PREVALENCE AND RISK FACTORS OF WORK RELATED MUSCULOSKELETAL DISORDERS AMONG WORKERS IN A WOODEN FURNITURE FACTORY AT BINH DUONG PROVINCE, VIETNAM

BY

THIEN THUC TRAN

**A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
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ENTITLED

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was approved as partial fulfillment of the requirements for
the degree of Master of Science

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ABSTRACT

Furniture workers are often required physically demanding tasks of manual materials handling that lead to work-related musculoskeletal disorders (WMSDs). The objective of this research was to identify work-related musculoskeletal disorder prevalence and its risk factors among wooden furniture workers in a production factory in Binh Duong Province, Vietnam. A cross-sectional study with the sample size 231 participants was conducted along with serveral ergonomic tools including the Washington State 's caution zone checklist, Rapid Entire Body Assessment and vibration exposure were measured. The results revealed WMSDs prevalence in at least one body part during the last 12 months was 72.7%. Risk factors were found to be associated with WMSDs such as body mass index, smoking, training non-attendance, hand(s) over shoulder height posture, load weight, high psychological demands, low decision on autonomy, and low social support. Findings from this study may be utilized to improve working conditions among furniture workers.

Keywords: Ergonomics, Musculoskeletal disorders, Occupational health, Vietnam.

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Words cannot express how grateful I am to my colleague for their endless support. Last but not least, I owe a debt of thankfulness to my family for their unconditional supporting. They always let me chose my own way and encourage me. Without their great care, I could never have accomplished this Master program study.

Thien Thuc Tran

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LIST OF ABBREVIATIONS

Symbols/Abbreviations	**Terms**
ACGIH	American Conference of Governmental Industrial Hygienists
AFMA	American Furniture Manufacturing Association
BMI	Body Mass Index
CI	Confidence Interval
CTS	Carpal Tunnel Syndrome
GDP	Gross Domestic Product
GNP	Gross National Product
HAV	Hand-Arm Vibration
HSE	Health and Safety Executive
ITC	International Trade Centre
ITTO	International Tropical Timber Organization
MSDs	Musculoskeletal Disorders
NIOSH	National Institute for Occupational Safety and Health
NRC	National Research Council
OR	Odds ratio
PPE	Personal Protective Equipment
QEC	Quick Exposure Check
REBA	Rapid Entire Body Assessment
RULA	Rapid Upper Limb Assessment
SNQ	Standardized Nordic Questionnaire
WHO	World Health Organization
WMSDs	Work-related Musculoskeletal Disorders

CHAPTER 1
INTRODUCTION

1.1 Background

Work-related Musculoskeletal Disorders (WMSDs) have been considered as the most prevalent occupational health problem in almost all industries during the recent decades (Bureau of Labor Statistics, 2015; European Agency for Safety Health at Work, 2019; Schneider, Copsey, & Irastorza, 2010). WMSDs are the result of the cumulative influence of repeated traumas associated with specific work-related conditions in the workplace (McCauley-Bush, 2011; National Research Council [NRC], 1998; 2001). It is well-known that the strong association between the development of WMSDs and the working conditions reported by a number of literature review and epidemiological studies (da Costa & Vieira, 2010; Putz-Anderson et al., 1997), indisputably the physical risk factors related with jobs, tasks or activities sometimes called as ergonomic factors in the workplace e.g., inappropriate posture, forceful exertion, excessive repetition, prolonged static position, extreme temperature or vibration exposure. Recently, psychological stress, job dissatisfaction and other psychosocial factors were also proven to be the momentous factors that gradually contribute to the occurrence of these disorders (European Agency for Safety Health at Work, 2019; Macfarlane et al., 2009; van den Heuvel et al., 2005). Furthermore, personal characteristic factors such as age, gender, lifestyle, fitness also were likely to be a determined component in the progression of WMSDs (da Costa & Vieira, 2010; NRC, 1998; Nunes & Bush, 2012). WMSDs and their interference were widely known to cause work limitations and restrictions, leave of absence, productivity outflow and reduction in work performance as well as exacerbation in health care expenses, workers' reimbursement and disability payments across many countries including all the member states of the European Union (Bevan, 2015), those of the United States (Bhattacharya, 2014), even among developing countries (Piedrahita, 2006) in particular Vietnam. A study conducted in working-age population among all the Eurozone member nations had estimated the cost of WMSDs to be about 2% of Gross Domestic

Product (GDP) (Bevan, 2015). Notably, in France, the recent figure illustrated an increase on WMSDs costs from losses in 2005 of 6.5 million workdays to losses in 2006 of 7 million workdays equivalent to 700 million euro value (Schneider et al., 2010). A similar issue was reported in the Germany, the Federal Institute of Occupational Safety and Health reported that WMSDs had been responsible for the highest proportion of productivity loss as 23.7% of all lost workdays and 23.9 billion Eurodollar, which approximately 1.1% of the Gross National Product (GNP) in lost productivity (Schneider et al., 2010). Meanwhile, in the United States, Bhattacharya (2014) revealed that WMSDs costs were reported as much as 1.5 billion dollar on direct costs for workers' compensation, and 1.1 billion dollar that much for indirect costs. His study also reported that the average medical costs and other related costs per case went up during the period from 2003 to 2007. The Bureau of Labor Statistics (2015) revealed WMSDs made up 31% of the total occupational injuries and illnesses cases covering days away from work in 2015. The median number of days away for WMSDs in private industry was 12 compared to a 8-day median away from work for all cases. Most recently, costs of WMSDs had accounted for 24% of work-days lost (6.6 million working days lost) according to the result of Labor Force Survey in England from the Health and Safety Executive [HSE] report (2018).

With regard to above cases, the furniture manufacturing sector is one of few industries has struggled with problems associated with WMSDs (Mirka, 2005; Putz-Anderson et al., 1997). An ergonomic study in the furniture industry from Denmark (Christensen, Pedersen, & Sjøgaard, 1995) indicated that the prevalence of WMSDs symptoms during the last 12 months at least one body region (75%) was remarkably high among workers, in particular the low back and upper limb regions had accounted the highest proportions with 42% and 40%, respectively. Consistently, the same study of Iranian workers (Nejad et al., 2013) showed those 12-month symptoms of lower back (35.6%), wrists or hands (29.5%) complaints occupied the highest prevalence. Moreover, the study of Hagen, Magnus, and Vetlesen (1998) in furniture industry showed the higher proportion of one-year WMSDs in the manual workers compared to administrative workers, their findings were similar to a cross-sectional survey in Thailand (Thetkathuek & Meepradit, 2018) in which office personnel considered non-exposure to WMSDs risk across almost every body parts. Most of furniture workers are required a large amount of heavy manual work such as sanding, rubbing, stapling, lifting, pushing, pulling and spraying with work piece or monolithic products that made them exposure to physical stressors as well as ergonomic risk hazards such as forceful repetitive motions within short cycle time; static awkward posture (e.g. prolonged forward and lateral flexions, bending or twisting of the neck and trunk, gripping the spray gun, abduction and wrist deviation, etc.); (Björing & Hägg, 2000; Christensen et al., 1995; Mirka, 2005; Nejad et al., 2013). Furniture workers are also exposure to other occupational risk from using of vibratory tools that causes WMSDs in the upper limbs (Bovenzi et al., 2005; Gauthier, Gélinas, & Marcotte, 2012). Besides that, several psychosocial stressors such as job strain, high psychological demands, low job control have been confirmed to increase on the occurrence of WMSDs among industrial workers by study of (Bugajska et al., 2013); Eatough, Way, and Chang (2012). However, the psychosocial factors have not found investigated in many previous studies among furniture workers.

In Vietnam, the wooden furniture sector is one of the most booming industries over recent years (Maraseni et al., 2017). Among developing countries, Vietnam has been standing at the high position as a country of processing and exporting forest products and wood-based furniture according to an overview of forest governance in Vietnam of the Asia regional office under the European Forest Institute for Forest Law Enforcement, Forest Governance and Forest Trade (Maraseni et al., 2017; Phuc & Canby, 2011). Most of wood processing enterprises are foreign owned (Dawson, 2008), that actually has raised domestic concerns about the compliance with environmental and occupational health policies for workers in Vietnam. Besides, technology and machinery lines are designed in accordance with the European anthropometric index, but when exporting to Vietnam, it may not be suitable for the size of Vietnamese anthropometry (Phuc & Canby, 2011). Along with its flourishing development of the wood processing industry is the raising in the number of employment opportunities and employee health issues (Nguyen, 2016). Previous studies have been revealed that the furniture manufacturing sector is one of few industries that has struggled with problems related to WMSDs (Christensen et al., 1995; Nejad et al., 2013; Nicoletti et al., 2008; Thetkathuek & Meepradit, 2018). However, there is no published literature on WMSDs among furniture workers in Vietnam, in particular data on the prevalence and specific risk factors among workers are lacking and poorly documented in national reports. Lack of awareness about occupational hazards, shortage of prevention measures, and poor safety in the workplace are likely to considerably increase the disability of musculoskeletal disorders among workers in the context of a developing country (Piedrahita, 2006) like Vietnam. Therefore, there is a need for research concerning WMSDs prevalence and potential risk factors contributing to WMSDs among furniture manufacturing employees in Vietnam.

Hence the findings of this study was to provide basic information and help to strengthen the healthcare promotion so that employees working in this industry can recognize and take some measures to prevent risk factors associated with WMSDs in order to enhance their own health.

1.2 Study area

The research conducted in Binh Duong province, that had attracted thousands of factories because of its connection with major wood-processing regions in the Southeast of Vietnam. There is a remarkable increase in the number of workers immigrating to Binh Duong province in recent years (Huy, 2011). Additionally, the exporting figure of wood-processing products like furniture from Binh Duong reached 4 billion dollars, representing for 54.8 % of total wood exports in Vietnam. In 2018, their production amounted to 1.5 billion dollar (Das, 2018) that made the government concerned about this industry in Binh Duong province. However, information on worker's health regarding WMSDs problems in general and furniture manufacturing workers' health in particular is still limited.

1.3 Reseach question

1.3.1 What was the prevalence of WMSDs among furniture workers in a wooden factory in Binh Duong province of Vietnam?

1.3.2 Which are potential risk factors associated with WMSDs among furniture workers of a wood furniture factory?

1.4 Objectives

1.4.1 To determine the prevalence of WMSDs among furniture workers at a wooden factory in Binh Duong province of Vietnam.

1.4.2 To determine the relationship between potential risk factors and WMSDs among workers at a wooden furniture factory in Binh Duong province.

1.5 Hypotheses

1.5.1 The prevalence of WMSDs among furniture workers at a wooden factory in Vietnam is correspond to the commonplaceness of WMSDs among furniture workers in other countries.

1.5.2 The potential risk factors including individual factors, organizational factors, psychosocial factors and physical factors have been confirmed in relationship with the prevalence of WMSDs among workers at a wooden furniture factory in Vietnam.

1.6 Conceptual framework

Independent variables **Dependent variable**

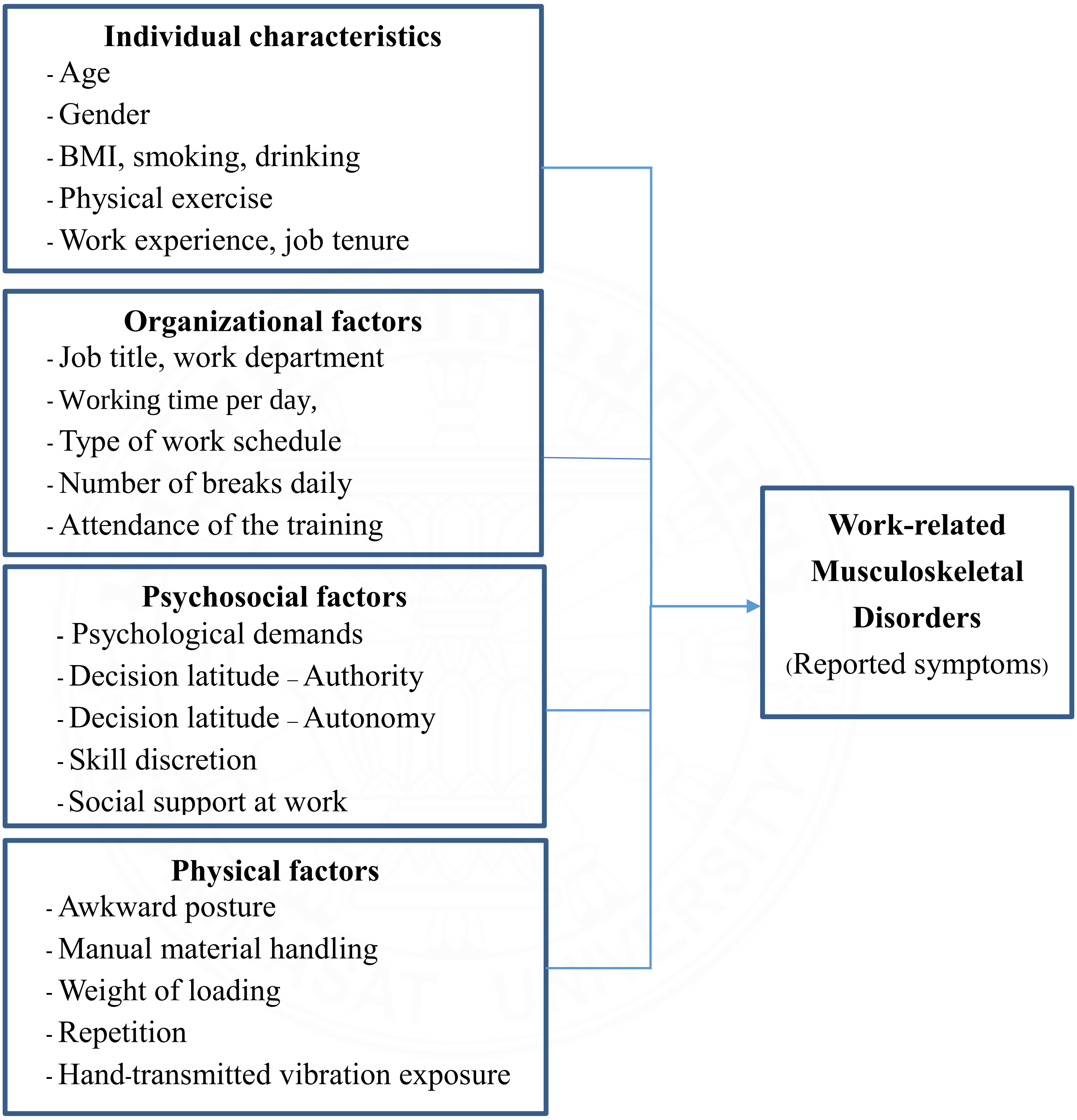


Figure 1.1 Conceptual framework

1.7 Operation definition

1.7.1 Definition of WMSDs

Work-related musculoskeletal disorders (WMSDs) are described as damages that affects the musculoskeletal system of the worker body with the common symptoms such as ache; pain; numbness; or discomfort. Those symptoms related to the work activities and conditions were recorded by interviewing the Standardized Nordic Questionnaire (Kuorinka et al., 1987) during the past 12 months in the following the nine body areas: neck; shoulder; elbow; wrists or hands; upper back; lower back; hip and thigh; knee; and ankle. Prevalence of WMSDs was calculated by the proportion of any musculoskeletal symptoms in at least one body part during the last 12 months.

1.7.2 Definition of independent variables

1.7.2.1 Individual factors

(1) Age

Age is defined as the number of years. The age of objects was identified from the year of birth recorded in the identity card until the current year of the study.

(2) Gender

Either of the two divisions: male and female, designated by which was identified from the participants' identity card.

(3) Body mass index

Body mass index (BMI) is a simple measure of relative size based on weight for height of an individual that is ordinarily used to clarify underweight, overweight and obesity. It is established as the person's weight in kilograms divided by the person's height in square-meters (kg/m^2) as the formula following: $\mathrm{BMI} = \frac{\mathrm{kg}}{\mathrm{m}^2}$. According to the report coordinated by the WHO with the International Diabetes Research Institute in 2000 (World Health Organization, 2000), BMI was adjusted for Asian population as following:

1. BMI $<$ 18.5: Under weight
2. 18.5 $\leq$ BMI $<$ 25: Normal weight
3. BMI $\geq$ 25: Overweight

(4) Smoking status

Smoking status is an activity that is practiced by a person that are associated with the burning and inhalation of a cigarette, a cigar, or a pipe at the current moment. This current status was characterized as following:

1. Never smoke
2. Occasionally smoke
3. Smoking daily
4. Used to smoke but quit

(5) Smoking duration

Smoking duration was defined as the number of years or the length of time that participants had smoked by interview at the moment of the study.

(6) Alcohol consumption

Drinking alcohol is the status of habit that was described by the frequency of using within the past 12 months of the respondents was divided into 4 levels as following:

1. Never
2. Once per month or less
3. Twice to four times a month
4. Twice or more times per week

(7) Level of alcohol drinking

The average amount of alcohol units used drink when the respondents estimated by themselves. The quantity of units were calculated according to the prescribed standard cup which either 120ml for beer, wine or 30ml strong liquor cup (Babor et al., 2001)

(8) Physical exercise

Physical exercise is the set of activities that is structured and regular in order to develop or maintain fitness and overall health (Caspersen, Powell, & Christenson, 1985). Workers had exercise except during working time at the factory.

(9) History of musculoskeletal injuries/ surgeries

The history ever encountered musculoskeletal injuries related objects occupation forced to surgery or hospital visits with a few days off.

(10) Work experience

The working experience was the time of professional service counted by years that participants had worked in the current occupation or career in the furniture industry.

(11) Work tenure at this factory

The tenure was the time of professional service counted by years that participants had worked in the current position at the wooden furniture production factory, was calculated from the first day start working to the time at which the investigation occurring.

1.7.2.2 Organizational factors

(1) Job title

The job title is a term that describes the employee's position or the main task in the recruitment information. There were some job titles for the participant working at factory in the study as below:

1. Quality control worker/ manager
2. Moulder operator (cutter)
3. Forming operator
4. Sander
5. Assembler
6. Painters

7. Packaging operator/ loader

8. Upholster

(2) Department

The department or work location is a term that describes the place of work in which a currently employed person performs his or her activities. There were some departments at factory in the study as below:

1. Moulder
2. Line A
3. Line B
4. Line C
5. Line D
6. Line Sofa
7. Line Toilet chair
8. Line Table top
9. Line Sewing
10. Line Accessories
11. Quality control
12. Warehouse

(3) The working time per day

The working time in a day is the period of time that a person works on average per day in accordance with the company's regulations, estimated in hours. The standard hours of work shift for employees were either 8,10 or 12 hours a day. It was also able to infer the number of working hours per week.

(4) Type of work schedule

A list of patterns or schedules in which an employee was expected to work. There were three type of working schedule including office hour work – standard business day, shift work and part time.

(5) The break time per day

The break time was the amount of the short period for workers to rest or stop working, defined as the number of minutes in a break.

(6) Break times daily

The break times daily were counted by the number of breaks during working time for workers that stop working to relax.

(7) Participation in occupational safety training

Whether or not the engagement of employees in the work health and safety training when they start carrying out their job in the first time.

1.7.2.3 Psychosocial factors

The Karasek - Job Content Questionnaire (Karasek et al., 1998) was applied to access psychosocial burden in the workplace by a set of 35 questions from a Vietnamese version (Hoang et al., 2013). This questionnaire consists of five psychosocial factors below:

(1) Psychological demands (9 items)

Psychological demands include cognitive requirements, time pressure, heavy workload, interruption, intense concentration and conflicting demands. The 9-item version is used including task-related constraints (i.e. quantity, time limits)

(2) Decision latitude – Authority (4 items)

The decision authority reflects the particular behavior of individual influence over the process of work, regarding to the ability of engaging in the decision-making process.

(3) Decision latitude – Autonomy (9 items)

Autonomy is the capacity of managing and controlling the chronology of work or task performance, i.e. have the freedom to work, set the time to start and finish the job.

(4) Skill discretion (5 items)

The self-esteem of employees for using of skills to employ, opportunities to gain or develop new skills, to make more creativities and to reduce the repetitive motions or activities when performing the work.

(5) Social support at work (8 items)

The dimension involves the social-emotional integration and support from supervisors and colleagues, the level of assistance be offered by others when performing the tasks.

1.7.2.4 Physical factors

The structured checklist was created for recording the physical risk factors. This screening tool was designed to evaluate jobs or tasks with high potential for causing WMSDs in term of four categories: working posture, manual handling (forceful exertion), repetition, hand-arm vibration exposure.

(1) Awkward posture

- The posture of the hand(s) or the elbow(s) above the shoulder height more than 2 hours per day.

