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# Ergonomic risk factor-related musculoskeletal disorders among wood furniture workers in Binh Duong Province, Vietnam

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## Abstract

Furniture workers are exposed to many adverse factors, leading to work-related musculoskeletal disorders (WMSDs). This paper is a cross-sectional study designed to identify ergonomic risk factors related to musculoskeletal disorders among wood furniture workers. Convenience sampling was used to select 231 wood furniture workers from Binh Duong Province. A five-part questionnaire generated data, including demographics, work organization, psychosocial factors, work conditions, and self-reported WMSDs. Rapid Entire Body Assessment (REBA) and hand-arm vibration were measured to assess ergonomic exposure. Multivariate regression analysis was used to identify risk factors for WMSDs. WMSDs prevalence in at least one body part during the past 12 months was 72.7%. Highest WMSDs prevalences were in the lower back (36.4%); shoulder (32%); and hand/wrist (27.3%), respectively. Factors significantly associated with reporting WMSDs (*p-value* <0.05) were body mass index (odds ratio (OR), 1.20; 95% confidence interval (CI) 1.05-1.38); smoking (OR, 3.19; 95% CI 1.49-6.82); absenteeism from training (OR, 2.63; 95% CI 1.28-5.39); awkward hand posture (OR, 3.27; 95% CI 1.29-8.26); high psychological demands (OR, 2.32; 95% CI 1.12-4.78); low autonomous decision-making (OR, 3.59; 95% CI 1.78-7.22); and low social support (OR, 2.66; 95% CI 1.15-6.15). These findings suggest that furniture workers at risk of WMSDs might be helped by implementing occupational health preventive programs focusing on ergonomic risk factors.

**Keywords:** Ergonomics, Furniture factory, Musculoskeletal disorders, Vietnam, Working posture

## 1. Introduction

Work-related musculoskeletal disorders (WMSDs) are a common occupational health problem in different industries [1,2]. WMSDs resulting from work-related events or working conditions are diagnosed by musculoskeletal symptoms of pain, aching or discomfort; loss or hypersensitivity of sensation, including numbness, tingling, and stiffness; weakness of muscle strength; abnormal changes to skin color or redness; inflammation; and abnormal motion or stability of joints affecting the body structure, such as joints, tendons, muscles, and nerves [3]. WMSDs and their severity cause decisive limitations at work, sickness absence, productivity loss, reduced work efficiency, and increased healthcare expenses, disability, and worker complaints internationally, including in developed European Union nations [2], Australia [3], the United States [4], as well as developing countries [5], especially Vietnam.

In line with the aforementioned concerns, most furniture work involves substantial manual materials handling (MMH), including sanding, rubbing, stapling, lifting, and spraying workpieces or wooden products [6,7]. This exposes workers to physical stressors as well as ergonomic risk factors, such as forceful repetitive motions in assembly processes; static awkward posture (frequent forward and sideways bending or twisting postures, standing for long intervals, gripping hand-held tools, wrist abduction and deviation); and vibration exposure [7-9]. Psychosocial factors in job demand-control models have been widely adopted to investigate the relationship between job characteristics and demands that function as stressors and are hazardous to worker health [10]. Karasek [11] mentioned that exposure to high job demands combined with low decision latitude increases job strain risk. If this condition is sustained, the probability of developing musculoskeletal disorders increases. In recent decades, the association between psychosocial factors and WMSD development has been well established [2,3,12]. This is illustrated by the findings of Eatough [13] that psychosocial stressors such as low job control, high work disagreement, and job strain have increased WMSD frequency among industrial workers. These findings are consistent with a study by Widanarko [14], who found that psychosocial risk factors associated with musculoskeletal symptoms include low decision latitude, high job strain, high psychological demands, and low social support. Lack of awareness about occupational hazards, shortage of prevention measures, and poor workplace safety are likely to considerably increase worker musculoskeletal disability disorders in developing nations [5] such as Vietnam.

In recent years, the Vietnamese wood furniture industry has been rapidly expanding [15]. Among developing countries, Vietnam ranks high as a wood-based product processor and exporter [15], boosting the Vietnamese economy by offering employment and attracting a substantial domestic workforce. Previous studies have indicated that the furniture manufacturing sector is one of the few industries struggling with WMSD-related issues [6-9,16]. A preliminary ergonomic study of the Danish furniture industry revealed that the 12-month prevalence of WMSDs for at least one body part was notably high (75%) among workers, among whom lower back (42%) and upper limb disorders (40%) accounted for the highest rates [8]. Similarly, research from Iran [6] showed WMSD complaints among furniture workers of the lower back (35.6%), wrists or hands (29.5%) were of the highest prevalence during the past year. The most recent study in Thailand [9] also found a significantly higher prevalence of WMSDs distributed across all body parts among exposed production unit groups compared to control groups, including office workers. Current evidence suggests that WMSDs appear to be a serious occupational health problem in the furniture industry. However, research into WMSDs among furniture workers in Vietnam is scarce; data on prevalence and specific risk factors among workers are lacking in the published literature. Therefore, this study aimed to determine the prevalence and associated risk factors of work-related musculoskeletal disorders among workers in a wood furniture factory in Vietnam.

