contributing to the high incidence of LBP. Average indoor temperature for catering service industry, for example during cooking, could be high. When exposed to sudden cold environment, a higher muscular load could be created and lead to the occurrence of LBP. Therefore, when working temperatures are constantly changing which is uncontrollable, personal protective equipment should be considered to protect worker's health.

It is worth mentioning that the main work contents, work progress, work methods and the use of machines and tools may suffer from self-report bias [14], although self-report assessment has been considered as a cost-effective means of gathering large amounts of data [15,16]. In this study, the questionnaire was evaluated and analyzed before the formal implementation and validity. The reliability of the final self-report questionnaire were conducted by experts to minimize the bias [17].

CONCLUSIONS

In conclusion, this study can be regarded as a pioneer study on ergonomics of catering service personnel in ice and snow industry in China. Future research will be conducted to systematically evaluate the ergonomic workspace involving more staff performing more types of job tasks. This study will be helpful to understand the incidence of musculoskeletal injury among ice and snow service workers in northeast China. It can also be used as a reference for the improvement of public health.

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