- Repeatedly elevating or working with the posture of hand(s) or the elbow(s) above the shoulder height more than once time every minute with more than 2 hours per day.

- The posture of neck twisted or side bent more than 2 hours per day

- The posture of back bent or twisted more than 2 hours per day

- The posture of kneeling or squatting posture more than 2 hours per day

- Prolonged standing posture if one or more body parts are held for longer than 2 hours per day (static)

(2) Manual material handling

- Manual material handling is a performance of transporting or handling a heavy load or objects by hand(s) or several biomechanical functions of the body more than 2 hours per day. The most strenuous activity for manual handling of heavy loads when performing the main task, consists of 3 kinds: lifting; carrying; pushing and pulling.

- Squeezing any unsupported object weight at least 1 kg per hand; or using a force of at least 2 kg per hand

- Gripping any unsupported object weight at least 5 kg per hand; or using a force of at least 5 kg per hand

(3) The weight of loading

- The average weight of loads that workers handed per workday. They consisted of four levels, which adopted from force/load score of Rapid Entire Body Assessment tool (REBA).

1. < 5kg (Light).
2. 5-10 kg (Moderate).
3. 11 – 20 kg (Heavy).
4. >20 kg (Burdensome).

(4) Repetitive motion

The conceptual of receptiveness in respect of exertion and rest per time unit of working cycle, which can propose that the higher frequency of exertions, the shorter the recovery time. In this study, repeating the same motion or small range movement with more than 4 times per minute could be considered as repetition exposure, which have been adopted from the activity score calculation of REBA method.

(5) Hand-transmitted vibration exposure

- Hand-arm vibration exposure was recorded if workers had to manipulate with the hand-held vibratory tools or hand-fed vibrating machine.

- Daily exposure duration: the estimated amount of time that a worker uses vibration tools, recorded in the total time by interview.

- Daily vibration exposure was calculated as the eight-hour energy-equivalent frequency-weighted acceleration magnitude *A[8]* of all the hand-held tools. Then those were categorized with the recommend values of the ACGIH (American Conference of Governmental Industrial Hygienists, 2018) for vibrational exposure.

1. Below the action value (< 2.5 m/s^2)
2. From 2.5 to 5 m/s^2
3. Over the limit value (> 5 m/s^2)

1.7.3 Assessment of hand-arm vibration exposure level

In order to calculate the 8-hour energy-equivalent frequency-weighted acceleration dose, all acceleration values for the hand-held vibratory tools and hand-fed machine were measured by a Human vibration meter with all required weighting filters for human vibration measurements, then combining with the exposure duration for each operation that the worker performing each vibratory tool or machine.

1.7.4 Assessment of WMSDs risk level by REBA tool

In order to assess adequately the physical exposures in the working environment, beside with structured checklist, the observational assessment tool in the current study - Rapid Entire Body Assessment tool (Hignett & McAtamney, 2000) was utilized as a systematic technique to evaluate postural musculoskeletal disorder of the whole body of all participants, which appreciated for evaluating the static or strenuous posture in long time. The REBA score was categorized into four groups as table below:

1. Low risk level (2-3)
2. Medium risk level (4-7)
3. High risk level (8-10)
4. Very high risk level (≥11)

CHAPTER 2
REVIEW OF LITERATURE

2.1 Wood furniture process

In the context of market globalization, a boom in real estate and hospitality industries would accelerate the growth of the furniture sector (International Trade Centre [ITC], International Tropical Timber Organisation [ITTO],2005). According to the report of ITC and ITTO (2005), wood has a promising perspective of becoming one of the most valuable material in furniture products, especially there is an increase of customer preferences for customized household furniture.

A field direct observation survey and the factory's profile showed that hand-operated work accounted the majority of furniture processing. Almost furniture products in the factory are tables, chairs and others such as wooden sofa or interior decoration. The manufacturing process of producing these furniture products is relatively simple and can be illustrated as follows: At first, the processing process starts with receiving the work piece materials from storages, then each piece would be put into sawing machine to cut into smaller blocks according to design requirements such as wood quality, size of each customer order. From the wood panels are selected, it is handled at the molding or forming section in order to achieve the required shapes and sizes for furniture manufacturing. Molded wood is processed by different forming machines (drilling, grafting, cutting detail) depending on its shape and design to obtain product requirements. The next stage of the process, these components are sanded properly to eliminate the roughness of the edges and flatten the surface of the timber. This process is carried out by hand sanding again to round all sharp edges to create smoothness for the product before going through the painting process. Paint is sprayed on wooden parts, covering the surface to create color, anti-mold and natural longevity for the product. After finishing painting, each component is being joined up according to the requirement of a finished product (tables, chairs, etc.). All joints are connected together to form a strong bond. Sometimes, wooden dowel pin is employed to put two parts of furniture together. In some cases, paint spraying is proceeded after the assembly is completed. Then, the created parts are stockpiled and labeled for further identification according to customer requirements. The final product (table, chair, etc.) after assembly is checked and evaluated by the Quality Controllers (QC) workers. Finally, finished products are packed, stored and waiting for shipment.

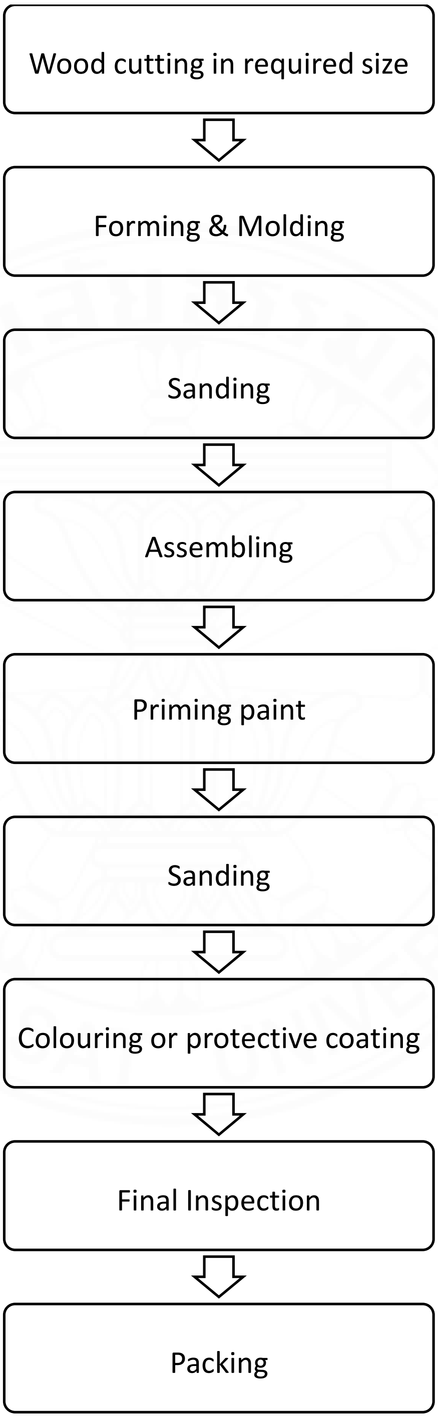


Figure 2.1 Furniture production process

2.2 Work-related Musculoskeletal disorders

2.2.1 Overview of WMSDs

Musculoskeletal disorders (MSDs) involving the soft tissues of the body – the muscles, tendons, ligaments, joints, nerves, cartilage and supporting structures of the body with common symptoms as pain, discomfort, weakness, tingling, swelling, and numbness (World Health Organization [WHO], 2003). The term of "work-related musculoskeletal disorders" or WMSDs is a subcategory of MSDs referring to injuries and illnesses that are caused or aggravated by working activities and conditions. WMSDs are typically exposure to repetitive, forceful or awkward work over a period of time due to repeated wear and tear or micro traumas without adequate recovery (Stack, Ostrom, & Wilhelmsen, 2016). Other common names for WMSDs are "repetitive motion injuries", "repetitive strain injuries" in Australia, Canada and Netherlands, "cervicobrachial syndrome", "occupational cervicobrachial disorders" in Sweden and Japan, "cumulative trauma disorders" in USA, and many more terms (Nunes & Bush, 2012).

The classification of the conditions in medicine field based on structures impacted by WMSDs (Nunes & Bush, 2012), there are usually classified into the following 5 categories as follow: 1. Tendon - involve swelling of the tendons or their synovial sheaths. The phenomena are usually identifying as tendonitis, which is the swelling of tendons; tenosynovitis, which are injuries involving tendons and their sheaths (epicondylitis - elbow tendonitis, de Quervain's disease - tenosynovitis of the thumb trigger finger), and synovial cysts, which are the subsequent of abrasion in the tendon sheath. 2. Bursa – its swelling is described as bursitis. 3. Muscles – excessively stretching can lead to muscles strain and overtiredness, such as tension neck syndrome. 4. Nerves - include the compression of a nerve (carpal tunnel syndrome and thoracic outlet syndrome). 5. Arteries and vessels – a hindrance or obstruction of blood flow supply by vascular compression or vasospasm (Raynaud's syndrome - white finger phenomenon). The WMSDs illustrated in this document are listed in Table 2.1, arranged by the area of the body and the afflicted anatomical body structure.

In general, the signs of WMSDs can progress either slowly or suddenly in three stages as follow: Early stage: ache and fatigue of the affected limbs occur during the working shift, but these symptoms will disappear at night and day off work. This stage does not reduce the ability to work. Middle stage: aches and fatigue occur early in the work shift; these symptoms do not settle at night or day off. Actually the capacity for doing repetitive tasks can be reduced, aches or pains can persist over weeks or months. Late stage: Symptoms like pain, fatigue, muscle weakness persists even while resting, insomnia and reduced ability to work (even performing the light work). Those symptoms usually not reversible, and prolongs for months or years. However, not everyone has to go through these stages in turn. In fact, musculoskeletal disorder symptoms are often discrete and episodic in the early stages. Pain is the most prevalent symptom of general musculoskeletal disorders. Pain arranges from mild to severe and from acute and short to chronic and lasts for a long time and may be localized or widespread (diffuse). Pain is a first sign that muscles and tendons should take a break to recover. The action to reduce risks should be taken immediately upon recognition of these symptoms. Additional care may be required including physiotherapy, drugs, and other medical treatments, including surgery. Early recognition of these symptoms allows for more efficient treatment and complete recovery. Besides, it is crucial to identify any potentially harmful risk factors as soon as possible for effectively implementing the preventing program.

Table 2.1 The distribution of WMSDs by each body part and impacted structure adapted from a review of Nunes and Bush (2012)

<table>
<tr><th rowspan="2">Impacted Structures</th><th colspan="8">WMSDs</th></tr>
<tr><th>Neck</th><th>Shoulder</th><th>Elbow</th><th>Wrist/ hand</th><th>Back</th><th>Thigh/hip</th><th>Knee</th><th>Leg/foot</th></tr>
<tr><td>Tendon and sheath</td><td>-</td><td>Shoulder tendonitis</td><td>Epicondylitis</td><td>de Quervain’s disease
Tenosynovitis
Synovial cyst
Trigger finger</td><td>-</td><td>Piriformis syndrome</td><td>Pre-patellar tendonitis
Shin splints
Infra-patellar tendonitis</td><td>Achilles tendonitis</td></tr>
<tr><td>Bursa/ capsule</td><td>-</td><td>Shoulder bursitis
Frozen shoulder (adhesive capsulitis</td><td>Olecranon bursitis</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Muscle</td><td>Tension neck syndrome</td><td>-</td><td>-</td><td>-</td><td rowspan="2">Low back pain</td><td>Trochanteritis
Hamstring strains</td><td>-</td><td>-</td></tr>
<tr><td>Nerve</td><td>Cervical spine syndrome</td><td rowspan="2">Thoracic outlet syndrome</td><td>Radial tunnel syndrome
Cubital tunnel syndrome</td><td rowspan="2">Carpal tunnel syndrome
Guyon’s Canal syndrome
Raynaud syndrome</td><td>Piriformis syndrome</td><td>-</td><td>-</td></tr>
<tr><td>Blood vessel</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>Varicose veins
Venous disorders</td></tr>
<tr><td>Bone/ cartilage</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>Sacroiliac joint pain</td><td>Pre-patellar tendonitis</td><td>-</td></tr>
</table>

2.2.2 WMSDs screening method

For monitoring the health problem in the workplace, self-report symptoms and signs which obtained by questionnaires can demonstrate disorders on the subjects that sometimes are not diagnosed by clinical findings. It is also a significant tool for the evaluation of the impact of the WMSDs to the affected subjects in term of work capacity and social activities. The relative easiness in collecting data makes this method widely applicable in large scale investigations. However, the method has intrinsic characteristics of non-specificity, individual dependence, and can be influenced by other factors; all can affect the finding of true association between exposure and WMSDs. Temporal concepts such as onset, acute or chronic case also introduce ambiguity in evaluation of the WMSDs.

Standardized Nordic Questionnaire proposed by Kuorinka et al. (1987) is used to record the musculoskeletal problems of the workers at their workplace. It records general troubles with locomotive system at different parts on the interviewee body during the past twelve months and seven days; as well as examines the particular trouble of MSDs in each body part as well as the impacts on the respondent's work and life activities. The questionnaire also includes the body map that would make the respondents easily to point out their trouble location. The Nordic questionnaire (Kuorinka et al., 1987) had been extensively employed in epidemiologic studies to record symptoms and signs on major parts of the body. It has been evaluated for the reliability and validity in different studies in different group of industrial subjects in many countries over the world (López-Aragón et al., 2017).

2.3 Risk factors for WMSDs in the workplace

Being recognized as multifactorial diseases by WHO (1985), there are several risk factors contribute to initiation and exacerbation of WMSDs including physical, work organizational, psychosocial, and individual aspects. A comprehensive review of epidemiological studies determined the strong evidences between WMSDs with those risks in the workplace such as non-neutral postures, repetitive motions, forceful exertions, vibration, temperature extremes and combinations of these exposures as well as strain and other psychosocial factors that seem to be combined lead to occurrence of WMSDs (NRC, 2001; Putz-Anderson et al., 1997; Schneider et al., 2010). It is possible to consider four sets of potential risk factors in the progression of WMSDs as follow:

- Physical (also known as biomechanical) factors: forceful exertion, sustained or awkward posture, repetition of the similar motions, hand-transmitted vibration, whole body vibration, extreme cold temperatures, local contact stresses, prolonged activities and high static muscle load.
- Work organizational factors: personnel structure, work station layout, production standards, work methods, interaction with objects, work-rest cycle, job diversity, job rotation, workload, and pressure of deadline.
- Psychosocial factors: psychological demands, lack of job control, work pace, monotony or tediousness, and limited social support from colleagues and supervisors.
- Personal factors: age, gender, previous injuries or history of MSDs, anthropometric conditions, physical exercise, and life styles such as alcohol consumption, smoking, nutrition habit.

Whether or not a risk factor will lead to a WMSDs depends on the duration or the length of exposure time; the regularity or exposure frequency; and the intensity or the magnitude of the risk factor; and combinations of risk factors, since workers are exposed simultaneously to numerous risk factors on a body region in the workplace and there was evidence that the risk is increasing when the synergistic of multiple risk factors occur (Putz-Anderson et al., 1997). It is important to take this complexity or interaction into account in order to control risk factors, rather than focusing on a single risk factor. For example, when workers perform the lifting task, we should consider how heavy is the object lifted, how far over have to bend to pick it up, how long they get job, how often they lift daily and how much rest they get in…

2.3.1 Individual factors

Individual or personal risk factors contributed to or may exaggerate the occurrence of WMSDs (McCauley-Bush, 2011). Such factors could include age, gender, life style activities, endurance, anthropometry, joint degenerative diseases and previous problems of the musculoskeletal system.

Ergonomics may be especially important to pay attention to personal factors when accommodating a variety of workers. It can be useful to recognize individual factors in providing administrative controls, training programs, and awareness against WMSDs among workers at the workplace.

2.3.1.1 Age

Elderly people are more likely to suffer from aging muscular body parts. The abrasion of joints over time, the phenomenon of aging takes place leading to decreases in musculoskeletal functions, the amount of blood to feed the joint areas significantly decreases nutrient deficiency, functional impairment would affect the musculoskeletal system causing age-related degenerative disorders (i.e., osteoarthritis). The previous study from Iran suggested that growing up 1 year old would result in 3% increase of the likehood for low back pain (Biglarian et al., 2012). Similarly, a survey in Thailand of 439 furniture factory workers also concluded that aging is a risk factor for knee pain, especially for people aged over 50 years old with adjusted OR 18.49 (95% CI: 1.5 - 226.4) (Thetkathuek & Meepradit, 2018).

2.3.1.2 Gender

Female are more likely to experience MSDs than male. In 2011, the U.S. Government revealed that female were more three times prone to Carpal Tunnel Syndrome (CTS) compared to male (U.S. Department of Health and Human Services). Hormonal changes that make women more possible to suffer from CTS during pregnancy and menopause, also the differences in muscular strength, anthropometry put them at greater risk of getting WMSDs. By ultilizeing logistic regression from the data from National Health Survey of Iran, their research had proven that women are 3.05 times more likely to suffer from WMSDs pain than men (Biglarian et al., 2012). In a retrospective cohort study of Nicoletti et al. (2008), CTS in female workers was almost 3 times higher than in men (RR = 2.92; 95% CI: 1.57-5.43) stratified work groups from preparation, operating leather cutting machines, sewing to leather-covered production line.

2.3.1.3 Body mass index

Some research indicated that the high score of body mass index have been increased the risk of WMSDs. The previous study from Iran showed that overweight has aggressively impacted the development of WMSDs (Biglarian et al., 2012). In particular, their findings demonstrated that a person who is obese will have 15% more low back discomfort than a person who is not obese. A meta-analysis by reviewing various studies which indicated the association between the overweight and low back disorder, meaning that MSDs were more common in obese people than in non-obese people. The fact was similar among the fish processing worker (Nag et al., 2012), in which overweight women have a greater chance of developing in the upper back than those have BMI below 18. It can be concluded that obesity contributed the burden of low back disoders.

2.3.1.4 Smoking

Smoking was proven as a contributor to the development of low back pain, rheumatoid arthritis, sciatica, and intervertebral disk herniation due to the bone mineral loss and bone erosion. Smoking that caused the bone structure very easily to be broken, would lead to an increase in the rate of musculoskeletal injuries in the workplace (Abate et al., 2013). There is a numerous amount of experimental researches demonstrated that smoking habit associated to the development of WMSDs, especially low back pain and rheumatoid arthritis (Abate et al., 2013). These studies have reported that smoking adversely affected on the bone-forming cells production, the calcium absorption as well as reduced the blood supply to bone, broken down estrogen in the body (Abate et al., 2013). Moreover, cigarette smoking had delayed fracture and tendon healing due to the deleterious effect of nicotine (Abate et al., 2013). The results of an online survey of 6514 British adults who had smoked and 3184 who had not showed that those who had smoked in the past or were now smoking were more likely to have discomfort in any part of the body than those never smoked (K. T. Palmer et al., 2003). When compared to those who had never smoked, those who had discomfort in the previous year and were either current or former smokers were 10% to 30% more at risk of developing musculoskeletal pain. Smokers exhibited an association with low back pain, according to a survey of 25,307 Iranian women and men with low back pain (29.3%). Additionally, by controlling for factors such as age, gender, income, education level, marital status, place of residence, and obesity using logistic regression, they deduced that smokers are 40% more likely than non-smokers to experience low back pain (Biglarian et al., 2012). Similarly, the research in Thailand among furniture workers using a logistic regression model have indicted the correlation between smoker with the symptom of MSDs (Thetkathuek & Meepradit, 2018). It found that smoking tobacco workers was 2.1 times more likely than those who have never smoked.

2.3.1.5 Physical exercise

Another aspect of daily life activities outside workplace, such as sports/fitness and household chore can also pose physical stress to the musculoskeletal health. Although physical exercise is recognized to have its musculoskeletal benefits for people, there are conflicting results about physical fitness may cause injuries. The study among working population concluded that general physical exercises and sports activities had no effect on incident knee osteoarthritis and sciatic pain (Miranda, Viikari-Juntura, Martikainen, & Riihimäki, 2002; Miranda, Viikari-Juntura, Martikainen, Takala, et al., 2002). Overall, benefits of regular physical activity have been consistently and positively correlated with musculoskeletal system and cardiovascular health, but irregular or excessively heavy exercise could potentially lead to the negative consequences (Curtis et al., 2017).