## 2. Materials and methods

### *2.1 Participants*

A cross-sectional study was conducted in a wooden furniture production factory at Binh Duong Province, Vietnam from June to December 2020. The sample size was calculated based on a formula for estimating finite population [17] with 695 workers in the production factory, confidence level of 95%, acceptance error of 5%, and previous WMSDs prevalence of 26.6% from the same industry in China [18]. To avoid dropouts, an attrition rate by 10% was applied and the final sample size was 231 subjects. Convenience sampling was used according to population proportionsin each department with the required sample size of workers. Participants, aged from 18 to 65, were recruited on inclusion criteria that their current work seniority must be at least twelve months. Exclusion criteria were musculoskeletal deformities, scoliosis, history of rheumatologic disease, and pregnancy. Data was collected simultaneously with an annual health checkup course with investigators including the principal researcher and four physicians from the Ho Chi Minh City Institute of Public Health. To avoid overcrowding and the risk of Novel Coronavirus 2019 (COVID-19) transmission, the personnel manager scheduled each participant for a fixed time, maintaining social distancing and wearing masks during all interviews.

### *2.2 Measurement of variables*

#### *2.2.1 Questionnaire*

The study instrument consisted of a five-part questionnaire developed from the literature review. The first section contained items about individual characteristics, including gender, age, body mass index (BMI), current smoking status, alcohol consumption habit, and physical exercise. The second included work organization factors. The third featured items about current workplace psychosocial exposure. It used a Vietnamese-language version of Karasek's job demand-control-support model [11] with five major components: psychological demands, authority, autonomy, skill discretion, and social support. Psychological demand questions reflected cognitive requirements, time pressure, hard work, working pace, concentration intensity, and conflicting demands. Job control questions comprised three major aspects: 1) decision authority, including ability to engage in the decision-making process, work process, and task sequencing; 2) decision autonomy, about management and control capacity for task performance chronology, including setting times for starting and pausing when needed as well as influencing work speed; and 3) skill discretion in terms of self-esteem for using employment abilities, new skill development, creativity required, and repetitive activities such as priming. The final component, social support, reflected social emotional integration and assistance from supervisors and peers. Each item had a response set of four-point Likert scales: 1 (strongly disagree); 2 (disagree); 3 (agree); and 4 (strongly agree). All questionnaire items were validated in the Vietnamese language by Hoang and a colleague [19]. Based on frequency distribution, each dimension was calculated for a median score representing the cut-off point dividing subjects into Karasek job strain groups [11]. Any worker who scored above, or equal to, the median, was designated as "high," while one under median ranking was designated as "low." The fourth section included a work condition checklist, adapted from the Washington State Caution Zone Checklist [20]. This screening tool was designed to evaluate the task with high potential for causing WMSDs in four main categories: 1) awkward working posture; 2) manual handling; 3) excessive repetition; and 4) vibration exposure.

The final section was adapted from the Standardized Nordic questionnaire [21], investigating WMSD prevalence by recording any related symptoms, including aches, pains, or discomfort experienced over the previous 12 months in at least one of nine bodily regions. Participants were interviewed by investigators to identify sites of discomfort or pain on body parts as specified on a body map. The question asked was: "Have you had any significant discomfort or pain in any of the following body parts which interfered with your usual activities?" The score was categorized as a dichotomous dependent variable consisting of two values: 0 (no symptom) or 1 (with any symptoms).

Contents and appropriateness of the Vietnamese version of the questions were reviewed and modified by a physician and lecturer specializing in occupational medicine in Vietnam. The pilot questionnaire was also tested with 30 workers to determine internal consistency for all five subscales of psychosocial exposure with Cronbach's alpha ($\alpha$) values ranging from 0.61 to 0.89, showing acceptability for instrumental validity.

*2.2.2 Ergonomic risk assessment*

Risk assessment was evaluated for two independent variables, including measurement of working posture and vibration exposure.