2.3.2 Work organizational factors

Working in long hours than usual are more likely to develop the WMSDs in the workplace. Job schedule in woodworking alike to the other processing industries, most of manufacturing workers in Vietnam have three types of working schedule including shift work, the office hour (8:00 am - 5:00 pm) and part-time under 35 hours per week. Almost shifts have a whole 1-hour rest for lunch at noon. The cross-sectional study among processing line workers in Brazil revealed that employees in shift work especially night shift had more prevalence of lower extremity pain than those have day-shift (Barro et al., 2015). The study indicated that female have to work the night shift in extreme-temperature conditions and those who had been working longer on the same shift had 1.75 and 1.69 times, respectively higher of lower extremity pain. Meanwhile the night shift male workers reported higher prevalence of arm issue than those had day shift. A number of factors relating to workplace organization were considered to be significant with regard to WMSDs, particularly restricted rest break opportunity, limited peer contact and overtime (Nunes & Bush, 2012). It is crucial to take breaks throughout work to recover, unwind, get rid of weariness, and reduce stress because a lack of rest might result in musculoskeletal issues.

2.3.3 Psychosocial factors

Psycho-social problems may produce increased muscle tension and reduce the awareness of work practice; furthermore, the possibility of developing a musculoskeletal disorder may be occurred with tiredness, stress, job dissatisfaction and depression. Recently, there are some studies try to find the relationship between psychosocial factors and WMSDs of workers. These include high job strain or high psychological demands (Hooftman et al., 2009; IJzelenberg, Molenaar, & Burdorf, 2006), low decision latitude , low workplace social support (Bongers et al., 1993; Putz-Anderson et al., 1997).

The relationship between MSDs and psychosocial factors, such as work demands, work control, social support at work, personal traits, stress symptoms, and physical and mental health indicators, was evaluated by Bongers et al. (1993). For psychological demands and controlling in job, the author reviewed and paid attention to the monotonous work, highly focused work, high responsible work, much workload, limitation of time, less chance for break, unclear job, low control and little autonomy. The researcher revealed that the relationship between low back pain and monotonous work was proven among cross-sectional studies. The latest study indicated that several research had linked negative upper extremity symptoms to at least work-related psychological factors (Denis et al., 2008).

Additionally, the association between psychological demand, decision-making ability, social support, discomfort with complaining of WMSDs, and repetitive injuries was also investigated in a prospective cohort research. (Bugajska et al., 2013). The research used the Karasek's JCQ questionnaire (1998) to assess the psychology factors in workplace and whereby through logistic regression analysis, the author demonstrated that an increase in psychological needs and decision-making ability will lift the risk of CTS. Therefore, psychosocial factors may be used to predict the prevalence of WMSDs.

Psychosocial factors can increase the risk of injury if combined with physical risk factors, which has been confirmed by numerous research (Bugajska et al., 2013; Widanarko et al., 2014). Therefore, if psychological awareness at work is negative, physiological and psychological stress may have also detrimental reactions. Such responses can lead to physical problems; i.e. muscle or tendon strain. Otherwise, employees may have unsuitable behaviors and habits in the workplace, for example, using inaccurate working methods, using excessive force to carry out a task, or skipping the rest intervals necessary to recovery or just to reduce fatigue. Any condition could potentially cause WMSDs.

2.3.4 Physical factors

The National Institute for Occupational Safety and Health (NIOSH) announced a comprehensive review that there was adequate evidence of causal relationship between WMSDs with several physical stressors in the workplace (Putz-Anderson et al., 1997). The physical factors sometime also known as biomechanical factors include forceful exertion, high task repetition, awkward posture, vibration, or temperature extremes are widely accepted over the world. The summary of all physical risk factors for WMSDs was described as table 2.2 below.

Table 2.2 Summary of physical exposure caused WMSDs

Physical factor	Localization	Physical exposure
Awkward posture	Neck and neck/shoulder	Extreme or static posture of head/neck
	Shoulder	The angle between arm and torso increases when the arm is flexed, extended, or abducted
	Elbow	Repeated extension or flexion, pronation, supination of the wrist, either alone or in combination with flexion and extension of the elbow
	Hand – wrist	Deviations from the neutral position of hand, wrist and/ or finger-wrist extension or flexion, ulnar or radial deviance full grip, or pinch grip.
	Lower back	Unusual trunk postures (referred to bending, twisting) in inappropriate position or at extreme angles or kneeling, squatting, and stooping. Static posture relates to isometric positions that very little motion take place, in conjunction with cramped or inactive postures including prolonged standing or sitting and sedentary job.
Repetition	Neck and neck/shoulder	Cyclical or repeated neck motions or repetitive arm or shoulder movements.
	Shoulder	Cyclical abduction, rotation, extension, or flexion of shoulder joint.
	Elbow	Cyclical extension or flexion of the elbow or regular extension, flexion, pronation, or supination of the hand/wrist.
	Hand – wrist	Cyclical or repeated actions that involve either hand-finger or wrist movements (i.e., gripping,

		pinching) or extension-flexion, radial- ulnar deviation, and supination or pronation. Frequent repetitions have been determined as a cycle time less than 30 seconds or more than 50% of the task cycle spent performing the same activity (Silverstein, Fine, & Armstrong, 1987).
	Lower limbs	Cyclical or repetitive movements of kneeling, squatting or climbing, heavy lifting, carrying, or standing.
Force	Neck and neck/shoulder	Loads to the muscles of trapeze and neck
	Shoulder	Strenuous work to exert force in the shoulder
	Elbow	Strenuous activities with the forearm extensors or flexors
	Hand – wrist	Forceful manual exertions, with or without a hand tool, during manipulative task activities
	Lower back	Lifting/ forceful movement such as pushing, pulling, or other efforts.
Vibration	Shoulder	Low or high frequency hand-arm vibration
	Hand – wrist	Manual work involving vibratory power equipment or hand tools.
	Lower back	Whole body vibration refers to mechanical energy oscillations, usually transfer into the human body via a seat or a platform when performing work.
Cold environment	Hand – wrist	Exert more force than required, impacting on muscles, soft tissues, and joints. Cold environment involves gloves that have been shown to influence sensation thus resulting in greater exertion of force.

2.3.4.1 Awkward posture

Bending, twisting, lowering, stretching, extension/flexion, kneeling or squatting, and static muscle loading are examples of awkward postures (Stack et al., 2016). Awkward posture invokes to positions of some parts of the body that deviate significantly from the neutral position during the performance of work. Bending is the movement of the trunk in a forward or sideway orientation to change from the neutral posture to another position, while the vertebral column is rotated or twisted. Maintaining an awkward posture is a popular leading factor to musculoskeletal disorders (Vieira & Kumar, 2004).

Among the workers in wood processing perform manual manipulations including lifting, carrying, pushing or pulling, and even spray painting, about 44% disclosed that they had to work with their neck bending forward, 32% have a crouching position forward more than 15 degrees, and 9% of somewhat have the bending posture combined with the body rotation or bend to the side when performing their work (Christensen et al., 1995). These repetitive postures that are repeated many times would probably cause fatigue in the muscle tissues during the working day, and the neck and shoulder disorders would be extended day by day if no prompt measures.

In the study of Thetkathuek and Meepradit (2018), the ergonomic elements of arthritis tool was applied in order to assess the hazards for each factory part, this study indicated that the workers at the assembly part forcing to stand during 8 hours per day were often in a bended position had the proportion of WMSDs in thigh area higher than that of administrative workers with the odd ratio 4.90 (95% CI: 1.10 - 21.85)

2.3.4.2 Manual material handling

There are many types of adverse working conditions for example lifting height from below the knee joint to above the shoulder, having to turn or bend its position while lifting objects, manual handling in one hand, or handling in unpredictable situations. It is difficult to compare working conditions with heavy objects, these conditions can have various effects on the wrist/hand area of workers. Repetitive lifting, carrying, pushing or pulling the heavy objects such as work pieces or other objects without any supporting of apparatus/equipment is a latent risk of WMSDs. According to Christensen et al. (1995), almost half of workers working in operation and cleaning tasks at wood cutters had to regularly handle manual operations with high frequency and short work cycles would often prone to injuries while lifting materials throughout the work shift. With a high intensity of manual material handling, high daily tonnage and a small level of work diversity, especially when lifting regularly, woodworking jobs might be cause musculoskeletal symptoms in employees who would experience these matters.

The results of the ergonomic evaluation according to the checklist in the study of Nejad et al. (2013) once again revealed that the indicators of manual handling of heavy objects, design of working position and working posture have played a major role related to musculoskeletal symptoms reported in the lumbar region, knees and upper limbs.

2.3.4.3 Repetitive motion

Repetitive motion is the another contributing factor for the development of WMSDs. There was a critical review about epidemiology evidence of WMSDs from NIOSH (Putz-Anderson et al., 1997).

In the study of furniture processing industry in female sanding worker of Bovenzi et al. (2005), the use of the SI (strain index) set by Steven Moore and Garg (1995), a semi-quantitative tool based on physiology, biomechanics and the epidemiology is directly evaluated by an occupational physician and an industrial hygienist (Bovenzi et al., 2005), concluding that workers are always exposed to high frequency of repetition. Research by in Thailand also found that assembly workers often require repeated their operations without breaking time more likely to suffer symptoms of WMSDs than the administrative worker group (Thetkathuek & Meepradit, 2018).

2.3.4.4 Vibration

Human vibration exposure can be classified due to their peculiarities. Two types of vibration: (i) Whole Body Vibrations: vibrations affect the entire body that can be transmitted through working surfaces that workers sitting or standing on, particularly in a frequency range 0.5 to 80 Hz. These occupational exposures have been reported in transportation workers, such as bus and truck drivers, construction workers, etc. (ii) Hand-Arm vibration: vibrations that can be transmitted from the use of oscillatory power-tools like pneumatic hand tools or the machinery via work pieces to the hand or palm surface, especially in a frequency range from 6.3 to 1250 Hz. In furniture industry, the vibration from the handle of the vibratory machine can get transmitted to the upper limbs of the operator. It makes discomfort to the operator and lead to early fatigue. This vibration induced a range of health conditions including: white finger, Raynaud's phenomenon, carpel tunnel syndrome, sensory nerve damage, and MSDs in hands and arms. It should be noted that this classification is formal, so that both types of vibration can be exposed simultaneously. Workers exposed to hand-transmitted vibration often report on some negative health consequences and suffered from loss of touch sensation, dexterity that may interfere with their activities, thereby increasing the risk of WMSDs complaints or injuries (Krajnak, 2018).

An increase in the risk of MSDs among female workers who routinely exposed to local vibration factors in a cross-sectional study by Bovenzi et al. (2005), symptoms of white finger vibration have been recorded in only 16% of cases, meanwhile CTS is considered to be the most severe. In addition, workers who manually work with saws and cutting machines are exposed to local vibration elements in the hand arm region (Bovenzi, 1998).

In the UK, a national survey of the working-age population estimated that 1.2 million males (20.5%) and 44 thousand females (2.9%) were exposed to hand-arm vibration factors. The average dose of 8 hours is greater than 2.8 m/s^2 (K. Palmer et al., 2001)

Studying workers in a factory in Thailand, the use of drilling equipment has been linked to symptoms of neck pain, neck shoulder, forearm, elbows and hands, especially symptoms of shoulder pain with adjusted odds ratio of 4.08 (95% CI: 1.1 - 15.21) have been reported (Thetkathuek & Meepradit, 2018). The use of drilling equipment continuously for many hours in a working day is damaging to muscle and nerve tissues in a short time. However, depending on the state of health, working posture and skillful experience such as gripping the instrument too tightly, constantly twisting the fingers / hands combined with exposure to factors vibrating. The long-term set is strongly associated with the WMSDs as well as the neck and upper limb disorders.

Vibration measurement is usually quantified on all vibratory equipment and tools operated by furniture production workers. Vibration measurements are made in accordance with International Organization for Standardization (2001a).

2.4 Introduction of Ergonomics

According to definition of (International Ergonomics Association [IEA], 2000), “Ergonomics is the scientific discipline concerned with the fundamental understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance”. This term originated in the Greek ergon (work) and nomos (laws) to nominate the science of work. Within the broad discipline of ergonomics, IEA (2000) have established three domains of specialization consisting of physical ergonomics, cognitive ergonomics and organizational ergonomics.

In the occupational health field, Ergonomics is the field of study that involves evaluation of working environment, working conditions and practice of designing jobs, tools and workplaces to match the capabilities and limitations of the human body (Stack et al., 2016). The philosophy of ergonomics is to fit the jobs, tasks, tools, and workplaces to the individual, rather than making individual adapt to fit them. An important goal of ergonomics is creating a balanced work environment in which the requirements of the job in line with the worker capability so that injuries, illness, compensation claims, loss time at work, absenteeism can be reduced while productivity, health and safety, quality, job satisfaction and morale of workers can be increased (Stack et al., 2016). Once ergonomics is the science of work, it is often easy to think of ergonomic-related problems depending on the type of body system affected, one of the most positive is an increase in the likelihood of the worker developing a musculoskeletal disorder (CDC, 2018). When a worker is asked to do work that is beyond the capabilities and limitations of his body, his musculoskeletal system is put at risk. Some physical jobs are thought to have ergonomic features that make the musculoskeletal system particularly susceptible to a variety of occupational injuries and diseases. An ergonomics assessment begins with a basis evaluation of the workstation design will show that whether or not the worker's recovery system be able to keep up with the fatigue induced by performing their job. These evaluations can inform the existence of ergonomic risk factors, and if the worker exposed to the risk of musculoskeletal imbalance, musculoskeletal disorders are an inevitable and imminent reality. An ergonomics program at workplace proposes to prevent or monitor occupational injuries and diseases through the use of administrative and technical control measures to eliminate or minimize workers ' exposure to WMSDs risk factors. In some cases, personal protective equipment is also used, but it is the least effective control in the workplace to address ergonomic hazards. (CDC, 2018).

2.5 Ergonomic risk assessment methods for WMSDs

Most workers who had worked on wood and wood-based products processing have to remain permanently in the awkward posture for a long time (Björing & Hägg, 2000; Christensen et al., 1995; Mirmohamadi et al., 2004; Nejad et al., 2013; Thetkathuek & Meepradit, 2018), frequent repetitive movements, cyclical operations (Bovenzi et al., 2005; Nicoletti et al., 2008); and excessive force using, frequent with maneuvers of pressing or gripping wood-pieces during sanding and spraying paint process (Björing & Hägg, 2000; Bovenzi et al., 2005). Exposure to physical ergonomic factors in the working environment would be the cause or contribution to the occurrence of WMSDs, so that the identification of risk factors is extremely necessary for the risk assessment programs in the workplace (Andreas & Johanssons, 2018). According to the evaluation report on ergonomic methods of evaluating the exposure of WMSDs by David (2005), it is concluded that the observation methods generally provide convenience, accuracy and generalization ability, which consider adequate to the needs of occupational safety hygienists. The REBA is kind of observational methodology that developed on the basis of the Rapid Upper Limb Assessment (RULA) toolkit (McAtamney & Corlett, 1993) which is widely used to measure and assess the risks associated with physical activities in screening for musculoskeletal exposure at a level across the body, taking into account the weight of the operational burden (Hignett & McAtamney, 2000), for example, just searching for the keyword "REBA Ergonomics "On the Google Scholar system there were over 4000 results, with a relatively high intrinsic reliability reported ICC = 0.925 and an external confidence level average of IRR = 0.54 (Schwartz, Albin, & Gerberich, 2019).

2.6 Research review

Working in furniture production facilities is believed to be similar to other jobs in manufacturing industry such as forestry, milling, assembly line work. According to the report from NIOSH, WMSDs can occur in specific industries with the frequency up to three or four times higher than the overall rate (Putz-Anderson et al., 1997). High risk occupations include nursing; transportation; heavy industry such as mining; food processing; manufacturing (auto mobile, furniture, appliances, electronic products, textiles, apparel and shoe). The researchers on the WMSDs outcomes of furniture workers are primarily from cross-sectional design studies which does not allow etiological considerations, but their findings entirely suggest the significant relationship between some risk factors and WMSDs among furniture workers.

Christensen et al. (1995) investigated the musculoskeletal disorders among workers in Danish wood and furniture industry from 100 factories and reported that there was a high prevalence of 75% of the employees underwent WMSDs symptoms during the past 12 months. Author also determined that the highest proportion reported of WMSDs belonged to the lower back pain with 42% and neck-shoulder pain symptoms with 40%, in which 57% of workers complained pain, ache or discomfort at least any three different parts on the body.

Another cross-sectional study was carried out in forestry industry of Norway by using the self-reported questionnaire in connection with health checkup showed that prevalence of low back pain symptoms prolonged more than 30 days over the previous year accounted for 23.6% employees, as well as the corresponding 27.7% for neck/shoulder disorders (Hagen et al., 1998). Hagen found that there was a significant difference of neck-shoulder disorders between machine operators and administrative officers with OR = 3.37. Similarly, neck-shoulder and low-back section had higher WMSDs risk among manual workers compared to controls (administrative worker) which were 2.34 times and 1.98 times higher, respectively.

Among the wood processing duties in furniture industry, employees also have responsible for spray painting the work-piece or the final product, Björing and Hägg (2000) indicated that compared the reference material wood-workers, spray painters had higher prevalence of WMSDs symptoms followed by the right shoulder pain, wrist/hand, and elbow with 43%, 21%, and 14% respectively. However, they had significantly less symptoms in some parts of musculoskeletal system including the left shoulder, elbow, both shoulders, the foot and ankle joint(s).

Sanding or polishing is the most common task of furniture manufacturing activities. A research conducted on female workers who carried out either mechanical or hand sanding found that nearly a half of workers reported sensorineural disorders

(46%), meanwhile shoulder, neck, wrist pain accounted for 38%, 30%, and 25% respectively of furniture workers (Bovenzi et al., 2005). The authors found that there was a significant difference of CTS, peripheral sensorineural disturbances and upper-limb disorders between furniture workers and controls (female officers). Additionally, Gauthier et al. (2012) confirmed that the higher risk of WMSDs among furniture workers were exposure to ergonomic stressors in the work nature compared to controls.

Mirmohamadi et al. (2004) used the Quick Exposure Check (QEC) assessment method and Nordic questionnaire to study the incidence of WMSDs in a furniture producing facilities, workers from multiple work groups were observed and videotaped. The results showed high incidence of MSDs which included back pain (50%), knee (48%), and neck pain (24%).

Nejad et al. (2013) carried out a study on furniture workers in Iran, used direct observation checklist to evaluation the ergonomic working aspects in the workplace. Prevalence of musculoskeletal symptoms were screened by the Nordic self-administered questionnaire during the past 12 months. The results showed that knees, lower back and wrists/hands were three most prevalent disorders with 39%; 35.6%; and 29.5% respectively. Working posture, manual material handling, and improper workstation design were significantly associated with those reported disorders.

Most recently a study with the cross-sectional design on WMSDs in a furniture factory in Chachoengsao province of Thailand (Thetkathuek & Meepradit, 2018) showed shoulder pain was the most common symptom which were reported with 53.9%, especially 39.6% of those complained in both shoulders. Author also indicated that the highest reported of WMSDs symptoms were revealed in the drilling workstation with 62%, followed by edging workstation with 60.8%.

Table 2.3 WMSDs and risk factors among furniture workers reported in the reviewed papers

<table>
<tr><th rowspan="2">Author</th><th rowspan="2">Country</th><th rowspan="2">Population</th><th rowspan="2">Size</th><th rowspan="2">Study design</th><th colspan="6">Prevalence over the previous 12 months (%)</th><th rowspan="2">Assessment tools</th><th rowspan="2">Risk factors</th></tr>
<tr><th>Overall</th><th>Neck</th><th>Shoulder</th><th>Back</th><th>Hand/ wrist</th><th>Knee</th></tr>
<tr><td>Christensen et al. (1995)</td><td>Denmark</td><td>Woodworking, painting workers</td><td>281</td><td>Cross-sectional study</td><td>75</td><td colspan="2">40</td><td>42</td><td>-</td><td>-</td><td>SNQ; observation survey with videotaping</td><td>Repetitive work with short cycle time, manual handling</td></tr>
<tr><td>Hagen et al. (1998)</td><td>Norway</td><td>Manual workers; machine operators; administrative workers</td><td>835</td><td>Comparative study</td><td>-</td><td colspan="2">27.7</td><td>23.6</td><td>-</td><td>-</td><td>SNQ; Karasek’s demand/control questionnaire</td><td>Psychological demand; intellectual discretion</td></tr>
<tr><td>Björing and Hägg (2000)</td><td>Sweden</td><td>Spray painters (compared with other manual workers)</td><td>35</td><td>Cross-sectional study</td><td>-</td><td>25</td><td>43 (right side)</td><td>46</td><td>21 (right hand)</td><td>18</td><td>SNQ; postural measurement with angle transducer, goniometer; measuring tape for height of table, piles of work piece</td><td>Abduction the right upper-arm; gripping the spray gun trigger</td></tr>
<tr><td>Mirmohamadi et al. (2004)</td><td>Iran</td><td>Furniture unite workers</td><td>500</td><td>Cross-sectional study</td><td>-</td><td>24</td><td>17</td><td>50</td><td>23</td><td>48</td><td>Nordic questionnaire; QEC method</td><td>Workgroup</td></tr>
</table>

Author	Country	Population	Size	Study design	Prevalence over the previous 12 months (%)						Assessment tools	Risk factors
					Overall	**Neck**	**Shoulder**	**Back**	**Hand/ wrist**	**Knee**		
Bovenzi et al. (2005)	Italy	Female workers	100	Cross-sectional study	CTS 19%	30	38	-	25	-	Vibration Injury questionnaire; accelerometer; checklist, strain index	Vibration exposure; Ergonomic stress
Nejad et al. (2013)	Iran	Workshop employee	410	Cross-sectional study	-	18.3	22.7	35.6	29.5	39	Self-administered questionnaire; working condition checklist.	Manual material handling; poor workstation and awkward posture
Thetkathuek and Meepradit (2018)	Thailand	MDF furniture workers	439	Cross-sectional	-	32.2	53.9	37.5	37.8	33.1	SNQ; ergonomic assessment for arthritis technique	Age; working seniority; work department; smoking and heat exposure.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Study design

The cross-sectional study was conducted in a wooden furniture production factory at Binh Duong Province of Vietnam from June 2020 to December 2020.