Rapid Entire Body Assessment (REBA) was used to evaluate WMSDs risk related to working posture for all participants. Postural score increased when posture diverged from the neutral position. Group A included trunk, neck, and legs and group B upper and lower arms and wrist. This assessment device was developed by Hignett and McAtamney [22]. The evaluator asked participants to clarify job tasks and initially observed movements and postures for two work cycles. Posture selection to be assessed was based on the following criteria and order of priority: the most difficult postures and work tasks or posture where the highest force load occurs. This study prioritized the most strenuous postures during work performance for either the right or left side of the body which represented a worst-case possibility or risk of greatest exposure to WMSDs. REBA evaluates four levels for risk (low, medium, high, and very high) estimation [22].

To assess hand-arm vibration exposure, the Svantek SV 106 Human Vibration Meter & Analyser, a digital vibration level meter with 1/3 octave analysis (6.3-1250 hertz (Hz)), was used with calibration by Institute of Public Health of Vietnam technicians before measurements were taken. The instrument calibration certificate was granted annually by an independent calibration accuracy testing agency. Measurement and evaluation techniques with weighting factors applied were followed according to detailed guidelines from international organization for standardization (ISO) 5349-1:2001 standards [23]. The measuring time for each sample was one minute. If the machine or tools were held by two hands, both hand locations were measured, and the highest value was picked for vibration magnitude calculation. Each type of hand-held tool was measured three times for calculating average vibration value ($a_{hv}$) to minimize bias from different modes such as idling or working under load in the same operation. Six most common vibrating hand-held tools and their accelerations ($a_{hv}$) follow: orbital sander (6.44 $m/s^2$); edge sander (3.04 $m/s^2$); pistol drill machine (8.15 $m/s^2$); screwdriver (4.77 $m/s^2$); upholstery stapler (0.91 $m/s^2$); and paint spray gun (1.52 $m/s^2$). Vibration exposure was calculated for an employee based on self-reported daily exposure duration and vibration magnitude ($a_{hv}$), expressed in terms of an eight-hour energy-equivalent frequency-weighed vibration total value $A$ (8). Daily exposure duration from each instrument used was determined by interview. Then $A$ (8) was grouped into three classifications (below action value = 2.5 $m/s^2$, between 2.5 $m/s^2$ and 5 $m/s^2$, and above exposure limit value 5 $m/s^2$) [24].

*2.3 Statistical analysis*

Data analysis was carried out by IBM SPSS Statistics program version 22. Statistical analysis was performed by chi-squared test, Fisher's Exact test, student's t-test, and simple bivariate regression to detect independent variables associated with WMSDs prevalence during the previous 12 months for at least one body part as study outcome. Subsequently, the multiple logistic regression model using backward elimination was applied to identify potential risk variables related to outcome. All variables were included in multiple logistic regression analysis. The statistical significance level was set at a $p$-value lower than 5% ($p$< 0.05).

## 3. Results

### *3.1 General characteristics of participants*

231 wooden furniture factory production workers agreed to participate in the study. Most were male with average age (standard deviation) of 35.0 (7.2). Most participants were of normal weight with BMI 18.5 to 24.9 (79.7%). Results were that only 49.8% of workers reported participation in occupational safety and injury prevention program training before starting factory work, as shown in Table 1.

**Table 1** General participant characteristics and distribution of prevalent WMSDs symptoms over the previous 12 months (n=231).

| Variables | Total n=231 (%) | Without WMSDs n=63 (%) | With WMSDs n=168 (%) | *p*-value |
|---|---|---|---|---|
| Age (years) | | | | |
| Mean ± SD | 35 ± 7.2 | 35.05 ± 6.8 | 35.1 ± 7.4 | 0.960[c] |
| Gender | | | | |
| Male | 137 (59.3) | 34 (54.0) | 103 (61.3) | 0.312[a] |
| Female | 94(40.7) | 29 (46.0) | 65 (38.7) | |
| BMI | | | | |
| Mean ± SD | 22.1 ± 2.7 | 21.4 ± 2.2 | 22.4 ± 2.8 | 0.005[c] |
| Normal | 196 (84.8) | 59 (93.7) | 137 (81.5) | 0.023[a] |
| Obese | 35 (15.2) | 4 (6.3) | 31 (18.5) | |
| Smoking | | | | |
| Never | 144 (62.3) | 48 (76.2) | 96 (57.1) | 0.038[a] |
| Occasionally | 19 (8.2) | 3 (4.8) | 16 (9.5) | |
| Daily | 53 (22.9) | 11 (17.5) | 42 (25.0) | |
| Did formerly, but quit | 15 (6.5) | 1 (1.5) | 14 (8.4) | |
| Drinking alcohol | | | | |
| Never | 102 (44.2) | 31 (49.2) | 71 (42.3) | 0.258[a] |
| Once monthly | 51 (22.1) | 16 (25.4) | 35 (20.8) | |
| 2-4 times monthly | 65 (28.1) | 15 (23.8) | 50 (29.8) | |
| ≥2 times weekly | 13 (5.6) | 1 (1.6) | 12 (7.1) | |
| Do exercise or physical activity | | | | |
| Yes | 63 (27.3) | 47 (74.6) | 121 (72.0) | 0.743[a] |
| No | 168 (72.7) | 16 (25.4) | 47 (28.0) | |
| Work experience (years) | | | | |
| 1 -2 | 9 (3.9) | 3 (4.8) | 6 (3.6) | 0.945[a] |
| 3 - 5 | 29 (12.6) | 7 (11.1) | 22 (13.1) | |
| 6 - 10 | 121 (52.4) | 34 (54.0) | 87 (51.8) | |
| ≥ 11 | 72 (31.2) | 19 (30.1) | 53 (31.5) | |
| Job tenure (years) | | | | |
| 1 - 10 | 211 (91.3) | 53 (84.1) | 144 (85.7) | 0.835[a] |
| ≥ 11 | 20 (8.7) | 10 (15.9) | 24 (14.3) | |
| Job title | | | | |
| Quality Controller | 43 (18.6) | 16 (25.4) | 27 (16.1) | 0.144[b] |
| Moulder | 14 (6.1) | 4 (6.3) | 10 (6.0) | |
| Forming Operator | 17 (7.4) | 7 (11.1) | 10 (6.0) | |
| Sander | 57 (24.7) | 16 (25.4) | 41 (24.4) | |
| Assembler | 25 (10.8) | 7 (11.1) | 18 (10.6) | |
| Painter | 30 (13.0) | 2 (3.2) | 28 (16.6) | |
| Packager | 30 (13.0) | 8 (12.7) | 22 (13.1) | |
| Upholster | 8 (3.5) | 2 (3.2) | 6 (3.6) | |
| Loader | 7 (3.0) | 1 (1.6) | 6 (3.6) | |
| Work hours | | | | |
| 8 | 85 (36.8) | 27 (42.9) | 58 (34.5) | 0.507[a] |
| 10 | 88 (38.1) | 21 (33.3) | 67 (39.9) | |
| 12 | 58 (25.1) | 15 (23.8) | 43 (25.6) | |
| Type of schedule | | | | |
| Office hour | 152 (65.8) | 45 (71.4) | 107 (63.7) | 0.281[a] |
| Shift | 79 (34.2) | 18 (28.6) | 61 (36.3) | |
| Occupational safety and injury prevention training program | | | | |
| Never attended | 116 (50.2) | 18 (28.6) | 98 (58.3) | <0.001[a] |
| Attended | 115 (49.8) | 45 (71.4) | 70 (41.7) | |

Note: BMI, Body mass index; SD, Standard deviation; [a] Chi-squared test; [b]Fisher's exact test; [c]Student t-test. Variables were removed from the regression model *(p*>0.05*)*.

### *3.2 Working conditions and psychosocial characteristics*

Results revealed that about two-thirds of the workers (66.2%) had to perform lifting activities regularly. The average weight of heavy loads frequently handled with manual operations was principally recorded from 5 to 10 kg (54.5%). About one fourth of subjects (26.4%) were exposed to strain by Karasek's job demands-control model, characterized by high psychological demands and low decision job control latitude, as shown in Table 2.

**Table 2** Working conditions and psychosocial factors with WMSD prevalence over the previous 12 months among workers (n=231).