The study consisted of three main parts: The first was an interview for investigating the prevalence of WMSDs symptoms and several background factors with the structured questionnaire. The second part was a distribution of self-reported survey form among workers to collect information on the psychosocial factors by themselves. The third part was a walk-through survey inside the factory to explore the physical risk factors by a checklist, an observation tool and a hand-transmitted vibration measurement.

Inclusion and exclusion criteria

Participation was completely voluntary and authorized by the employer. The selection criteria included age of the respondents from 18 to 65 years old and their current work position must be hold for at least twelve months before research implement.

Participants were disqualified if they suffered from scoliosis; musculoskeletal deformities; or had history of rheumatologic disease. Pregnant women and persons with disabilities were rejected from the study. Workers felt uncomfortable answering or desired to withdraw from study anytime during the research period.

3.2 Sample size of the study

The number of participants was calculated based on formula for sample size estimation for a population proportion:

$$n = Z^2_{1-\frac{\alpha}{2}} \frac{p\ (1\text{-}p)}{d^2}$$

Where:

p: Using proportion of WMSDs among workers from the previous study.

n: Sample size of workers

d: Relative error

Given α = 0.05, $Z^2_{1-\frac{\alpha}{2}}$ = 1.96, d= 0.05

Acording to the previous study in China (Liu et al., 2014), the overall prevalence of WMSDs among the furniture industry workers was 26.6%. The estimated sample size for simple random sampling was 301 participants. When sampling is from a finite population (Daniel & Cross, 2018), we reduced the sample size:

$$n_f = \frac{n}{1 + \frac{n}{N}} = \frac{301}{1 + \frac{301}{695}} = 210$$

Where:

n: numbers of sample size of simple random sampling above

N: total population of workers in factory

n_f: estimated sample size after adjusted for size of population

To avoid dropout, the sample size increased by 10% of the attrition rate and the total sample size was 231 participants for the study.

3.3 Sampling technique

The sampling technique used was convenience sampling with the proportional stratified random method based on the list of departments supplied by the factory. We divided the ratio according to the proportion of the population in each department with the required sample size of workers, then randomly invited participants for each department until the sample size was sufficient. Those departments were different from each other according to its required product like table, chair, sofa, toilet chair... However, they have the same personnel structure including forming operator, cutter, sander, assembler, painter, upholster, packager and quality controller.

Table 3.1 The sample size located for every department

No	Name of department	Population	Actual sample
1	Moulder	73	18
2	Line A	92	32
3	Line B	71	19
4	Line C	70	28
5	Line D	61	21
6	Line Sofa	55	19
7	Line Toilet chair	45	17
8	Line Table Top	80	28
9	Line Sewing	30	10
10	Quality Product	14	5
11	Warehouse	43	15
12	Line Accessories	61	19
	Total	**695**	**231**

3.4 Data collection

The interview was carried out at the same time as the annual health checkup course taking place at the factory during three days in November 2020, the investigation team consisted of the main researcher and physicians from Institute of Public Health Ho Chi Minh City interviewed the participants by the structured questionnaire consisting of investigating symptoms of musculoskeletal disorders in the regions of their body as well as some demographic characteristics of participants, their lifestyle, working history, and the organizational factors. The collection finished within three days' allowance by factory permission, 231 subjects were investigated. Due to avoiding of crowded gathering that could increase the risk Covid-19 transmission, the personnel manager arranged each participant according to a fixed time frame to maintain social distancing and forced them to wear a mask during the interview. After finishing the interview, the interviewer issued a self-reported questionnaire on psychosocial factors for the subject, instructions for answering and making an appointment to collect the questionnaire. All filled questionnaires were collected by a human resource officer at the health care station of their factory. Finally, the walk through survey team included the main researcher and one assistant carried out the field survey at the factory to collect the physical exposure data within two days in December 2020. We measured and observed some characteristics of the physical stressors as well as the working environment including awkward postures, manual handling, repetition, vibration exposure by the checklist and REBA tool for all participants took part in the interview. The hand-arm vibration exposure level was also measured by the hand-transmitted vibration meter in different hand-held tools or hand-fed machine, the measurement was performed on the handle of the vibratory tools or at the surface of work-piece that contacting with hands of worker. There were total 6 kinds of operations related with HAV exposure including: operating with orbital sanders; edge sanders; drilling; screwing; upholstering; and paint spraying. Specifically, in term of sanding activities, there were 2 types of hand-held tool exposed to hand-transmitted vibration. Frist called orbital sander, and second was the type of hand-fed machine involved belt sanding machine called the edge sanding (exposure to HAV via work-piece). After data collection, the data cleaning process was done manually by identifying errors, mistakes, duplicate data then correcting or adding more information in order to validate data accuracy.

Figure 3.1: Two types of sanding exposure to vibration

Figure 3.2: Performing task with drilling and screwing

Figure 3.3: Performing task with upholstering and paint spraying

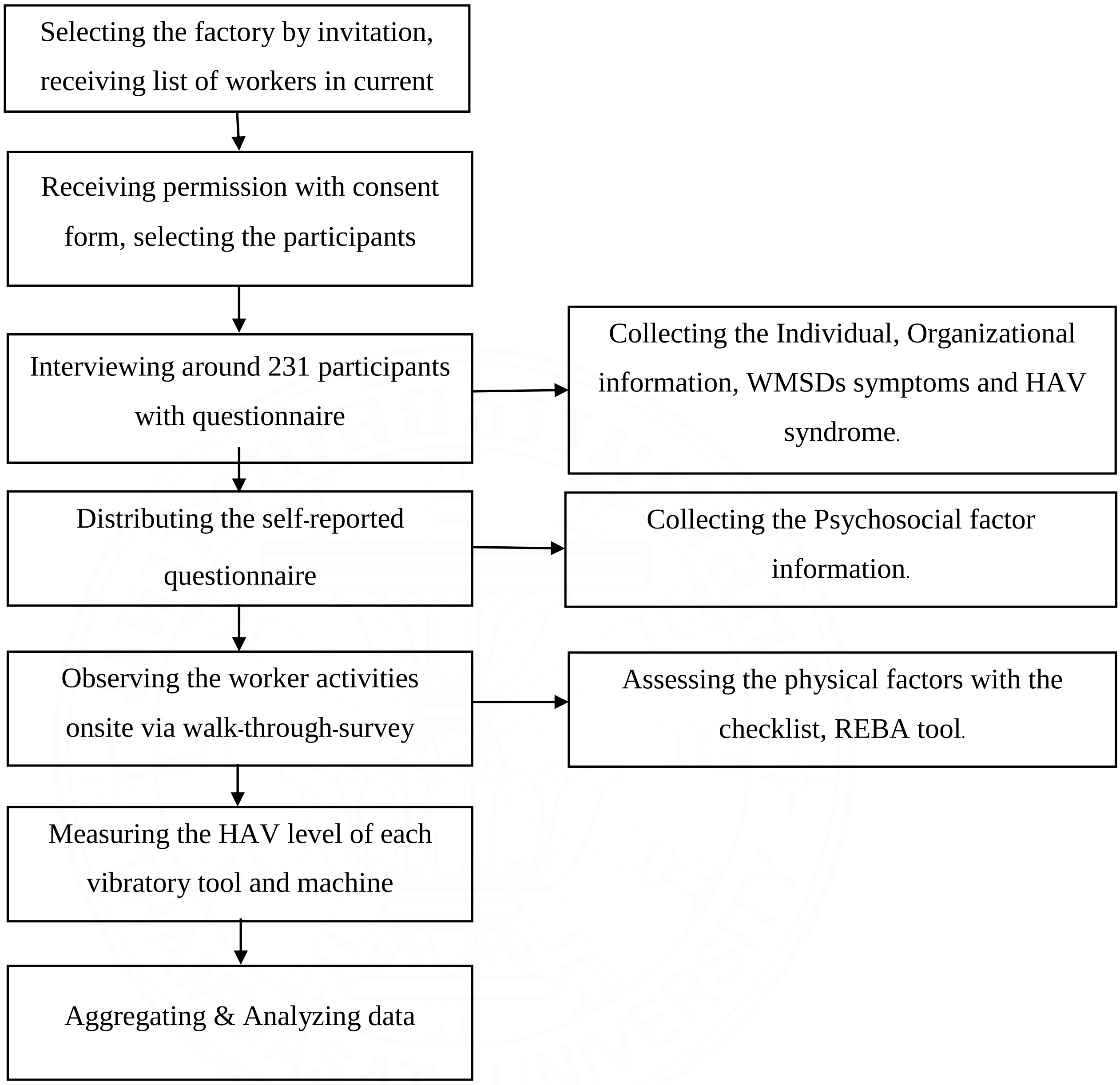


Figure 3.4: **The flow-chart of collecting data**

3.5 Material and measure tools

3.5.1 Questionnaire

There were two kinds of questionnaire in this study.

3.5.1.1 The structured questionnaire

This questionnaire consisted of four sections, in which the first section contained the individual characteristics; the second part was the work organization information; the third section was adapted from the Standardized Nordic questionnaire (Kuorinka et al., 1987) used for the screening of musculoskeletal disorders symptom; and the last section was hand arm vibration syndrome investigation. The participants were interviewed face to face through the annual health check-up course taking place at the factory.

- Part 1: Individual characteristics including: gender, age, BMI, current smoking status and total years of continuous smoking, alcohol consumption habit and consumption level of drinking, sport or physical exercise habit and its frequency, information regarding the past musculoskeletal disorders (injury history, treatment history); their work experience and their tenure at this factory.

- Part 2: Organizational factors included questions following: job title, working time, average working hours per day, frequency and duration of taking a break during a shiftwork, and occupational safety training attendance when starting the job.

- Part 3: This section was adapted from the Standard Nordic Questionnaire, that consisted of the WMSDs symptoms such as ache, pain, numbness, or discomfort during the previous 12 months in the following nine regions: neck, shoulders, elbow, wrists/hands, upper back, lower back, hip and thigh**,** knee, ankle/feet. For each body part, the score was categorized as a dichotomous variable consisting of two values: no symptom and have any symptoms such as ache, or pain, or numbness, or discomfort. Besides that, information on WMSDs symptoms within the last 7 days also was recorded to discover the pattern for the proposed intervention, awareness of where the cause came from at workplace or outside of work, and level of uncomfortable/ pain intensity if experienced those symptoms in the last 12 months. The numerical rating scale was utilized to access level of uncomfortable/ pain intensity, in which the score ≤ 3 correspond to mild, 4-6 to moderate and ≥ 7 to severe level (Boonstra et al., 2016).

This Nordic questionnaire had been proven to be both reliable and valid (Crawford, 2007; López-Aragón et al., 2017). It had already translated into Vietnamese according to Technical regulations in Occupational health and Environment 2015 of National Institute for Occupational & Environmental Health in Vietnam.

- Part 4: Hand-arm vibration syndrome questionnaire consisted of questions about white symptoms on cold exposure, regularity, symptoms after 20 minutes using vibrating tools, wake at night by syndrome. This section was used to investigate the employees who performed the vibrating instrument/ tool such as vibratory tools or hand-fed machines.

3.5.1.2 The self-reported questionnaire

This questionnaire was dispatched into every participant after carefully explained the instructions, then they had to answer by themselves with respect to privacy. After that, the completed questionnaire was gathered on the following day at the factory health-care station.

This questionnaire regarding psychosocial exposures in the current workplace was utilized the Vietnamese version of Karasek's job demand-control- support model (Karasek et al., 1998), that included of five conceptual dimensions: Psychological demands; Decision latitude – Authority; Skill discretion; Decision latitude – autonomy; Social support from supervisor and colleagues. For each question there are four responses using a 4-point Likert scale with the choice 1: Strongly disagree; 2: Disagree; 3: Agree and 4: Strongly agree. All items in the questionnaire had already been validated in Vietnam by Hoang et al. (2013). The internal consistency of all five sub-scales was estimated by Cronbach's alpha test (α) with 30 pilot samples. The 9 questions on psychosocial demand reflected cognitive requirements, time pressure, working hard, working pace, intense concentration, and conflicting demands ($\alpha = 0.61$); the 4 questions on decision authority included aspects such as ability of engaging in the decision making process, the process of works and the sequence of tasks ($\alpha = 0.85$); the 9 questions on decision autonomy regarding to capacity of managing and controlling the chronology of task performance such as set time to start and pause when needed, influence on work speed ($\alpha = 0.88$); the 5 questions on skill discretion involved the self-esteem for using skill to employ, developing new skills, required creativities, and repetitive activities when perming the work ($\alpha = 0.68$); and the 8 questions on social support reflected social emotional integration and assistance from supervisor and peers, ($\alpha = 0.89$). Values for Cronbach's alpha range from 0.61 to 0.89, exhibiting acceptable for instrument validity.

During analyzing the psychosocial factors, the aforementioned five conceptual dimensions were converted into three main dimensions: psychosocial demand; job control (summary of decision-latitude authority, decision-latitude autonomy and skill discretion scores), and social support. Based on the frequency distribution, each of three dimensions were calculated for the median score representing as the cut-off to divide the subjects into Karasek's job strain quadrants (Karasek et al., 1998). If any worker has more than or equal to the median score designated as "high", while worker who has less than the median value designated as "low".

At first using the demand-control model, subjects were classified into 2 groups with the first group, called the "no-strain" job, is characterized by low demand and high control; high demand and high control; low demand and low control. The second was "strain" job had characterized by high demand and low control.

Finally, transferring into the demand-control-support model, workers were arranged into 4 groups as followed having: 1. no-strain & high social support jobs; 2. no-strain & low social support jobs; 3. strain & high social support jobs; and 4. strain & low social support jobs.

3.5.2 Assessment tool of physical factors

In order to assess adequately the physical exposures in the working environment, many authors have proposed combining at least 2 sets of evaluation tools to achieve full detection of WMSDs risk levels (Punnett & Wegman, 2004). In the study, we simultaneously used both a physical checklist and an observational tool to collect the physical factors based on every worker's main task.

3.5.2.1 Physical risk factors checklist

The physical risk factors checklist was adapted from Washington State 's hazard and caution zone checklist. This screening tool was designed to evaluate tasks/jobs with high potential for causing WMSDs in the following four main categories: awkward working posture, manual handling, excessive repetition, and hand-arm vibration exposure.

In this checklist, we interviewed directly the participants in their work position and observe their task performance for each participant. We recorded the most common or the worst case scenario among them.

3.5.2.2 Observational Assessment Tool (REBA)

The observational assessment tool in the current study was Rapid Entire Body Assessment as a systematic technique to evaluate postural musculoskeletal disorder of the whole body of all participants. This ergonomic assessment tool was developed by Hignett and McAtamney (2000) to evaluate primary awkward body posture in which combining with forceful exertions, type of movement or action and coupling in the workplace for a shift work. REBA also assessed biomechanical and postural loads including the positioning of the neck, trunk and leg, arm and wrist, angulations of the joints, degree of movement, weight of load handling or power grip.

The evaluator interviewed the workers in advance to clarify the job tasks and initially observed the movements and postures during a couple of work cycles. Then the photos capturing all postures of employees during working were recorded. Pictures of all workers performing their work were obtained. Selecting the postures to be assessed based on criteria in order of priority as following: 1. The most difficult postures and work tasks or 2. The posture where the highest force load occurs. In the study, we prioritized the most strenuous postures during work performance with either the right or left side of the body in which represented the worst-case or greatest exposure to MSDs risk.

The basic principle is that the body is divided into two groups A and B. Group A includes all 60 combined postures of the body, neck and legs. After adding the force / load factor, Group A reduced to 9 points remaining. Group B includes all 36 poses for forearms, arms and wrists, after adding a combined point, Group B draw down to 9 ability points. The two groups combined produce the REBA score. Based on the final score, the working posture of workers was assessed for risk level of MSDs risk and direction of action resolved. The final score was categorized into four groups as table below:

Table 3.2 Assessment of MSD risk level by REBA

REBA score	Risk level	Action
≤3	Low	May be necessary change
4 -7	Medium	Further investigate, change soon

8 - 10	High	Investigate and implement change
≥ 11	Very High	Implement change immediately

3.5.2.3 Hand-arm vibration exposure

(1) Hand-arm vibration exposure measurement

The hand-arm vibration was measured by the hand-transmitted vibration meter, that employed by 2 technicians from Institute of Public Health of Vietnam. The institute fully satisfied the requirements of provisions on working environment measuring and examining units according to Circular No.19/2011/TT-BYT on guiding the management of labor hygiene, laborers' health and occupational diseases.

In the study, Svantek 106 Human Vibration Meter & Analyser (Poland) was used as digital vibration level meter with 1/3 octave real time analysis. The device met with the ISO 8041-1 (2017) specifications for hand-arm vibration measuring instruments in the frequency range depending on the parameters of the attached accelerometer.

Figure 3.5. Svantek 106 – vibration measuring equipment

Hand - transmitted vibration measurement and evaluation complied with the detailed guidance given in ISO 5349-1:2001 and ISO 5349-2:2001 standards.

Measurement of vibration magnitude was performed on the handle of the vibratory tools with the recommended mounting location for each type of hand-held tool that given in ISO 5349:2001-Part 2: Practical guidance for vibration measurement at workplace. The location of the transducers was located as close as possible to the halfway along the gripping zone length, minimized the interfering with the normal activities of the operator. The magnitude of vibration was expressed as the vibration acceleration (m/s^2). The measuring time for each sample was 1 minute for each measurement. If the machine or tools are held by two hands, both hand locations were measured and the highest value was picked up for vibration exposure calculation. The hand-arm vibration was measured on six types of hand-held tools including: orbital sander, edge sander, pistol drill machine, screwdriver, upholstery stapler and paint spray gun. Each tool was measured three times for calculating the average total vibration value (a_{hv}).

According to standard practices, the basicentric coordinate system adopted and vibrations transmitted to the hand-arm were measured in three axis directions simultaneously (x, y, z) according to an orthogonal coordinate system as defined in ISO 5349-1:2001. X-axis is perpendicular to the palm, y-axis is parallel to the handle of equipment, while z-axis is perpendicular to the handle of equipment. The frequency-weighted acceleration values for the x-, y- and z-axes can be obtained from the 1/3 octave band frequency spectra analysis with 24 weighting factors ranged from 6.3 to 1250 Hz by using equation as follow:

$$a_{hw} = \sqrt{\sum_i (W_{hi} a_{hi})^2} \quad (1)$$

Where W_{hi} = the weighting factor for the *i* th one-third-octave band;

a_{hi} = the measured acceleration for the *i* th one-third-octave band.

Then, according to ISO requirements, the total vibration acceleration a_{hv} were obtained by integrating three frequency-weighted values for the x, y, z axes. The total vibration acceleration a_{hv} were obtained by this following formula (2):

$$a_{hv} = \sqrt{a_{hwx}^2 + a_{hwy}^2 + a_{hwz}^2} \quad (2)$$

Where a_{hv} = total acceleration value or hand-arm vibration level, in m/s^2

a_{hwx} = weighted acceleration along measurement axis x_h in m/s^2

a_{hwz} = weighted acceleration along measurement axis z_h in m/s^2

a_{hwy} = weighted acceleration along measurement axis y_h in m/s^2

The result of each operation or vibratory tool was presented following the form in Appendix E.