| Variables | Total n=231 (%) | Without WMSDs n=63 (%) | With WMSDs n=168 (%) | *p*-value |
|---|---|---|---|---|
| Awkward posture | | | | |
| Working with hand(s) above shoulder(s) | 58 (25.1) | 7 (11.1) | 51 (30.4) | 0.003[a] |
| Repeatedly raising | 44 (19.0) | 4 (6.3) | 40 (23.8) | 0.003[a] |
| Working with the neck bent or twisted | 119 (51.5) | 31 (49.2) | 88 (52.4) | 0.667[a] |
| Working with the back bent forward or twisted | 134 (58.0) | 33 (52.4) | 101 (60.1) | 0.289[a] |
| Kneeling or squatting | 10 (4.3) | 3 (4.8) | 7 (4.2) | 0.843[a] |
| Prolonged standing | 175 (75.8) | 48 (76.2) | 127 (75.6) | 0.925[a] |
| Handling manual materials | | | | |
| Lifting | 153 (66.2) | 38 (60.3) | 115 (68.5) | 0.244[a] |
| Carrying | 70 (30.3) | 15 (23.8) | 55 (32.7) | 0.188[a] |
| Pushing/Pulling | 109 (47.2) | 32 (50.8) | 77 (45.8) | 0.501[a] |
| Squeezing an unsupported object | 14 (6.1) | 2 (3.2) | 12 (7.1) | 0.260[a] |
| Gripping an unsupported object | 19 (8.2) | 5 (7.9) | 14 (8.3) | 0.922[a] |
| Average load (kg) | | | | |
| Light (< 5) | 32 (13.9) | 15 (23.8) | 17 (10.1) | 0.002[a] |
| Moderate (5-10) | 126 (54.5) | 38 (60.3) | 88 (52.4) | |
| Heavy (11-20) | 44 (19.0) | 8 (12.7) | 36 (21.4) | |
| Very heavy (>20) | 29 (12.6) | 2 (3.2) | 27 (16.1) | |
| Excessive repetition (repeated the same motion over times per minute) | | | | |
| Exposure | 118 (51.1) | 34 (54.0) | 79 (47.0) | 0.377[a] |
| Non-exposure | 113 (48.9) | 29 (46.0) | 89 (53.0) | |
| Psychological demands | | | | |
| Low | 110 (47.6) | 40 (63.5) | 70 (41.7) | 0.005[a] |
| High | 121 (52.4) | 23 (36.5) | 98 (58.3) | |
| Decision latitude (authority) | | | | |
| Low | 109 (47.2) | 26 (41.3) | 83 (49.4) | 0.270[a] |
| High | 122 (52.8) | 37 (58.7) | 85 (50.6) | |
| Decision latitude (autonomy) | | | | |
| Low | 127 (55.0) | 23 (36.5) | 104 (61.9) | 0.001[a] |
| High | 104 (45.0) | 40 (63.5) | 64 (38.1) | |
| Skill discretion | | | | |
| Low | 109 (47.2) | 24 (38.1) | 85 (50.6) | 0.090[a] |
| High | 122 (52.8) | 39 (61.9) | 83 (49.4) | |
| Social support at work | | | | |
| Low | 70 (30.3) | 10 (15.9) | 60 (35.7) | 0.003[a] |
| High | 161 (69.7) | 53 (84.1) | 108 (64.3) | |
| Job strain (Demand – control model) | | | | |
| Non strain | 170 (73.6) | 56 (88.9) | 114 (67.9) | 0.001[a] |
| Strain job | 61 (26.4) | 7 (11.1) | 54 (32.1) | |

Note: [a]Chi-squared test. Variables were removed from the regression model ($p$>0.05).

### *3.3 Ergonomic risk assessment*

The working posture of laborers was fully evaluated by REBA, with 55.8% of postures representing medium risk. In terms of exposure to hand-arm vibration, 44% (102/231) of participants reported frequent use of vibratory tools or equipment. Nearly 19.6% (20/102) of subjects had daily exposures above the limit value (> 5m/s$^2$), as shown in Table 3.

**Table 3** Ergonomic risk exposure among participants (n=231).

| Variables | Total n=231 (%) | Without WMSDs n=63 (%) | With WMSDs n=168 (%) | p-value |
|---|---|---|---|---|
| Hand-transmitted vibration exposure | | | | |
| Exposure to hand-arm vibration | 102 (44.2) | 22 (34.9) | 80 (47.6) | 0.083[a] |
| Daily vibration intensity – *A* (8) | | | | |
| Below the action value (< 2.5 m/s$^2$) | 47 (46.1) | 8 (36.4) | 39 (48.8) | 0.586[a] |
| From 2.5 m/s$^2$ to 5 m/s$^2$ | 35 (34.3) | 9 (40.9) | 26 (32.5) | |
| Over the value limit (>5 m/s$^2$) | 20 (19.6) | 5 (22.7) | 15 (18.7) | |
| Working posture risk level (REBA score) | | | | |
| Low risk (2-3) | 40 (17.3) | 14 (22.2) | 26 (15.5) | 0.010[a] |
| Medium risk (4-7) | 129 (55.8) | 42 (66.7) | 87 (51.8) | |
| High risk (8-10) | 58 (25.1) | 7 (11.1) | 51 (30.4) | |

**Table 3** (continued) Ergonomic risk exposure among participants (n=231).

| Variables | Total n=231 (%) | Without WMSDs n=63 (%) | With WMSDs n=168 (%) | p-value |
|---|---|---|---|---|
| Very high risk (≥11) | 4 (1.7) | 0 | 4 (2.3) | |