(2) Hand-arm vibration exposure calculation

The daily exposure to hand-transmitted vibration calculation was conducted according to the recommended ISO 5349-1: 2001 Standard. The daily vibration exposure was estimated for an employee performing a process or operating one equipment can be calculated from vibration magnitude and exposure duration, expressed in term of the 8-hour energy-equivalent frequency-weighed vibration total value A[8], as using the equation (3):

$$A[8] = a_{hv}\sqrt{\frac{T}{T_0}} \qquad (3)$$

Where a_{hv} is the vibration total value of frequency-weighed acceleration or the vector sum of three measured axes of vibration (m/s^2);

T is the daily duration of exposure to the vibration magnitude a_{hv};

T_0 is the reference duration of eight hours.

If the operator performs several operations with different hand-held tools, then the daily vibration exposure shall be estimated using equation (4):

$$A[8] = \sqrt{\frac{1}{T_0}\sum_{i=1}^{n} a_{hvi}^2 T_i} \qquad (4)$$

Where a_{hvi} is the vibration total value for the *i* th hand-held tool (m/s^2);

n is the number of individual vibration exposures;

T_i is the duration of the *i* th operation.

Before calculating the daily vibration exposure A[8], the vibration total magnitude for each type of hand-held tool was obtained calculated from equation (2). The daily duration of exposure to the vibration from each tool being used was determined by interviewing the workers with the physical checklist. Almost operators have used a hand-held machine or hand-fed machine to remove large amounts of material over several hours so that the work pattern can be considered as continuous exposure to vibration. It was estimated the time representing the working day by asking them how much time they performing their operation with each machine or tool.

After the daily vibration exposure calculation, in order to categorize the risk level with the current standard, the 8-hour energy-equivalent frequency-weighted acceleration A[8] for each operator was compared with the recommended standard (action value = 2.5 m/s^2 and exposure limit = 5 m/s^2) of the American Conference of Governmental Industrial Hygienists (ACGIH, 2018)**.**

3.6 Validity and reliability of the research tools

3.6.1 Questionnaire and checklist control

In order to certain the validity and reliability, the questionnaire and the structured checklist were sent for approval from experts. The expert team included one physician and one lecturer specializing in either occupational medicine or public health. After receiving two Vietnamese and English version translations of the questionnaire, the expert team amended and verified the structure, the contents and the appropriateness of the adapted questionnaire and the checklist to confirm validity.

The questionnaire and checklist were pre-tested with 30 workers from different factory in order to find out any problems during the interviews.

3.6.2 Hand-Arm vibration meter

To ensure quality monitoring, the Human vibration meter & analyzer must be calibrated by the hand-held tool called vibration calibrator at two frequencies 80Hz and 160Hz before conducting the study.

Besides that, the periodic calibration had been conducted annually by the independent testing agency of calibration accuracy. The certificate of the instrument calibration is presented in appendix F, and is considered valid from April 1st 2019 to April 1st 2020.

3.6.3 Bias control

Before conducting the investigation on large scale, a pilot survey was implemented for considering potential problems, obstacles may occur.

Understanding the operation situation of the factory, contact the representative for the specific schedule.

Team of interviewers mainly physicians of Institute of Public Health. Interviewers were trained thoroughly on how to guide the subjects answered independence, emphasizing the seriousness and the benefits of research to bring in order to increase the accuracy of information.

During data collection, the questionnaires, after being retrieved, were immediately coded and re-checked whether they have been completed or not to avoid losing information.

After data collection, the data entry process be done carefully.

The self-reported questionnaires were dispatched to the participants who bring home to fill out. We made an appointment to collect the questionnaire and fully explain the subjects about benefits, interests by emphasizing the importance of the research, the participant could contact the researcher by phone if there were questions about the question.

3.7 Variable definition

3.7.1 Independent variable

Individual information: gender, age, BMI, current smoking status and total years of continuous smoking, alcohol consumption habit and consumption level of drinking, physical exercise habit and its frequency, information regarding past musculoskeletal disorders (injury history, treatment history), work experience, work tenure at this factory.

Organization factors: job title, workstation or department, working time, average working hours per day, and frequency and duration of taking a break during a shiftwork, participation in occupational safety training.

Psychosocial factors: decision latitude – authority, skill discretion, psychosocial demands, decision latitude – autonomy, social support at work.

Physical factors: awkward posture, manual material handling, repetitive motion, hand-transmitted vibration exposure.

3.7.2 Dependent variable

Work-related musculoskeletal disorder symptoms during the previous 12 months in the following 9 body regions: neck; shoulder; elbow; wrists or hands; upper back; lower back; hip or thigh; knee; and ankle.

Table 3.3 Definition of study variables

Category	**Variables**	**Definition**	**Data type**	**Collection**
Individual factors	Age	from year of birth to 2020	Continuous	Interview
	Gender	Male Female	Binary	Interview
	BMI	Non overweight: < 25 Overweight: ≥ 25	Nominal	Interview of height and weight Calculation
	Smoking habit	Never smoke Occasionally smoke Smoking daily Used to smoke but quit	Nominal	Interview
	Smoking duration	Number of years smoking	Continuous	Interview
	Drinking alcohol consumption	Never Once time or less per month 2 to 4 times per month 2 or more times per week	Nominal	Interview
	Level of drinking alcohol per time	Number of units (1 standard cup is equivalent to 120 ml beer bottle or 30 ml cup of spirit wine)	Continuous	Interview
	Physical exercise	Yes No	Binary	Interview
	Exercise frequency	Number of days per week	Continuous	Interview
	Exercise intensity	Vigorous Moderate	Nominal	Interview

		Light		
	History of injury/surgery	Yes No	Binary	Interview
	Work experience	Number of years working	Continuous	Interview
	Tenure at this factory	Number of years working at this factory	Continuous	Interview
Work organization factors	Title job	Quality control (QC) Moulder (cutter) Forming operator Sander Assembler Painter Packing operator Sewer Loader/ Warehouse keeper	Nominal	Interview
	Department	Moulder Line A Line B Line C Line D Line sofa Line toilet chair Line table top Line sewing Line accessories Quality control Warehouse	Nominal	Interview
	Working hours daily	number of hours	Continuous	Interview
	Type of work schedule	Standard business day Shift work Part time	Nominal	Interview
	Time for rest daily	Number of minutes	Continuous	Interview
	Break times daily	Number of breaks during working time	Continuous	Interview
	Attendance in occupational	Yes No	Binary	Interview

	safety training before starting the job			
Psychosocial factors	Psychological demands	High Low	Binary	Self-report Questionnaire, Calculation
	Decision latitude - Authority	High Low	Binary	Self-report Questionnaire, Calculation
	Decision latitude – Autonomy	High Low	Binary	Self-report Questionnaire, Calculation
	Skill discretion	High Low	Binary	Self-report Questionnaire, Calculation
	Social support	High Low	Binary	Self-report Questionnaire, Calculation
	Job strain quadrants	1. No-strain + high social support jobs 2. No-strain + low social support jobs 3. Strain + high social support jobs 4. Strain + low social support jobs	Nominal	Calculation
Physical ergonomic factors	**Awkward posture**			
	Hand(s) above the shoulder height	Yes No	Binary	Interview and observation checklist
	Repeatedly raising or working with the hand(s) or the elbow(s) above the shoulder height more than once time per minute	Yes No	Binary	Interview and observation checklist
	Neck twisted or side bent	Yes No	Binary	Interview and observation checklist

	Back bent or twisted	Yes No	Binary	Interview and observation checklist
	Kneeling or squatting	Yes No	Binary	Interview and observation checklist
	Static posture if at least one body positions are held for longer than 1 minute	Yes No	Binary	Interview and observation checklist
	Manual material handling			
	The most strenuous activity for manual handling of heavy loads	Lifting Carrying Pushing & Pulling	Nominal	Interview and observation checklist
	The average weight of loading	Light (<5kg). Moderate (5-10 kg). Heavy (11 – 20 kg). Very heavy (>20 kg).	Nominal	Interview and observation checklist
	Squeezing an unsupported object weight ≥1 kg per hand; or using a force of ≥2 kg	Yes No	Binary	Interview and observation checklist
	Gripping an unsupported object weight ≥5 kg per hand; or using a force of ≥5 kg	Yes No	Binary	Interview and observation checklist
	Repetitive motion			
	Repeating the similar motion or minor range action with more than 4 times per minute	Yes No	Binary	Interview and observation checklist

	Hand-transmitted vibration exposure			
	Exposure to vibration machine or hand-held tool	Yes No	Binary	Interview and observation checklist
	Daily exposure duration for the main operation	Number of hours for exposure to the main or 1st vibratory tool/machine	Continuous	Interview
	Daily exposure duration for the second operation	Number of hours for exposure to the next or 2nd vibratory tool/machine	Continuous	Interview
	Daily exposure duration for the extra operation	Number of hours for exposure to the extra or 3rd vibratory tool/machine	Continuous	Interview
	Daily vibration intensity	Below the action value (< 2.5 m/s^2) From 2.5 m/s^2 to 5 m/s^2 Over the limit value (>5 m/s^2)	Nominal	Measuring and calculation
Work-related Musculoskeletal disorders	Musculoskeletal symptoms in the previous 12 months and the previous 7 days in the following nine body parts	Neck	Binary	Interview
		Shoulder	Binary	Interview
		Elbow	Binary	Interview
		Wrist/ hand	Binary	Interview
		Upper back	Binary	Interview
		Lower back	Binary	Interview
		Hip and thigh	Binary	Interview
		Knee	Binary	Interview
		Ankle	Binary	Interview
	Prevalence of WMSDs	At least one body part had any symptom during the past 12 months 1. With 2. Without	Binary	Calculation

	Awareness of the pain came from	At work Outside of work Don’t know	Nominal	Interview
	Level of uncomfortable or pain	Numerical rating pain scale	Continuous	Interview
Hand-arm vibration syndrome	The fingers gone while on cold exposure (blanching) while working	Yes No	Binary	Interview
	The regularity of HAV	Several times a year Several times a month Several times a week Everyday	Nominal	Interview
	Numbness or tingling more than 20 minutes after using vibrating equipment	Yes No	Binary	Interview
	HAV at any other time	Yes No	Binary	Interview
	Wake at night due to HAV syndrome	Yes No	Binary	Interview

3.8 Statistical analysis

The data was entry by Epidata software version 3.1. The statistical analysis was carried out by using the IBM Statistical Package for Social Sciences software with version 22. Descriptive statistics were conducted for all subjects, these descriptive data.

The association between all independent variables and WMSDs was explored by bivariate logistic regression analysis between each of independent variables (individual factors, organizational factors, psychosocial factors, and physical factors) with the outcome (prevalence of WMSDs), prevalence of low back, and hand/wrist regions. After adjusting for potential confounding factors like gender and age, multiple logistic regressions with a back stepwise method were used to identify the significant factors related with the prevalence of WMSDs, low back, and hand/wrist disorder.

The statistical significance level was set at a *p*-value lower than 5% ($p<0.05$). The relationships between risk factors and outcomes in our study was displayed by the crude odds ratio (*OR*) and adjusted odds ratio (a*OR*) with corresponding 95% Confidence Interval (*CI*).

3.9 Research ethic

This study was approval by the Ethical Review Sub-Committee Board for Human Research Involving Sciences, Thammasat University, No. 3 [No:67.04.2/(EC3)475] Project code 029/2563 dated 23 June, 2020].

CHAPTER 4
RESULTS AND DISCUSSION

4.1. The Results

The goal of the study is to determine the prevalence of WMSDs among furniture makers in a Vietnamese province called Binh Duong and to investigate potential risk factors for WMSDs.

4.1.1 General information

4.1.1.1 Individual characteristic of participants

Table 4.1 Demographic background of participants in the furniture factory

Characteristics			Frequency	Percentage (%)
Age (years)				
		Mean ± SD (range)	**35 ± 7.24 (19 – 57)**	
		Below 30	59	25.5
		From 31 to 40	122	52.8
		From 41 to 50	45	19.5
		Above 50	5	2.2
Gender				
		Male	137	59.3
		Female	94	40.7
BMI				
		Mean ± SD (range)	**22.15 ± 2.74 (14.7 – 17.6)**	
		Under weight	12	5.2
		Normal	184	79.7
		Overweight	35	15.2
Smoking				
		Never	144	62.3
		Occasionally	19	8.2
	Duration of smoke	Mean ± SD (range)	**7.52 ± 1.4 (1 – 24)**	
		Daily	53	22.9
	Duration of smoke	Mean ± SD (range)	**11.64 ± 0.8 (2 – 30)**	
		Used to but quit	15	6,5
	Duration of smoke	Mean ± SD (range)	**6.13 ± 0.7 (2 – 10)**	
Drinking alcohol				
		Never	102	44.2
		Once time per month	51	22.1
		2 to 4 times per month	65	28.1
		2 or more times per week	13	5.6

Drinking level per time (cups)	Mean ± SD (range)	**4.4 ± 5 (1 – 10)**	
Do exercise per week (days)		63	27.3
	Mean ± SD (range)	**3.7 ± 2.5 (1 – 7)**	
Exercise intensity			
	Light	35	55.5
	Moderate	16	25.4
	Vigorous	12	19.1
MSDs history			
	Have had injuries or surgery before	21	9.1
Working experience (years)			
	Mean ± SD (range)	**9.1 ± 3.54 (1 – 16)**	
	≤ 2	9	3.9
	3 - 5	29	12.6
	6 - 10	121	52.4
	≥ 11	72	31.2
Job tenure (years)			
	Mean ± SD (range)	**5.8 ± 3.5 (1 – 16)**	
	1 - 10	211	91.3
	≥ 11	20	8.7

The table 4.1 shows the demographic characteristics of furniture workers in Vietnam. Their average age is 35 years old with the largest group of age from 31 to 40 (52.8%). Most of them are male (59.3%). According to the BMI classification, only 15.2% of participants belongs to the overweight group (BMI ≥25). Their average work experience was 9.1 ± 3.54 years. Only 9.1 % of the participants reported that they had the musculoskeletal injury before at least 2 years ago.

4.1.1.2 Work organization characteristic of participants

Table 4.2 Workplace organizational description

Characteristics		**Frequency**	**Percentage (%)**
Job title			
	Quality Controller	43	18.6
	Moulder / Cutter	14	6.1
	Forming Operator	17	7.4
	Sander	57	24.7
	Assembler	25	10.8
	Painter	30	13
	Packager	30	13
	Upholster	8	3.5
	Loader	7	3

Working time		
8 hours	85	36.8
10 hours	88	38.1
12 hours	58	25.1
Type of schedule		
Office hour	152	65.8
Shift	79	34.2
Work Injury Prevention Education and Safety Training program		
Not Attended	116	50.2
Attended	115	49.8

The demension of work arrangement among furniture workers is seen in Table 4.2. According to the classification of the job title as well as the main task of the participant, the sander group accounts for the highest proportion (24.7%), followed by quality inspectors (18.6%), assemblers (10.8%), painters and packers (13%), and the last position is the loader with the least proportion (3%). Most workers mainly work in the time frame of office workday (65.8%) with average working time per day of 10 hours accounting for the highest proportion (38.1%). The study also finds that the percentage of workers participating in training of occupational safety and injury prevention program before starting the job at the factory is only 49.8%.

4.1.1.3 Psychosocial characteristic of participants

Table 4.3 The aspects of psychosocial factors among workers

Characteristics	Frequency	Percentage (%)
Psychosocial demands		
Low	110	47.6
High	121	52.4
Decision latitude (authority)		
Low	109	47.2
High	122	52.8
Decision latitude (autonomy)		
Low	127	55
High	104	45
Skill discretion		
Low	109	47.2
High	122	52.8
Social support		
Low	70	30.3
High	161	69.7
Job strain (Demand – control model)		
Low strain	55	23.8
Active	60	26
Passive	55	23.8

High strain	61	26.4
Psychosocial work quadrants (Demand – control – support model)		
No strain & high social support	127	55
No strain & low social support	43	18.6
Strain & high social support	34	14.7
Strain & low social support	27	11.7

Table 4.3 showed that the highest quadrant was observed in the high strain group (26.4%) illustrated by high psychological demands and low job control. Taking into account the demand-control-support model, the study revealed that the vast majority of participants (55%) had no strain and high social support, in contrast to those had strain and low social support accounting for the least proportion (11.7%).

4.1.1.4 Working conditions of furniture workers

Table 4.4 Physical and ergonomic factors among participants

Characteristics	Frequency	Percentage (%)
Awkward posture		
Working with the hand(s) or the elbow(s) above the shoulder(s)	58	25.1
Repeatedly raising with the hand(s) or the elbow(s) above the shoulder(s)	44	19
Working with the neck bent or twisted	119	51.5
Working with the back bent forward or twisted	134	58
Kneeling or squatting	10	4.3
Prolonged standing (held for longer than a half of workday time)	175	75.8
Manual material handling		
Lifting more than two hours per day	153	66.2
Carrying more than two hours per day	70	30.3
Pushing/Pulling more than two hours per day	109	47.2
The average weight of loading with the most regular activity		
Light (< 5kg)	32	13.9
Moderate (5-10 kg)	126	54.5
Heavy (11-20 kg)	44	19
Very heavy (>20 kg)	29	12.6
Pinching the load weight 1 kg or more per hand more than two hours per day	14	6.1
Gripping the load weight 5 kg or more per hand more than two hours per day	19	8.2
Repetitive motion		
(Repeating the same motion or small range action with more than 4 times per minute)	118	51.1
Hand-transmitted vibration exposure		
Exposure to hand-arm vibration	102	44.15

Orbital sander	45	19.5
Edge sander	13	5.6
Pistol drill machine	15	6.5
Screwdriver	7	3
Upholstery stapler	8	3.5
Paint spray gun	29	12.6
Daily vibration intensity (TWA 8 hours)		
Mean ± SD (range)	**3.216 ± 1.82 (0.609 – 6.696)**	
Below the action value (< 2.5 m/s^2)	47	46.1
From 2.5 m/s^2 to 5 m/s^2	35	34.3
Over the limit value (> 5 m/s^2)	20	19.6
Level of MSDs Risk (REBA score)		
Mean ± SD (range)	**6.24 ± 2.13 (2 – 11)**	
Low risk (2-3)	40	17.3
Medium risk (4-7)	129	55.8
High risk (8-10)	58	25.1
Very high risk (≥11)	4	1.7

The table 4.4 presents the working conditions among the furniture workers. In term of working postures, there are more than three-quarters of the participants who have to regularly stand throughout the working time of longer than a half of workday time (75.8%). Regarding the survey of material manual handling, more than two-thirds of the workers have to regularly perform lifting activities (66.2%). The average weight of heavy object frequently handled with manual operations is recorded mainly from 5 to 10 kg (54.5%). Regarding of exposure to hand-arm vibration, 44% of the participants reported having to regularly use pneumatic equipment and equipment to process materials. In addition, among the workers exposed to hand-arm vibration, up to 19.6% of subjects have daily exposures above the limit value (> 5m/s^2).

The level of WMSDs risk based on REBA method of the workers, the results showed that the majority of workers were at medium risk level (55.8%), the high and very high risk level accounted for 25.1% and 1.7% respectively.

4.1.2 Prevalence of WMSDs

The table 4.5 presents that 72.7% of the respondents reported that they had abnormal symptoms of WMSDs in any one of the nine body parts during the last year. The prevalence of WMSDs among furniture workers during the past 12 months was highest for low back (36.4%), followed by pain in the shoulder (32%), the neck (28.1%) and the wrist/ hand (27.3%). In addition, the result of WMSDs within the last 7 days also indicated that most of employees suffered from pain at their lower back (14.7%), followed by the wrists or hands (12.6%), the least common is the hip-thigh area (0.4%) as represented in table 4.6.

Table 4.5 Prevalence of musculoskeletal symptoms distrubted over nine body regions in the previous 12 months among the furniture workers.

Body region	WMSDs	Severity			Acknowledge of the pain came from	
		Mild	Moderate	Severe	At work	Not sure
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Neck	65 (28.1)	9 (13.8)	44 (67.7)	12 (18.5)	50 (76.9)	15 (23.1)
Shoulder	74 (32)	8 (10.8)	51 (68.9)	15 (20.3)	59 (79.7)	15 (20.3)
Elbow	39 (16.9)	1 (2.6)	27 (69.2)	11 (28.2)	31 (79.5)	8 (20.5)
Wrist/ hand	63 (27.3)	2 (3.2)	43 (69.4)	17 (27.4)	55 (88.7)	7 (11.3)
Upper back	22 (9.5)	2 (9.1)	16 (72.7)	4 (18.2)	17 (77.3)	5 (22.7)
Low back	84 (36.4)	13 (15.5)	54 (64.3)	17 (20.2)	65 (77.4)	19 (22.6)
Hip/ thigh	12 (5.2)	2 (16.7)	8 (66.7)	2 (16.7)	9 (75)	3 (25)
Knees	31 (13.4)	4 (12.9)	18 (58.1)	9 (29)	27 (87.1)	4 (12.9)
Ankles/ feet	10 (4.3)	2 (20)	4 (40)	4 (40)	9 (90)	1 (10)
WMSDs (at least one part)	168 (72.7)	23 (13.8)	113 (67.7)	31 (18.6)	129 (77.2)	39 (22.8)

Table 4.6 Comparison of WMSDs prevalence in the last 12 months and 7 days among the furniture workers.

Body part	During the past 12 months		Within 7 days ago	
	WMSDs		WMSDs	
	n	%	n	%
Neck	65	28.1	24	10.4
Shoulder	74	32	25	10.8
Right side	70	30.3	22	9.5
Left side	66	28.6	22	9.5
Elbow	39	16.9	16	6.9
Right side	37	16	15	6.5
Left side	31	13.5	14	6.1
Wrist or hand	63	27.3	29	12.6
Right side	60	26	29	12.6
Left side	40	17.3	17	7.4
Upper back	22	9.5	4	1.7
Low back	84	36.4	34	14.7

Hip or thigh	12	5.2	1	0.4
Knees	31	13.4	9	3.9
Ankles	10	4.3	5	2.2
Any one part	168	72.7	90	39

4.1.3 Prevalence of HAV syndrome among furniture workers

Of the 102 respondents who using hand-held vibrating tools or machines or hand-fed processes, 8/102 (7.84%) individuals were recorded as the hand-arm vibration syndrome at any time within their daily life, and 7/102 (6.86%) persons were afflicted with numbness or tingling more than 20 minutes after using vibrating device, possibly similar to carpal tunnel syndrome. However, nobody reported have any white signal (blanching) on their fingers when performed with vibrating tools or machines.

Table 4.7 Occurrence of hand-arm vibration syndrome of participants

Characteristics	Frequency	Percentage (%)
Numbness or tingling at least 20 minutes after using vibrating tool or equipment	7	6.86
Hand arm vibration syndrome at any other time	8	7.84

4.1.4 Factors related with WMSDs among furniture workers

The result indicated that low back and wrist/hand pain proportion accounted the highest prevalence among WMSDs symptoms were considered to be the outcome variable in order to elaborate those risk factors related with WMSDs.

Table 4.8 Association between WMSDs, low back pain, wrist/hand pain and independent variables (n=231)

Independent variable	Total n (%)	WMSDs	Low back pain	Wrist/hand pain
		Crude *OR* (95% CI)	Crude *OR* (95% CI)	Crude *OR* (95% CI)
Demographic characteristics				
Age (years)				
≤ 34	113 (48.9)	1	1	1
> 34	118 (51.1)	0.781 (0.437 – 1.398)	1.17 (0.684 – 2.001)	0.781 (0.437 – 1.398)
Gender				
Male	137 (59.3)	1	1	1
Female	94 (40.7)	0.74 (0.412 – 1.328)	*0.404 (0.226 – 0.72)	1.236 (0.688 – 2.22)
BMI group				
Non-overweight	196 (84.8)	1	1	1
Overweight	35 (15.2)	*3.338 (1.128 – 9.878)	*2.75 (1.321 – 5.724)	2 (0.945 – 4.232)

Independent variable	Total n (%)	WMSDs	Low back pain	Wrist/hand pain
		Crude *OR* (95% CI)	Crude *OR* (95% CI)	Crude *OR* (95% CI)
Smoking				
Non-smoker	144 (62.3)	1	1	1
Smoker	87 (37.7)	*2.4 (1.246 – 4.622)	*2.267 (1.304 – 3.941)	1.233 (0.682 – 2.228)
Drinking alcohol				
Never	102 (44.2)	1	1	1
Once per month	51 (22.1)	0.995 (0.462 – 1.975)	1.425 (0.701 – 2.897)	0.448 (0.195 – 1.028)
2 to 4 times per month	65 (28.1)	1.455 (0.712 – 2.975)	*2.057 (1.077 – 3.931)	0.627 (0.308 – 1.277)
≤ 2 times per week	13 (5.6)	5.239(0.652 – 42.072)	1.5 (0.454 – 4.959)	1.792 (0.558 – 5.755)
Exercise habit				
Do exercise per week	63 (27.3)	1.141 (0.59 – 2.207)	1.461 (0.808 – 2.641)	0.98 (0.511 – 1.88)
Injuries/ surgery history				
Had have injuries before	21 (9.1)	0.727 (0.279 – 1.895)	0.741 (0.298 – 1.839)	1.375 (0.528 – 3.582)
Working experience (years)				
≤ 2	9 (3.9)	1	1	1
3 – 5	29 (12.6)	1.571 (0.309 – 7.989)	0.255 (0.053 – 1.219)	3.6 (0.39 – 33.237)
6 – 10	121 (52.4)	1.279 (0.303 – 5.408)	0.441 (0.112 – 1.729)	3.256 (0.392 – 27.01)
≥ 11	72 (31.2)	1.327 (0.317 – 6.137)	0.54 (0.134 – 2.18)	2.667 (0.312 – 22.8)
Job tenure (years)				
1-9	197 (85.3)	1	1	1
≥ 10	34 (14.7)	0.883 (0.396 – 1.97)	1.099 (0.519 – 2.327)	1.9 (0.747 – 4.835)
Organizational characteristics				
Job title				
Quality Controller	43 (18.6)	1	1	1
Moulder / Cutter	14 (6.1)	1.481(0.398 – 5.513)	0.747 (0.2 – 2.79)	*5.417 (1.207 – 24.308)
Forming Operator	17 (7.4)	0.847 (0.269 – 2.665)	1.018 (0.314 – 3.3)	1.3 (0.215 – 7.855)
Sander	57 (24.7)	1.519 (0.651 – 3.54)	0.728 (0.311 – 1.709)	**7.091 (2.233 – 22.519)
Assembler	25 (10.8)	1.524 (0.523 – 4.442)	0.589 (0.194 – 1.792)	3.792 (0.983 – 14.618)
Painter	30 (13)	*8.296 (1.74 – 39.565)	1.867 (0.721 – 4.834)	**11.14 (3.179 – 39.061)
Packager	30 (13)	1.63 (0.589 – 4.512)	1.427 (0.549 – 3.715)	1.5 (0.344 – 6.537)
Upholster	8 (3.5)	1.778 (0.32 – 9.885)	1.12 (0.235 – 5.344)	1.393 (0.135 – 14.478)
Loader	7 (3)	3.556 (0.392 – 32.265)	*11.2 (1.231 – 101.886)	Not Applicable
Working time				
8-hour	85 (36.8)	1	1	1
10-hour	88 (38.1)	0.749 (0.356 – 1.577)	1.107 (0.59 – 2.077)	1.737 (0.874 – 3.453)
12-hour	58 (25.1)	1.113 (0.518 – 2.392)	1.542 (0.774 – 3.072)	1.543 (0.716 – 3.328)
Type of schedule				
Office hour	152 (65.8)	1	1	1
Shift	79 (34.2)	1.425 (0.759 – 2.678)	1.023 (0.582 – 1.799)	1.264 (0.692 – 2.308)
Training program				
Attended	115(49.8)	1	1	1
Not Attended	116(50,2)	**3.50 (1.87-6.55)	**2.46 (1.419 – 4.292)	1.603 (0.892 – 2.881)
Psychosocial characteristics				
Psychosocial demands				
Low	110 (47.6)	1	1	1
High	121 (52.4)	*2.435 (1.339 - 4.426)	*2.149 (1.238 – 3.732)	*2.05 (1.125 – 3.735)

Independent variable	Total n (%)	WMSDs	Low back pain	Wrist/hand pain
		Crude *OR* (95% CI)	Crude *OR* (95% CI)	Crude *OR* (95% CI)
Decision latitude (authority)				
Low High	109 (47.2) 122 (52.8)	1 0.72 (0.401 – 1.293)	1 1.131 (0.66 – 1.936)	1 *0.44 (0.243 – 0.796)
Decision latitude (autonomy)				
Low High	127 (55) 104 (45)	1 **2.826 (1.55 – 5.15)	1 1.687 (0.974 – 2.919)	1 1.77 (0.975 – 3.237)
Skill discretion				
Low High	109 (47.2) 122 (52.8)	1 1.664 (0.921 – 3.007)	1 0.903 (0.528 – 1.544)	1 *0.527 (0.293 – 0.948)
Social support				
High Low	161 (69.7) 70 (30.3)	1 *2.94 (1.397 – 6.207)	1 *2.097 (1.179 – 3.7428)	1 1.48 (0.801 – 2.734)
Job strain				
Non-strain Strain	170 (73.6) 61 (26.4)	1 *3.789 (1.62 – 8.865)	1 *2.281 (1.255 – 4.147)	1 *2.67 (1.43 – 4.987)
Psychosocial work quadrants				
No strain & high social support No strain & low social support Strain & high social support Strain & low social support	127 (55) 43 (18.6) 34 (14.7) 27 (11.7)	1 *2.658 (1.139 – 6.205) *3.524 (1.278 – 9.72) *7.595 (1.722 – 33.5)	1 1.893 (0.921 – 3.889) 2.075 (0.95 – 4.531) *3.823 (1.617 – 9.042)	1 2.183 (0.999 – 4.769) **4.522 (2.012 – 10.163) 2.261 (0.902 – 5.666)
Physical characteristics				
Awkward posture				
Hand(s) or elbow(s) above the shoulder height	58 (25.1)	*3.487 (1.488 – 8.173)	0.991 (0.534 – 1.84)	*2.185 (1.159 – 4.118)
Repeatedly raising or working with the hand(s) or the elbow(s) above the shoulder height	44 (19)	*4.609 (1.576 – 13.48)	1.269 (0.648 – 2.484)	*2.47 (1.244 – 4.903)
Working with the neck bent or twisted	119 (51.5)	1.135 (0.636 – 2.027)	0.909 (0.532 – 1.554)	1.145 (0.641 – 2.046)
Working with the back bent forward or twisted	134 (58)	1.37 (0.765 – 2.455)	*1.919 (1.095 – 3.362)	0.871 (0.486 – 1.563)
Prolonged standing	175 (75.8)	0.968 (0.491 – 1.907)	0.631 (0.342 – 1.164)	*3.294 (1.403 – 7.732)
Manual material handling				
Lifting	153 (66.2)	1.428 (0.783 – 2.602)	1.221 (0.688 – 2.166)	1.543 (0.814 – 2.923)
Carrying	70 (30.3)	1.558 (0.802 – 3.023)	1.62 (0.912 – 2.878)	1.214 (0.652 – 2.258)
Pushing / Pulling	109 (47.2)	0.82 (0.459 – 1.464)	1.388 (0.81 – 2.376)	*0.548 (0.302 – 0.994)
Pinching	14 (6.1)	2.346 (0.51 – 10.791)	2.474 (0.828 – 7.392)	0.714 (0.192 – 2.647)
Gripping	19 (8.2)	1.055 (0.364 – 3.059)	0.44 (0.141 – 1.372)	*2.633 (1.016 – 6.823)
The average weight of loading				
Light (< 5kg)	32 (13.9)	1	1	1

Independent variable	Total n (%)	WMSDs	Low back pain	Wrist/hand pain
		Crude *OR* (95% CI)	Crude *OR* (95% CI)	Crude *OR* (95% CI)
Moderate (5-10 kg)	126 (54.5)	2.043 (0.926 – 4.51)	0.983 (0.414 – 2.331)	3.5 (1.152 – 10.633)
Heavy (11-20 kg)	44 (19)	*3.971 (1.412 – 11.165)	1.942 (0.733 – 5.147)	2.333 (0.668 – 8.146)
Very heavy (>20 kg)	29 (12.6)	*11.912 (2.416 - 58.72)	**6.708(2.186 – 10.58)	1.826 (0.459 – 7.26)
Repetitive motion	118 (51.1)	1.321 (0.739 – 2.361)	0.746 (0.436 – 1.277)	**3.608 (1.912 – 6.806)
Hand-transmitted vibration exposure	102 (44.15)	1.694 (0.93 – 3.087)	0.79 (0.459 – 1.36)	**3.6 (1.953 – 6.636)
Daily vibration intensity				
< 2.5 m/s^2	47 (46.1)	1	1	1
From 2.5 to 5 m/s^2	35 (34.3)	0.593 (0.202 – 1.734)	0.467 (0.18 – 1.212)	1.275 (0.529 – 3.073)
> 5 m/s^2	20 (19.6)	0.615 (0.173 – 2.183)	0.45 (0.14 – 1.444)	0.45 (0.14 – 1.444)
REBA risk level				
Low risk (2-3)	40 (17.3)	1	1	1
Medium risk (4-7)	129 (55.9)	1.115 (0.529 – 2.354)	1.075 (0.505 – 2.288)	*4.24 (1.225 – 14.669)
High risk (≥8)	62 (26.8)	*4.231 (1.525 – 11.735)	1.602 (0.698 – 3.676)	**9.514 (2.647 – 34.192)

Note: *p<0.05*;* **p≤0.001*; OR* = odds ratio*; CI* = confidence interval*; REBA* = Rapid entire body assessment

Table 4.8 demonstrates the distribution of WMSDs prevalence among respondents by demographic characteristics, work-related factors such as organizational characteristics, psychosocial characteristics, and physical characteristics in the workplace. The simple binary logistic regression initially indicated risk factors were statistically significant related with the prevalence of WMSDs.

Table 4.9 Multiple logistic regression analysis for factors affecting WMSDs in furniture workers (n=231)

Independent variable	Adjusted *OR*	*p-value*	95% *CI*
BMI group			
Non-overweight (< 25)	1		
Overweight (≥ 25)	4.16	0.023	1.21 – 14.26
Smoking			
Non-smoker	1		
Smoker	2.84	0.008	1.316 – 6.167
Training program before working			
Attended	1		
Not Attended	2.69	0.008	1.29 – 5.63
Awkward posture (hold ≥ 2 hours total per day)			
	1		
Working with hand(s) or the elbow(s) above the shoulder(s) height	2.84	0.029	1.31 – 6.16

The average weight of loading			
Light (< 5kg)	1		
Moderate (5-10 kg)	1.84	0.191	0.73 – 4.63
Heavy (11-20 kg)	2.30	0.166	0.70 – 7.53
Very heavy (>20 kg)	8.66	0.019	1.43 – 52.53
Psychosocial demands			
Low	1	0.034	1.06 – 4.51
High	2.18		
Decision latitude (autonomy)			
High	1	0.001	1.69 – 6.49
Low	3.43		
Social support			
High	1	0.019	1.18 – 6.49
Low	2.76		

Note: *OR* = odds ratio*; CI* = confidence interval; Gender, age (quantitative variable) were included in the logistic regression to control bias.

Table 4.9 shows multivariate analysis indicated statistically significant association occupational factors and WMSDs in the past 12 months of workers in the furniture factory ($p < 0.05$). Associated factors were BMI (adjusted OR = 4.16: 95% CI; 1.21 – 14.26), smoking (adjusted OR = 2.84: 95% CI; 1.31 – 6.16), training (adjusted OR = 2.69: 95% CI; 1.29 – 5.63), awkward posture of hand (adjusted OR = 2.84: 95% CI; 1.31 – 6.16), manual handling more than 20 kg. (adjusted OR = 8.66: 95% CI; 1.43 – 52.53), psychosocial demand (adjusted OR = 2.18: 95% CI; 1.06 – 4.51), autonomy latitude (adjusted OR = 3.43: 95% CI; 1.69 – 6.49), and social support (adjusted OR = 2.76: 95% CI; 1.18 – 6.49).

4.2 Discussion

The cross-sectional study was implemented with the sample size 231 workers in a furniture manufacturing factory in Binh Duong province, Vietnam. The overall purpose of this study was to explore the prevalence of WMSDs and the related risk factors for WMSDs.

4.2.1 Discussion of the prevalence of WMSDs

The result of this study showed that 72.7% of participants had experienced any WMSDs symptoms such as pain, ache, or discomfort from at least one body region during the last 12 months. This study also determined that musculoskeletal disorder health problem was prevailing among workers in a furniture production factory. When compared to the same industry from other countries, our prevalence of WMSDs was as high as the one-year prevalence of MSDs reported in the study in the Denmark (Christensen et al., 1995), Iran (Nejad et al., 2013), and Thailand (Thetkathuek & Meepradit, 2018). For details, the highest ranking of affected body parts was found to be the low back area (36.4%), followed by shoulder region (32%), ranked third were neck and hand/wrist region with 28.1% and 27.3%, respectively. Our study results were similar to some research conducted in Denmark (Christensen et al., 1995), Sweden (Hagen et al., 1998) and Iran (Mirmohamadi et al., 2004), in which confirmed that the low back was the most frequently reported part by workers. (42%, 46%, and 50%, respectively). Recently the result among furniture workers from Thailand (Thetkathuek & Meepradit, 2018) demonstrated that the high prevalence of low back complaints was 37.5%, but the most frequent region was shoulder (53.9%) and hand/wrist (37.8%). The previou studies also showed higher symptoms in the neck, upper limbs, and knee region (Mirmohamadi et al., 2004; Nejad et al., 2013; Thetkathuek & Meepradit, 2018). This is completely consistent with the specialties of the manual work of the furniture industry, the workers often perform heavy manual operations including lifting, carrying, pushing and pulling with excessive force, exposed to adverse postures, repetition, in addition to exposure to vibration factors from hand tools (Mirka, 2005), those ergonomic risk factors would contribute significantly to WMSDs of the neck, upper limbs, and back (Putz-Anderson et al., 1997).

We tried to compare with several previous studies on WMSDs of workers in Vietnam, a research conducted in a seafood processing company in central Vietnam by researchers from the Hanoi School of Public Health showed that nearly 80% of female workers suffered musculoskeletal pain at least in one of nine body parts after work shift within the past year (Tran et al., 2016). Another study among nurse workers of a treatment system in Vietnam have showed congruent finding with 74.7% of WMSDs one-year prevalence (Luan et al., 2018). Most recently, there is a 2020 study by Van Nguyen et al. (2020) that indicated that the high rate of WMSDs among waste collectors in Vietnam capital was 74.4% during the last 12 months. Although there were only a few studies as well as different occupational sectors, those studies have supported the view that the prevalence of WMSDs is relatively high among the workforce of Vietnam. It has been suggesting that poor working conditions and lack of ergonomically workstation and tool/equipment design of occupational of exposure in the workplace existed in developing countries like Vietnam.

For details on common body regions affected by WMSDs among workers, our study compared the prevalence of WMSDs within the last 7 days with those within 12 months. The 7-day prevalence of WMSDs also showed the similar to 12-month prevalence with the most common part reported pain was the lower back (14.7%), followed by the hand wrist area (12.6%), and shoulder area (10.8%). Two patterns suggested that the musculoskeletal disorder pattern needed to be considered among workers at the furniture factory were the lumbar, hands/wrists and shoulder region in order to reduce the prevalence of WMSDs.

4.2.2 The risk factors related to WMSDs

An attempt to predict the factors for WMSDs among workers in a furniture factory, the personal characteristics, work organization factors, psychosocial and physical factors were investigated simultaneously to find the relationship with WMSDs.

4.2.1.1 Individual factors

(1) Body mass index

The first factor associated with WMSDs prevalence was BMI, in particular reported pain and discomfort of the lower back and wrist/hand regions. Compared to employees with non-overweight (BMI < 25), the overweight employees

(BMI ≥ 25) had higher risk for developing WMSDs symptoms over the past year with a*OR* [95%CI] = 4.16 [1.21, 14.26]. The results are in agreement with that of Nag et al. (2012), who found that the WMSDs within the previous 12 months were more frequent among overweight women than those had normal weight. The study was also similar to a cohort study of the working population in Netherland (Viester et al., 2013) that high BMI caused a higher 12-month prevalence of WMSDs. Additionally, several epidemiological studies have demonstrated that high BMI is associated with MSDs involving not only low back, but also upper and lower limbs (da Costa & Vieira, 2010; Walsh et al., 2018). Another study among Iranian population which revealed that BMI was a significant predictor of MSDs in which obese person would have a 15% more chance of developing the low back disorders (Biglarian et al., 2012). We suppose that the BMI indicator is an important determinant needed to be concerned in preventing WMSDs. Therefore, raising awessness and self mornitoring for a healthy lifestyle should be promoted to overweight employees.