Note: A(8), 8-hour energy-equivalent frequency-weighted acceleration; REBA, Rapid entire body assessment tool.
[a]*Chi-squared test. Variables were removed from the regression model (p>0.05).*

*3.4 Prevalence of musculoskeletal disorders among participants*

Results were that 72.7% of workers experienced WMSDs on one or more body parts over the previous 12 months. The 12-month prevalence was highest for lower back (36.4%), followed by shoulder pain (32%), neck

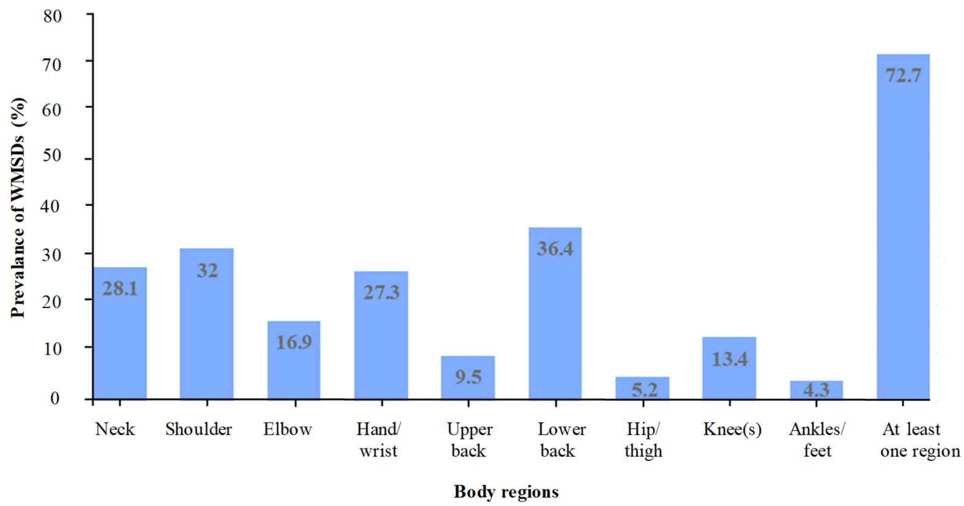


**Figure 1** WMSDs prevalence in different body regions over the previous 12 months.

*3.5 Factors related with WMSDs among workers*

Multivariate logistic regression analysis indicated the best model for statistically significant risk factors associated with WMSDs over the previous 12 months among furniture workers ($p < 0.05$), as shown in Table 4. BMI and smoking history increased the probability of experiencing WMSDs occurence over the previous year by 1.2 and 3.19 times, respectively. Workers who failed to attend occupational safety and injury prevention programs were 2.63 times likelier to develop WMSDs than those who did attend. The risk for WMSDs was significiantly increased for those with awkward hand postures working above shoulder height. Perceived high psychological demands, low autonomy latitude, and low social support were contributing risk factors for WMSDs with ORs of 2.32, 3.59 and 2.66, respectively, as shown in Table 4.

**Table 4** Associated risk factors for WMSDs over the previous 12 months among furniture factory workers.

| Factors | Total n= 231 | Number of WMSDs n=168(%) | Crude OR (95%CI) | *p*-value | Adjusted OR* (95%CI) | *p*-value |
|---|---|---|---|---|---|---|
| Age | 231 | | 1.00 (0.96 - 1.04) | 0.003 | - | - |
| Gender | | | | | | |
| Male | 137 | 103 (61.3) | 1 | 0.313 | - | - |
| Female | 94 | 65 (38.7) | 0.74 (0.41 1.32) | | | |
| BMI | 231 | | 1.16 (1.03 - 1.30) | 0.010 | 1.20 (1.05 - 1.38) | 0.007 |
| Smoking | | | | | | |
| Non-smoker | 144 | 96 (66.7) | 1 | | 1 | |
| Smoker | 87 | 72 (82.8) | 2.4 (1.24 - 4.62) | 0.009 | 3.19 (1.49 - 6.82) | 0.003 |
| Training program | | | | | | |
| Attended | 115 | 70 (60.9) | 1 | | 1 | |
| Did Not Attend | 116 | 98 (84.5) | 3.5 (1.87 - 6.55) | <0.001 | 2.63 (1.28 - 5.39) | 0.008 |
| Awkward posture Hand(s) above shoulder height | | | | | | |
| No | 173 | 117 (67.6) | 1 | | 1 | |
| Yes | 58 | 51 (87.9) | 3.48 (1.48 - 8.17) | 0.004 | 3.27 (1.29 - 8.26) | 0.012 |