(2) Smoking

The next lifestyle behavior related to WMSDs was smoking. Our result also found that smoking status was associated with increased prevalence of WMSDs by the multivariate logistic regression (p=0.008). Our study agreed with previous findings among furniture workers in Thailand (Thetkathuek & Meepradit, 2018). Furthermore, da Costa and Vieira (2010) had reviewed the numerous longitudinal studies that have established a plausible causal relationship between smoking and WMSDs. Smoking was recognized as a credible risk factor because of its detrimental effect on the musculoskeletal system (Al-Bashaireh et al., 2018). Cigarettes smoking had also contributed to development of rheumatoid arthritis, osteoarthritis, low back pain, tendinopathy and delayed fracture and wound healing (Abate et al., 2013). Because nicotine accelerates collagen degradation and lowers blood and oxygen circulation, blood vessels are damaged, particularly those between the arteries and the cervical vertebrae, that eventually leading to disorders in the musculoskeletal system (Abate et al., 2013). Therefore, it is crucial to encourage a smoking cessation campaign at the workplace.

(3) Gender

In our study, the proportion of male workers made up the majority (59.3%) with the percentage of WMSDs also higher than the female group (60.4%). From the result of simple logistic regression analysis, we found a significant difference of low back pain 12-month prevalence between the two genders in which male workers had greater of WMSDs prevalence than female workers. This finding is contradictory of previous studies conducted among Iranian population (Biglarian et al., 2012) indicated that female sex is a contributing factor for the increased rate of low back pain. This could be explained by typical profile of furniture wood manufacturing work in our study, where male often responsible for loading heavy materials or operating the physically demand work, while female usually responsible for doing work that requires more meticulous and lighter than male.

4.2.1.2 Organizational factors

(1) Training Attendence

One of the risk factors contributing to WMSDs was engagement of employees in the work health and safety training when they start carrying out their job in the first time. Actually the training program should be conducted annually, but from our interview with the manager of the factory, they convinced that it seems difficult to implement due to the lack of human resource and the most of managers only focuses on business operations. This result corresponded with the study conducted in Sweden (Parenmark, Engvall, & Malmkvist, 1988) which claimed that the workers who received ergonomic training from the beginning of their jobs significantly reduced the complaints of upper limbs symptoms compared to senior workers without training. Some previous studies have already confirmed the effectiveness of safety training and education programs in reducing the WMSDs risk factors at the workplace (Bell & Grushecky, 2006; McCauley-Bush, 2011). Safety training and illness prevention program aims to provide workers with safety knowledge and performance, in which helps them to recognize the risk factors for musculoskeletal disorders as well as to avoid and control those hazard risks (AFMA, 2003). Thus an ergonomics training program aims to provide workers with the undeniable benefits such recognition of risk factors, awareness of how to avoid and control hazard risks in order to reduce the number and severity of injuries and diseases related with MSDs, as well as the cost of treatment, compensation, absenteeism (AFMA, 2003). However, several meta-analytical studies did not find any positive effectiveness when training was the only intervention applied (National Research Council, 2001). Based on a review of the evidence for the benefits of ergonomics training in particular, Denis et al. (2008) suggested that the WMSDs prevention training should be incorporated with other interventions and adapted according to the specific exposure.

(2) Job title

In term of organizational factors in the workplace, we found that there was a significant difference between the WMSDs prevalence within the different job titles in the univariate analysis model, but this significance did not work in the final multivariate model. In detail, there is a significant difference in prevalence of WMSDs between the painters and the quality control workers (p<0.05). Also, low back pain was more common among the loaders who working as warehouse keepers than among the quality controllers (p<0.05). Eventually, results from multivariate logistic regression analysis revealed that there was only a significant relevance between the disorder occurrence in wrist/hand region of different job titles, in particular, working as the painter, sander, and moulder posed a risk of developing hand or wrist pain higher than the quality controller. Those groups considered to differ in their physical job demands and work activities (AFMA, 2003). From our observation, the quality control workers are mainly employed on monitoring the products at every single stages of furniture manufacturing process, they were not required to implement the manual material handling activities frequently, they also exposed to mixed sedentary work that why we categorized them as the reference group when comparing with the other job title groups, meanwhile, the rest of the workers had to put in a lot of physical effort to fulfil their duties involved in manual tasks or machine operation activities were reported to be much more frequent than in workers involved administrative activities. From the previous studies, the sanders who attributed to the hand-arm vibration transmitted by the hand-held tools or hand-fed machine with the long exposure duration could be exposed a risk of upper limbs disorder (Bovenzi et al., 2005). This relevance also is consistent with a previous study among painters in Sweden (Björing & Hägg, 2000), which indicated that those working as painters had more symptoms of upper limbs than the general material workers from woodworking, sawmill, metal, and construction industries. So that our result showed that those who had the main task as painters, sanders, moulder operators were at risk of developing the hand/ wrist disorders, a health surveillance should pay attention those subjects in preventing WMSDs.

4.2.1.3 Physical factors

Once utilizing the physical factors checklist, the study found the association between WMSDs and some awkward postures such as manipulating with the hand raised above the head or elbow above the shoulder height, and the back bent or twisted. Those posture were sustained more than 2 hours total per day without the support or the chance to vary posture.

(1) Awkward posture

Working with hand(s) or elbow(s) over the shoulder height was be found as an associated factor with WMSDs. This awkward posture in which the arm is abducted or elevated with the angle greater than 90 degrees from the neutral position (Putz-Anderson et al., 1997). Workers who had to work with the hand posture over the shoulder height more than 2 hours per day were 2.85 times more likely to be suffering from WMSDs compared to those who performed less than 2 hours or had no this posture. The result found that this inappropriate posture which is in agreement with the study conducted by Naidoo et al. (2009) among farmers, who showed that such awkward posture working with hands above shoulder height can lead to musculoskeletal morbidity in the multivariate models after adjustment for age and physical exertion. There were some upper limb postures such as arm abduction, flexion, and wrist deviation among woodworking workers during the painting operations also recorded by liquid-based angle transducers (Björing & Hägg, 2000). Our report also supported previous epidemiological studies and the literature review of working posture (European Agency for Safety Health at Work, 2019; Vieira & Kumar, 2004) that employee groups with extreme postures was at increased risk for neck and shoulder disorders, especially showing an increased risk of overhead, arm elevation and particular posture related to degrees of upper limb abduction or extension (European Agency for Safety Health at Work, 2019; Putz-Anderson et al., 1997). The reason why workers worked with hands at and above shoulder height during much long times more than 2 hours per day could be explained in some ways such as workstations were not designed to fit almost people (Dahlberg et al., 2004). It is suggested that the employer should provide some temporary standing platforms or adjustable desks that can be suitable for each single worker's height to change conveniently the work surface.

(2) Manual handling

This study also revealed that heavy weight when performing MMH was associated with WMSDs, especially in low back pain. Our results showed that the furniture workers perceived the most strenuous activities for manual handling were lifting (66%), followed by carrying, pulling and pushing (30.3%, 47.2% respectively). Our study found a statistically significance between working with the average load weighting more than 20 kg with the occurrence of WMSDs and low back pain. It also corresponded to the study among furniture manufacturing workers (Nejad et al., 2013) that the prevalence of muscle pain related with MMH factors such as load weight, movement distance, and frequency of handling, lifting, pulling, pushing. Previous studies (Naidoo et al., 2009; Putz-Anderson et al., 1997) have also reported that physical loads are known as the risk factor for developing WMSDs. Recently, one meta-analysis reported that the load weight and its characteristics are considered a risk factor of low back pain (Girish et al., 2015). Research suggests that more than 20kg of object weight could lead to an increased risk of WMSDs when performing MMH. With regard to the 20 kg limited weight, some measures should be introduced like machine aids, handholds, teamwork support, or even regulation of determining maximum acceptable weight of heavy objects.

(3) Hand-transmitted vibration exposure

Of the 102 participants using 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 (American Conference of Governmental Industrial Hygienists, 2018). The risk factor identified to cause musculoskeletal symptoms in the hand/wrist region was using the hand held vibratory tools when performing tasks by the Chi-square test and univariate logistic regression (p<0.001). The result showed that almost all workers had to exposed to HAV belonged to the job title groups such as painter, sanders, upholster operators with the higher proportions of WMSDs. However, hand-arm vibration exposure was not significantly associated with WMSDs prevalence in the multivariate analysis, our study still supported previous findings among furniture workers (Bovenzi et al., 2005; Gauthier et al., 2012; Thetkathuek & Meepradit, 2018) indicating that the prevalence of upper limb symptoms was significantly linked to hand-arm vibration exposure. Since our study only recorded WMSDs proportions over the past 12 months, a number of misleading factors may have occurred during the interview process, specifically workers used reporting pain symptoms, numbness, pains in the upper limbs only appears the first working day in the first year. But after getting used to it, those symptoms were reduced or even disappeared in the following years. Our study also tried to interview specifically in those hand arm vibration syndromes. However, the number of hand-arm vibration syndrome was too small (7.84% reported pain, tingling, numbness with 8 cases) for statistical analysis, even the Chi square test showed that more than 50% of cells had expected count less than 5. In the current situation of the factory, almost workers had to working in the hot environment so it is too rare for vasospastic reaction of vascular system to occur and wearing some gloves may be obscure the worker's recognition of those symptoms in their skin during the working day (Nejad et al., 2013; Thetkathuek & Meepradit, 2018).

(4) Evaluation of WMSDs risk level by utilizing REBA tool

In order to assess conveniently the ergonomic risk exposure in term of working posture for all furniture workers due to the limited time allowed in this study, the snapshot of working posture was utilized with rapid entire body assessment (REBA) observation tool. The selected posture was the most strenuous one in which the participants perform their main task or the positions in which they felt most uncomfortable. Nearly 55.8% of working postures were found to be medium risk level and 25.1% of high risk level so that they had to further examine and make modifications. Notably, an increased prevalence of wrist/hand disorders was significantly associated with an increasing level of REBA. Our study initially proved that the effectiveness of REBA tool in evaluating the risk of WMSDs by using simple logistic regression. This result agrees with studies identified earlier that furniture workers were at risk of MSDs due to working postures (Christensen et al., 1995; Mirka, 2005; Nejad et al., 2013). It is possible that harmful postures which were found while performing furniture tasks attributed to musculoskeletal injury exposure required corrective measures. This finding is in agreement with other studies that indicated inappropriate working postures cause musculoskeletal symptoms in the industrial workers (da Costa & Vieira, 2010; European Agency for Safety Health at Work, 2019; Vieira & Kumar, 2004). It is well recognized that mismatches between a person's anthropometric measurements and the dimensions of a given workplace, tool, or piece of equipment are a major contributor to increased discomfort, fatigue, and musculoskeletal injuries (Colim et al., 2019). It is recommended that a working posture assessment be performed in an ergonomically designed workplace while taking the workers' anthropometric dimensions into account.

4.2.1.4 Psychosocial factors

Although employees did not have to bear the intellectual burdens in the working process or their tasks were not too complicated, the monotony was at a high level, often working with repetitive operations in a circular nature in the processing of wood furniture with the same design, assembly line according to customer requirements. The research used the Karasek’s JCQ questionnaire (1998) to assess the psychosocial factors in the workplace. The methodology was proven in the effectiveness to quantify those psychosocial dimensions for WMSDs status by the previous study among general working population in Norway (Sterud & Tynes, 2013), in Swiss (Canjuga, Läubli, & Bauer, 2010), in Poland (Bugajska et al., 2013), and among workers in the United States (Yang, Haldeman, et al., 2016; Yang, Hitchcock, et al., 2016). The study indicated that psychosocial factors among the workers included perception of high psychosocial demands, limited job controls in term of autonomy, and low social support indicating the risk factors for WMSDs by the final logistic regression analysis after adjusting for personal characteristics and physical exposures ($p<0.05$). This finding was consistent with previous studies and literature reviews among workers (Bongers et al., 1993; Eatough et al., 2012; European Agency for Safety Health at Work, 2019). The present result was in agreement with that of van den Heuvel et al. (2005) with a follow-up period of 3 years, in which found that workers highly exposed to high level of psychological demands and low social support were more likely to report symptoms of neck, shoulder, hand/wrist disorders than the others. Moreover, consistent with our finding, a prospective study of Bugajska et al. (2013), who indicated that psychological job demands and decision latitude were the crucial predictors of musculoskeletal complains and repetitive strain injuries (RSIs) after stratifying underlying risk factors such as age, gender and physical variables.

Specifically, the study also revealed that workers who were in the job strain group had an increased risk for low back pain (a*OR*=2.8, 95%CI: 1.4 – 5.5). Some previous studies have shown that job strain is significant associated with low back pain (Canjuga et al., 2010; van den Heuvel et al., 2005; Vandergrift et al., 2012). This finding supported the job strain framework of Karasek Jr (1979) theory, in which, those workers who had high psychological demands combined with low job control were nominated to be in the strain job group, the combination rest were nominated in the non-strain job. Job psychosocial demands operationalized as work pace, time pressure, heavy workload, interruption, competing demands, meanwhile, job control is defined as a combination of decision latitude and skill discretion (Karasek Jr, 1979; Karasek et al., 1998).

One theoretical hypothesis illustrated that psycho-social problems may produce increased muscle tension and reduce a person's awareness of work practice; on the other hand, the possibility of developing MSDs may be occurred with tiredness, stress, and depression (Eatough et al., 2012). Despite of measuring at the individual level, psychosocial factors in our study are determined that could be objective and inaccurate due to recall bias and self-administrated questionnaire. Actually psychosocial factors combined with physical risk factors had increased the risk of injury and disorder, which has been confirmed by numerous studies (Bugajska et al., 2013; Widanarko et al., 2014). Widanarko et al. (2014) had examined the combined effect of the physical and psychosocial risk factor on musculoskeletal symptoms and reported that exposure to both awkward posture and work stress significantly increased the risk of neck - shoulder symptoms (OR 1.37, 95%CI 1.01-1.85) and adding of more a hand-movements factor had continued to increase the risk of neck/ shoulder symptoms (OR 3.14, 95%CI: 1.79-5.52). Our research indicated that the factory management should have utilized a multi-faceted approach involving avoiding physical risks while also enhancing the psychosocial environment, in order to reduce the prevalence of WMSDs among furniture employees. Regarding to social support as an emerging psychosocial risk factor recently, the study suggested that social support including supportive relationship between supervisor and peers may be the crucial factor in preventing WMSDs at the workplace. In order to improve coworkers and the spirit of mutual aid at work, the manager should think about establishing a variety of rewarding measures to ensure fairness, fostering a sense of teamwork and solidarity, planning union activities, and planning social activities to unite the labor collective.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The cross-sectional study confirmed that the high prevalence of WMSDs symptoms exists among workers in a furniture factory in Vietnam.

The results showed the prevalence of WMSDs during the last twelve months was 72.7%. Most workers had symptoms of WMSDs in the low back (31.2%), followed by the shoulder (28.6%), the wrist and hand region (26%). In addition, the study also showed some unfavorable working conditions such as awkward posture with standing during long periods of time accounting for 75.8%, postures with bending or rotating the neck and back at least two hours daily accounted for 51.5%; 58%; respectively. Specially, the arm posture raising above shoulder level at least two hours daily accounted for 25.1% of furniture workers. In term of manual material handling, 66.2% of workers had to regularly perform lifting activities, followed by the act of pulling and pushing the load (47.2%), and the act of carrying objects (30.3%), with the heavy weight of more than 20 kilogram accounted for 12%, notably. The results from REBA ergonomic assessment determined that most of workers performed working posture at medium risk level (55.8%), and high risk level (25.1%), which requiring a modification measure in the workplace.

Factors significantly associated with reporting WMSDs (*p*-value <0.05) were body mass index (OR = 4.16; 95% CI: 1.21 - 14.26), smoking (OR = 2.84; 95% CI: 1.31 - 6.16), training non-attendance (OR = 2.69; 95% CI: 1.29 - 5.63), awkward posture of hands (OR = 2.84; 95% CI: 1.31 - 6.16), load weight more than 20 kg (OR = 8.66; 95% CI: 1.43 - 52.53), high psychological demands (OR = 2.18; 95% CI: 1.06 – 4.51), low decision on autonomy, (OR = 3.43; 95% CI: 1.69 - 6.96), and low social support (OR = 2.76; 95% CI: 1.18 - 6.49). This finding suggest that intervention strategies should be considered for not only to ergonomic problems in the workplace but also organizational and psychosocial work factors in prevent WMSDs among workers.

5.2 Recommendations

The findings in this study demonstrate that personal, physical and psychosocial factors are significant predictors of WMSDs among workers. Recognizing the relationship between these variables will help in arranging, planning or actualizing preventive intervention programs for workers in order to reduce the incidence of WMSDs. This study also provides awareness for workers and the Vietnamese government regarding the issues of WMSDs in the workplace.

In order to minimize raising the hand above the head, the working posture should be adjusted according to the height of the font of the workstation. Managers can provide the table or platforms which can be adjusted the height.

Equipping a height-adjustable gear or forklift to lift or lower heavy objects, while also providing a solution that can change the way work is operated such as rotation job sessions or assigning more supporters to make the job easier for the worker, reducing the frequency and time of lifting heavy objects.

Providing a periodic educational program as well as ergonomic training can play a main role in reducing the musculoskeletal disorders resulted from the work position and postures.

Implementing a number of rewarding policies to ensure fairness, increase solidarity, teamwork spirit, organize union activities, as well as social activities to bring together the labor collective that is necessary to contribute to improving co-workers and mutual support at work.

Despite the small study sample size, some of the interesting findings could contribute to the knowledge about some potential risk factors for WMSDs or musculoskeletal health. Our study cannot mention all relevant factor according to literature review that contributed to WMSDs at the workplace. However, for factors exploited by the study are considered appropriate in the context of the data collection situation. For more general conclusions, further studies are required.

5.3 Limitation of the study

The strength of the study can be seen as the first report on WMSDs prevalence status and related factors among furniture workers in Vietnam. Since then, it is the premise that would likely to open the prospect for further studies in Vietnam on occupational risk in the workplace. Through the research results, it shows the effectiveness of applying the checklist to investigate physical risk factors about WMSDs, and the REBA observation toolkit to quickly assess the above risk level which apply measures to adjust and prevent in time the dangers that cause musculoskeletal disorders in the working environment. Besides, this study has used a reliable tool in quantifying the exposure to local vibration factors in the working environment.

The study has various limitations which might have implications to research results, including:

(1) Recall bias. Refer back to the data that was primarily collected base on the questionnaire during the last 12 months. Persons with disorders from musculoskeletal system may be more likely to report risks that could be connected with those symptoms.

(2) Not comprehensive data. The worst-case scenario was selected for implementing assessment tools that could lead to bias and inaccuracy issues. Observation time was too short for implementing REBA tool (about 5-10 minutes for each sample) could lead to the subjective and inaccuracy issues (just only focus on assessing the most unfavorable working posture or the posture that worker feeling most uncomfortable).

(3) Hand transmitted vibration exposure. Estimation of daily vibration exposure is based only on the self-estimated duration that the respondents provided, in addition, lack of attention to the combination of other factors such as manipulation habits, arm posture when performing, holding or contracting force on vibrating equipment/ tools, which could affect the accuracy of the problem in assessing exposure to hand-arm vibration factors.

REFERENCES

Abate, M., Vanni, D., Pantalone, A., & Salini, V. (2013). Cigarette smoking and musculoskeletal disorders. *Muscles, ligaments and tendons journal, 3*(2), 63.

AFMA. (2003). *American Furniture Manufacturing Association Voluntary Ergonomics Guideline for the Furniture Manufacturing*

Industry. Retrieved from

Al-Bashaireh, A. M., Haddad, L. G., Weaver, M., Kelly, D. L., Chengguo, X., & Yoon, S. (2018). The effect of tobacco smoking on musculoskeletal health: a systematic review. *Journal of environmental and public health, 2018*.

American Conference of Governmental Industrial Hygienists. (2018). *TLVs and BEIs Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents, and Biological Exposure Indices*.

Andreas, G.-W. J., & Johanssons, E. (2018). Observational Methods for Assessing Ergonomic Risks for Work-Related Musculoskeletal Disorders. A Scoping Review. *Revista Ciencias de la Salud, 16*(SPE), 8-38.

Babor, T. F., de la Fuente, J. R., Saunders, J., & Grant, M. (2001). The Alcohol Use Disorders Identification Test: Guidelines for use in.

Barro, D., Olinto, M. T. A., Macagnan, J. B. A., Henn, R. L., Pattussi, M. P., Faoro, M. W., . . . Paniz, V. M. V. (2015). Job characteristics and musculoskeletal pain among shift workers of a poultry processing plant in Southern Brazil. *Journal of occupational health*, 14-0201-OA.

Bell, J. L., & Grushecky, S. T. (2006). Evaluating the effectiveness of a logger safety training program. *Journal of Safety Research, 37*(1), 53-61.

Bevan, S. (2015). Economic impact of musculoskeletal disorders (MSDs) on work in Europe. *Best Practice & Research Clinical Rheumatology, 29*(3), 356-373.