**Table 4** (continued) Associated risk factors for WMSDs over the previous 12 months among furniture factory workers.

| Factors | Total n= 231 | Number of WMSDs n=168(%) | Crude OR (95%CI) | *p*-value | Adjusted OR* (95%CI) | *p*-value |
|---|---|---|---|---|---|---|
| Mean load (kg) | | | | | | |
| Light (< 5) | 32 | 17 (53.1) | 1 | | | |
| Moderate (5-10) | 126 | 88 (69.8) | 2.04 (0.92 - 4.51) | 0.077 | - | - |
| Heavy (11-20) | 44 | 36 (81.8) | 3.97 (1.41 - 11.16) | 0.009 | - | - |
| Very heavy (>20) | 29 | 27 (93.1) | 11.91 (2.41 - 58.72) | 0.002 | - | - |
| Psychological demands | | | | | | |
| Low | 110 | 70 (63.6) | 1 | | 1 | |
| High | 121 | 98 (81) | 2.43 (1.33 - 4.42) | 0.004 | 2.32 (1.12- 4.78) | 0.022 |
| Decision latitude (autonomy) | | | | | | |
| High | 104 | 64 (61.5) | 1 | | 1 | |
| Low | 127 | 104 (81.9) | 2.82 (1.55 - 5.15) | 0.001 | 3.59 (1.78 - 7.22) | <0.001 |
| Social support | | | | | | |
| High | 161 | 108 (67.1) | 1 | | 1 | |
| Low | 70 | 60 (85.7) | 2.94 (1.39 - 6.20) | 0.005 | 2.66 (1.15 - 6.15) | 0.021 |

Note: BMI, Body mass index; CI, confidence interval; OR, odds ratio; WMSDs, Work-related Musculoskeletal Disorders.

## 4. Discussion

This study demonstrated that WMSDs were common among furniture workers in a production factory. 72.7% of the studied population had experienced musculoskeletal pain or discomfort in at least one body area over the previous 12 months. In a similar case in Vietnam, nearly 80% of workers in a seafood processing company suffered musculoskeletal pain in at least one body part over previous 12 months [25]. Another study among waste collection workers in Hanoi, the capital of Vietnam, showed congruent finding with 74.4% of one-year MSDs prevalence [26]. Despite a paucity of published studies applying to different occupational sectors, these cases supported the view that WMSD prevalence was relatively high among the manual industrial population in Vietnam. Poor working conditions and lack of ergonomic principle application in workplace design have been reported concomitantly in developing countries, including Vietnam.

The commonest body area for complaints over the previous 12 months was the lower back (36.4%). This prevalence among furniture workers resembled those reported in other countries, for example Nigeria (35.6%) [6] and Thailand (35.9%) [9]. Other high symptom proportions in the neck and upper limbs were also reported, much as in previous studies [6,9]. This coheres with demands of furniture industry manual labor. Furniture workers often perform manual operations and are exposed to excessive force such as lifting, handling of heavy materials; adverse postures; repetitive motions; and vibration from hand tools. [7]. These issues demonstrated that lack of ergonomic workstation and tool/equipment design created occupational workplace exposure.

Among personal factors, BMI was associated with WMSD prevalence. Compared to employees of normal weight, obese employees (BMI $\geq$ 25) had a higher risk of developing WMSD symptoms. This agreed with a previous study [27] that WMSDs over the previous 12 months were more frequent among overweight workers as well as a cohort study of the working population [28] that high BMI caused a higher 12-month prevalence of MSDs. In addition, several epidemiological studies demonstrated that high BMI was associated with WMSDs involving the low back as well as upper and lower limbs [29]. Therefore, regular healthy lifestyle monitoring and assessment should be introduced to obese workers.

Smoking was also significantly associated with WMSDs. This finding supported previous studies of furniture workers in Thailand [9]. Several longitudinal studies confirmed a plausible causal relationship between smoking and WMSDs [29]. Cigarette smoking also contributed to development of rheumatoid arthritis, osteoarthritis, low back pain, tendinopathy, and delayed fracture and wound healing [30]. Therefore, a smoking cessation campaign should be promoted in the workplace.

In terms of organizational workplace factors, engagement of employees in work health and safety training when first hired significantly affected WMSD prevalence. This result indicated that significant ergonomic training from the start of job-related activity could reduce workplace WMSD complaints. Previous studies have confirmed the effectiveness of workplace safety training and education programs in comparing musculoskeletal disorders risk before and after training [31]. Prevention programs aim to provide workers with knowledge to work safely and recognize risk factors for WMSDs as well as avoid and control risk hazards [1,7].

Laborers who had to work with one hand above shoulder height at least two hours daily reported a much higher prevalence of WMSDs over the previous 12 months than those who with less than two hours or no time spent in this posture. This is consistent with a literature review of working posture [32]. A National Institute for Occupational Safety and Health review also indicated that workers with extreme postures were at increased risk for neck and shoulder disorders, especially with overhead, elevated arms, and specific postures related to degrees of upper limb abduction or extension [1]. Laborers are required to work with prolonged awkward hand postures for over two hours daily because workstations were not designed to fit employees. Factories might address this issue by providing standing platforms and adjusting the height of working surfaces to suit the sizes of individual workers.

Hand-transmitted vibration exposure results from 102 participants who used a hand-held or hand-fed machine revealed that 20/102 (19.6%) were exposed to average daily exposure above the upper limit of 5 $m/s^2$ [24]. Almost all workers exposed to hand-arm vibration were either painters, sanders, or upholstery operator, who experienced higher WMSDs rates than other job categories. This non-significant difference supported previous findings among furniture workers [7,9] indicating that prevalence of upper limb symptoms was significantly linked to hand-arm vibration exposure.

In addition, ergonomic risk assessment also revealed awkward postures among laborers working by REBA. Almost 55.8 % of participants were found to be at medium risk and another 25.1% of workers were at high risk, implying that working postures should be further examined and modified. This result agrees with the aforementioned studies that furniture workers were at risk of MSDs due to working postures [6-8]. Harmful postures may have been identified after performing furniture-related tasks leading to musculoskeletal injury exposure required corrective measures. This finding is in agreement with other research indicating that inappropriate working postures may cause musculoskeletal symptoms among industrial workers [29,32]. Mismatches between human anthropometric dimensions and workspace, tools, and equipment dimensions are known to be leading factors in increased discomfort, fatigue, and musculoskeletal injuries [16]. It is recommended that working posture assessment should help develop ergonomically designed workplaces taking into account anthropometric dimensions of workers.

Finally, psychosocial factors among workers including the perception of high psychological demands, low levels of autonomous job control, and limited social support was associated with a risk of WMSDs. This finding was consistent with previous research among working populations [1-3,13]. The present result concurred with a cohort study [12] finding that workers exposed to high levels of psychological demands and low social support were likelier to report symptoms of neck and upper limb disorders than others. It may be concluded that psychosocial factors at work such as heavy mental burdens associated with low levels of autonomy lead to situations of low job control-high job demand, increasing MSD risk, especially if line managers fail to provide workers with necessary support or recognition. In conclusion, to reduce WMSD prevalence among furniture workers, factories should adopt a multifaceted approach to avoid physical hazards and improve psychosocial conditions. In terms of social support as an emerging psychosocial risk factor, recent research suggests that social support, including supportive relationships between supervisors and peers, may be an essential factor for preventing workplace WMSDs [13]. Managers should consider implementing reward policies to ensure fairness and boost solidarity and team spirit by organizing union activities, as well as social activities to unite the labor collective. These steps would be essential for improving collegial spirits and mutual assistance at work.

Limitations of this study may relate to the fact that data was primarily collected by questionnaire. Workers with musculoskeletal system disorders may be likelier to report risks potentially connected with related symptoms. In addition, the worst-case scenario was selected to implement assessment instruments and vibration exposure measurement did not calculate inter-rater reliability, possibly leading to bias or accuracy issues. The outcome variable included only WMSD prevalence in at least one body part; analysis was not specific to any particular body part, which may have led to recall bias over the year-long duration of the study outcome. Self-reported WMSD at the one-year interval may have been affected by recall bias. Despite the cross-sectional design, these findings may nevertheless contribute to knowledge of primary risk factors for WMSDs among workers in Vietnam. Governmental agencies and policy makers should focus on the prevalence of musculoskeletal disorders among furniture workers.

## 5. Conclusion

This study revealed a high prevalence of WMSD symptoms among furniture factory workers in Vietnam. Several associated risk factors such as BMI, smoking, non-participation in training, awkward hand postures, and psychosocial exposure such as high psychological demands, low job control, and low social support have been confirmed as multifactorial causality of WMSDs. Ergonomic risk assessment results indicated a need for ergonomic intervention in the workplace to minimize or eliminate awkward postures. These findings should be considered for implementing workstation modification, organizational policies and social activities to improve work conditions and psychosocial aspects for laborers. In addition, annual training courses should be provided for workers to develop knowledge and raise awareness to reduce risks of WMSDs.

## 6. Ethical approval

The research protocol was approved by the Ethics Review Sub-Committee for Research Involving Human Research Subjects of Thammasat University, No. 3 (Code 029/2563, June 14, 2020).

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