Bhattacharya, A. (2014). Costs of occupational musculoskeletal disorders (MSDs) in the United States. *International Journal of Industrial Ergonomics, 44*(3), 448-454.

Biglarian, A., Seifi, B., Bakhshi, E., Mohammad, K., Rahgozar, M., Karimlou, M., & Serahati, S. (2012). Low back pain prevalence and associated factors in Iranian population: findings from the national health survey. *Pain research and treatment, 2012*.

Björing, G., & Hägg, G. M. (2000). Musculoskeletal exposure of manual spray painting in the woodworking industry–an ergonomic study on painters. *International Journal of Industrial Ergonomics, 26*(6), 603-614.

Bongers, P. M., de Winter, C. R., Kompier, M. A., & Hildebrandt, V. H. (1993). Psychosocial factors at work and musculoskeletal disease. *Scandinavian journal of work, environment & health*, 297-312.

Boonstra, A., Stewart, R., Köke, A., Oosterwijk, R., Swaan, J., Schreurs, K., & Preuper, H. R. (2016). Cut-Off Points for Mild, Moderate, and Severe Pain on the Numeric Rating Scale for Pain in Patients with Chronic Musculoskeletal Pain: Variability and Influence of Sex and Catastrophizing. *Frontiers in Psychology, 7*. doi:10.3389/fpsyg.2016.01466

Bovenzi, M. (1998). Exposure-response relationship in the hand-arm vibration syndrome: an overview of current epidemiology research. *International Archives of Occupational Environmental Health, 71*(8), 509-519.

Bovenzi, M., Della Vedova, A., Nataletti, P., Alessandrini, B., & Poian, T. (2005). Work-related disorders of the upper limb in female workers using orbital sanders. *International Archives of Occupational Environmental Health, 78*(4), 303-310.

Bugajska, J., Żołnierczyk-Zreda, D., Jędryka-Góral, A., Gasik, R., Hildt-Ciupińska, K., Malińska, M., & Bedyńska, S. (2013). Psychological factors at work and musculoskeletal disorders: a one year prospective study. *Rheumatology international*
33(12), 2975-2983.

Bureau of Labor Statistics. (2015). *Nonfatal Occupational Injuries And Illnesses Requiring Days Away From Work*. Retrieved from https://www.bls.gov/news.release/pdf/osh2.pdf

Canjuga, M., Läubli, T., & Bauer, G. F. (2010). Can the job demand control model explain back and neck pain? Cross-sectional study in a representative sample of Swiss working population. *International Journal of Industrial Ergonomics, 40*(6), 663-668.

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public health reports, 100*(2), 126.

CDC. (2018). Work-Related Musculoskeletal Disorders & Ergonomics. Retrieved from https://www.cdc.gov/workplacehealthpromotion/health-strategies/musculoskeletal-disorders/index.html

Christensen, H., Pedersen, M. B., & Sjøgaard, G. (1995). A national cross-sectional study in the Danish wood and furniture industry on working postures and manual materials handling. *Ergonomics, 38*(4), 793-805.

Colim, A., Carneiro, P., Costa, N., Arezes, P. M., & Sousa, N. (2019). Ergonomic assessment and workstation design in a furniture manufacturing industry—a case study. In *Occupational and Environmental Safety and Health* (pp. 409-417): Springer.

Crawford, J. O. (2007). The Nordic musculoskeletal questionnaire. *Occupational medicine, 57*(4), 300-301.

Curtis, G. L., Chughtai, M., Khlopas, A., Newman, J. M., Khan, R., Shaffiy, S., . . . Mont, M. A. (2017). Impact of physical activity in cardiovascular and musculoskeletal health: can motion be medicine? *Journal of clinical medicine research, 9*(5), 375.

da Costa, B. R., & Vieira, E. R. (2010). Risk factors for work-related musculoskeletal disorders: a systematic review of recent longitudinal studies. *American journal of industrial medicine, 53*(3), 285-323.

Dahlberg, R., Karlqvist, L., Bildt, C., & Nykvist, K. (2004). Do work technique and musculoskeletal symptoms differ between men and women performing the same type of work tasks? *Applied ergonomics, 35*(6), 521-529.

Daniel, W. W., & Cross, C. L. (2018). *Biostatistics: a foundation for analysis in the health sciences*: Wiley.

Das, K. (2018). Vietnam: Wood Products Exports to Reach Record High in 2018. *Vietnam Briefing: From Dezan Shira \& Associates*.

David, G. (2005). Ergonomic methods for assessing exposure to risk factors for work-related musculoskeletal disorders. *Occupational medicine, 55*(3), 190-199.

Dawson, T. (2008). *Vietnam's Wood Processing Industries–Status & Challenges.* Paper presented at the Papers at National workshop: opportunities & challenges for Vietnam wood processing industry in post–WTO.

Denis, D., St-Vincent, M., Imbeau, D., Jette, C., & Nastasia, I. (2008). Intervention practices in musculoskeletal disorder prevention: a critical literature review. *Applied ergonomics, 39*(1), 1-14.

Eatough, E. M., Way, J. D., & Chang, C.-H. (2012). Understanding the link between psychosocial work stressors and work-related musculoskeletal complaints. *Applied ergonomics, 43*(3), 554-563.

European Agency for Safety Health at Work. (2019). Work-related musculoskeletal disorders: prevalence, costs and demographics in the EU-European risk observatory report. In: European Agency for Safety and Health at Work.

Gauthier, F., Gélinas, D., & Marcotte, P. (2012). Vibration of portable orbital sanders and its impact on the development of work-related musculoskeletal disorders in the furniture industry. *Computers & Industrial Engineering, 62*(3), 762-769.

Girish, N., Iqbal, R., Khanzode, V., & De, A. (2015). Manual material handling and occupational low back disorders: a narrative literature review emphasising maximum acceptable weight of load. *International Journal of Human Factors and Ergonomics, 3*(3-4), 376-392.

Hagen, K. B., Magnus, P., & Vetlesen, K. (1998). Neck/shoulder and low-back disorders in the forestry industry: relationship to work tasks and perceived psychosocial job stress. *Ergonomics, 41*(10), 1510-1518.

Health and Safety Executive. (2018). *Work-related Musculoskeletal Disorders in Great Britain (WRMSDs), 2018*. In. Retrieved from http://www.hse.gov.uk/statistics/causdis/msd.pdf

Hignett, S., & McAtamney, L. (2000). Rapid entire body assessment (REBA). *Applied ergonomics, 31*(2), 201-205.

Hoang, T. G., Corbière, M., Negrini, A., Pham, M. K., & Reinharz, D. (2013). Validation of the Karasek-Job Content Questionnaire to measure job strain in Vietnam. *Psychological reports, 113*(2), 363-379.

Hooftman, W. E., Van Der Beek, A. J., Bongers, P. M., & Van Mechelen, W. (2009). Is there a gender difference in the effect of work-related physical and psychosocial risk factors on musculoskeletal symptoms and related sickness absence? *Scandinavian journal of work, environment & health*, 85-95.

Huy, H. T. (2011). Analysis of labour migration flows in the Mekong Delta of Vietnam. In *Environmental change and agricultural sustainability in the Mekong Delta* (pp. 115-140): Springer.

IJzelenberg, W., Molenaar, D., & Burdorf, A. (2006). Risk factors for musculoskeletal complaints and musculoskeletal sickness absence. *Prevention of Work-Related Musculoskeletal Complaints, 30*(1), 56-63.

International Ergonomics Association. (2000). *IEA Definitions of Ergonomics*. London and New York: Taylor & Francis.

International Organization for Standardization. (2001a). *ISO 5349-1:2001 Mechanical vibration—measurement and evaluation of human exposure to hand-transmitted vibration—Part 1: General Requirements*. Geneva: ISO.

International Organization for Standardization. (2001b). *ISO 5349-2:2001 Mechanical vibration – Measurement and evaluation of human exposure to hand-transmitted vibration – Part 2: Practical guidance for measurement at the workplace*: ISO.

International Organization for Standardization. (2017). *ISO 8041-1:2007 Human response to vibration — Measuring instrumentation — Part 1: General purpose vibration meters*: ISO.

International Trade Centre, & International Tropical Timber Organisation. (2005). *International Wooden Furniture Markets: A Review Geneva*. Retrieved from

Karasek Jr, R. A. (1979). Job demands, job decision latitude, and mental strain: Implications for job redesign. *Administrative science quarterly*, 285-308.

Karasek, R., Brisson, C., Kawakami, N., Houtman, I., Bongers, P., & Amick, B. (1998). The Job Content Questionnaire (JCQ): an instrument for internationally comparative assessments of psychosocial job characteristics. *Journal of occupational health psychology, 3*(4), 322.

Krajnak, K. (2018). Health effects associated with occupational exposure to hand-arm or whole body vibration. *Journal of Toxicology and Environmental Health, Part B, 21*(5), 320-334.

Kuorinka, I., Jonsson, B., Kilbom, A., Vinterberg, H., Biering-Sørensen, F., Andersson, G., & Jørgensen, K. (1987). Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Applied ergonomics, 18*(3), 233-237.

Liu, J., Huang, G., Li, X., Wang, S., Liu, L., & Liu, X. (2014). Study on prevalence of occupational musculoskeletal disorders and their risk factors among workers in three industries in Zhongshan, China. *Zhonghua lao dong wei sheng zhi ye bing za zhi= Zhonghua laodong weisheng zhiyebing zazhi= Chinese journal of industrial hygiene occupational diseases, 32*(6), 415-417.

López-Aragón, L., López-Liria, R., Callejón-Ferre, Á.-J., & Gómez-Galán, M. (2017). Applications of the standardized nordic questionnaire: A review. *Sustainability, 9*(9), 1514.

Luan, H. D., Hai, N. T., Xanh, P. T., Giang, H. T., Van Thuc, P., Hong, N. M., & Khue, P. M. (2018). Musculoskeletal Disorders: Prevalence and Associated Factors among District Hospital Nurses in Haiphong, Vietnam. *BioMed research international, 2018*.

Macfarlane, G. J., Pallewatte, N., Paudyal, P., Blyth, F. M., Coggon, D., Crombez, G., . . . Smeets, R. J. (2009). Evaluation of work-related psychosocial factors and regional musculoskeletal pain: results from a EULAR Task Force. *Annals of the rheumatic diseases, 68*(6), 885-891.

Maraseni, T. N., Son, H. L., Cockfield, G., Duy, H. V., & Dai Nghia, T. (2017). Comparing the financial returns from acacia plantations with different plantation densities and rotation ages in Vietnam. *Forest Policy and Economics, 83*, 80-87.

McAtamney, L., & Corlett, E. N. (1993). RULA: a survey method for the investigation of work-related upper limb disorders. *Applied ergonomics, 24*(2), 91-99.

McCauley-Bush, P. (2011). *Ergonomics: foundational principles, applications, and technologies*: CRC Press.

Miranda, H., Viikari-Juntura, E., Martikainen, R., & Riihimäki, H. (2002). A prospective study on knee pain and its risk factors. *Osteoarthritis and cartilage, 10*(8), 623-630.

Miranda, H., Viikari-Juntura, E., Martikainen, R., Takala, E.-P., & Riihimäki, H. (2002). Individual factors, occupational loading, and physical exercise as predictors of sciatic pain. *Spine, 27*(10), 1102-1108.

Mirka, G. A. (2005). Development of an ergonomics guideline for the furniture manufacturing industry. *Applied ergonomics, 36*(2), 241-247.

Mirmohamadi, M., Seraji, J. N., Shahtaheri, J., Lahmi, M., & Ghasemkhani, M. (2004). Evaluation of risk factors causing musculoskeletal disorders using QEC method in a furniture producing unite. *Iranian Journal of Public Health*, 24-27.

Nag, A., Vyas, H., Shah, P., & Nag, P. K. (2012). Risk factors and musculoskeletal disorders among women workers performing fish processing. *American journal of industrial medicine, 55*(9), 833-843.

Naidoo, S., Kromhout, H., London, L., Naidoo, R., & Burdorf, A. (2009). Musculoskeletal pain in women working in small-scale agriculture in South Africa. *American journal of industrial medicine, 52*(3), 202-209.

National Research Council. (1998). *Work-related musculoskeletal disorders: a review of the evidence*: National Academies Press.

National Research Council. (2001). *Musculoskeletal disorders and the workplace: low back and upper extremities*: National Academies Press.

Nejad, N. H., Choobineh, A., Rahimifard, H., Haidari, H. R., & Reza Tabatabaei, S. H. (2013). Musculoskeletal risk assessment in small furniture manufacturing workshops. *International Journal of Occupational Safety Ergonomics, 19*(2), 275-284.

Nguyen, D. H. (2016). *The development and future scenarios of wooden furniture exportation to the EU market. Case: Vietnam*.

Nicoletti, S., Consonni, D., Carino, M., Di, G. L., Trani, G., Battevi, N., . . . Ambrosi, L. (2008). Upper limb work-related musculoskeletal disorders (UL-WMSDs): a retrospective cohort study in three large factories of the upholstered furniture industry. *La Medicina del lavoro, 99*(4), 281-296.

Nunes, I. L., & Bush, P. (2012). Work-related musculoskeletal disorders assessment and prevention. *Ergonomics-A Systems Approach*.

Ojukwu, C. P., Anyanwu, G. E., Nwabueze, A. C., Anekwu, E. M., & Chukwu, S. C. (2017). Prevalence and associated factors of work related musculoskeletal disorders among commercial milling machine operators in South-Eastern Nigerian markets. *Work, 58*(4), 473-480.

Palmer, K., Griffin, M., Syddall, H., Pannett, B., Cooper, C., & Coggon, D. (2001). Exposure to hand-transmitted vibration and pain in the neck and upper limbs. *Occupational medicine, 51*(7), 464-467.

Palmer, K. T., Syddall, H., Cooper, C., & Coggon, D. (2003). Smoking and musculoskeletal disorders: findings from a British national survey. *Annals of the rheumatic diseases, 62*(1), 33-36.

Parenmark, G., Engvall, B., & Malmkvist, A.-K. (1988). Ergonomic on-the-job training of assembly workers: Arm-neck-shoulder complaints drastically reduced amongst beginners. *Applied ergonomics, 19*(2), 143-146.

Phuc, T. X., & Canby, K. (2011). Baseline study 3, Vietnam: overview of forest governance and trade. *EU FLEGT Facility, Kuala Lumpur*.

Piedrahita, H. (2006). Costs of work-related musculoskeletal disorders (MSDs) in developing countries: Colombia case. *International Journal of Occupational Safety Ergonomics, 12*(4), 379-386.

Punnett, L., & Wegman, D. H. (2004). Work-related musculoskeletal disorders: the epidemiologic evidence and the debate. *Journal of electromyography kinesiology, 14*(1), 13-23.

Putz-Anderson, V., Bernard, B. P., Burt, S. E., Cole, L. L., Fairfield-Estill, C., Fine, L. J., . . . Nelson, N. (1997). Musculoskeletal disorders and workplace factors. *National Institute for Occupational Safety and Health (NIOSH), 104*.

Schneider, E., Copsey, S., & Irastorza, X. (2010). *OSH [Occupational Safety and Health] in Figures: Work-related Musculoskeletal Disorders in the EU-Facts and Figures*: Office for Official Publications of the European Communities.

Schwartz, A. H., Albin, T. J., & Gerberich, S. G. (2019). Intra-rater and inter-rater reliability of the rapid entire body assessment (REBA) tool. *International Journal of Industrial Ergonomics, 71*, 111-116.

Silverstein, B. A., Fine, L. J., & Armstrong, T. (1987). Occupational factors and carpal tunnel syndrome. *American journal of industrial medicine, 11*(3), 343-358.

Stack, T., Ostrom, L. T., & Wilhelmsen, C. A. (2016). *Occupational ergonomics: a practical approach*: John Wiley & Sons.

Sterud, T., & Tynes, T. (2013). Work-related psychosocial and mechanical risk factors for low back pain: a 3-year follow-up study of the general working population in Norway. *Occupational and Environmental Medicine, 70*(5), 296-302.

Steven Moore, J., & Garg, A. (1995). The strain index: a proposed method to analyze jobs for risk of distal upper extremity disorders. *American Industrial Hygiene Association Journal, 56*(5), 443-458.

Thetkathuek, A., & Meepradit, P. (2018). Work-related musculoskeletal disorders among workers in an MDF furniture factory in eastern Thailand. *International Journal of Occupational Safety Ergonomics, 24*(2), 207-217.

Tran, T. T. T., Phan, C. T. T., Pham, T. C., & Nguyen, Q. T. (2016). After-shift Musculoskeletal Disorder Symptoms in Female Workers and Work-related Factors: A Cross-sectional Study in a Seafood Processing Factory in Vietnam. *AIMS public health, 3*(4), 733.

U.S. Department of Health and Human Services. Office on Women's Health. Retrieved from https://www.womenshealth.gov/a-z-topics/carpal-tunnel-syndrome

van den Heuvel, S. G., van der Beek, A. J., Blatter, B. M., Hoogendoorn, W. E., & Bongers, P. M. (2005). Psychosocial work characteristics in relation to neck and upper limb symptoms. *Pain, 114*(1-2), 47-53.

Van Nguyen, B., Tran, T. T. T., Hoang, N. T., Nguyen, B. N., & Nguyen, Q. T. (2020). Musculoskeletal pain and work-related risk factors among waste collectors in Hanoi, Vietnam: A cross-sectional study. *Open Access Macedonian Journal of Medical Sciences, 8*(E), 498-508.

Vandergrift, J. L., Gold, J. E., Hanlon, A., & Punnett, L. (2012). Physical and psychosocial ergonomic risk factors for low back pain in automobile manufacturing workers. *Occupational and Environmental Medicine, 69*(1), 29-34.

Vieira, E. R., & Kumar, S. (2004). Working postures: a literature review. *Journal of occupational rehabilitation, 14*(2), 143-159.

Viester, L., Verhagen, E. A., Hengel, K. M. O., Koppes, L. L., van der Beek, A. J., & Bongers, P. M. (2013). The relation between body mass index and musculoskeletal symptoms in the working population. *BMC musculoskeletal disorders, 14*(1), 238.

Walsh, T. P., Arnold, J. B., Evans, A. M., Yaxley, A., Damarell, R. A., & Shanahan, E. M. (2018). The association between body fat and musculoskeletal pain: a systematic review and meta-analysis. *BMC musculoskeletal disorders, 19*(1), 233.

Widanarko, B., Legg, S., Devereux, J., & Stevenson, M. (2014). The combined effect of physical, psychosocial/organisational and/or environmental risk factors on the presence of work-related musculoskeletal symptoms and its consequences. *Applied ergonomics, 45*(6), 1610-1621.

World Health Organization. (1985). *Identification and control of work-related diseases: report of a WHO expert committee. WHO Technical Report Series 714*. Retrieved from https://apps.who.int/iris/bitstream/handle/10665/40176/WHO_TRS_714.pdf

World Health Organization. (2000). *The Asia-Pacific perspective: redefining obesity and its treatment*: Sydney: Health Communications Australia.

World Health Organization. (2003). Protecting Workers' Health Series No. 5. *Preventing musculoskeletal disorders in the workplace*.

Yang, H., Haldeman, S., Lu, M.-L., & Baker, D. (2016). Low back pain prevalence and related workplace psychosocial risk factors: a study using data from the 2010 National Health Interview Survey. *Journal of manipulative and physiological therapeutics, 39*(7), 459-472.

Yang, H., Hitchcock, E., Haldeman, S., Swanson, N., Lu, M. L., Choi, B., . . . Baker, D. (2016). Workplace psychosocial and organizational factors for neck pain in workers in the United States. *American journal of industrial medicine, 59*(7), 549-560.

APPENDICES

APPENDIX A

QUESTIONNAIRE FOR INTERVIEW

Date of investigation: ………/………. / ....

Number code ID:………………………………..

PART 1. GENERAL INFORMATION OF THE PARTICIPANT

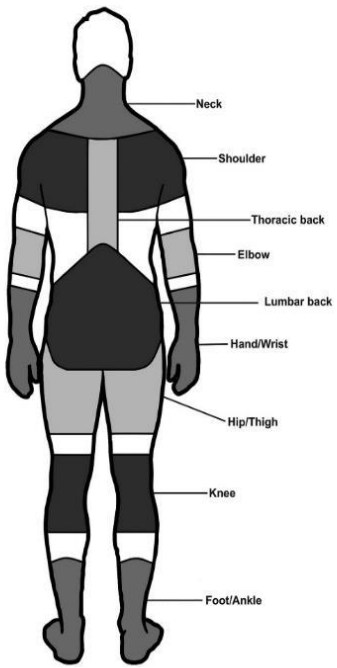
No	Question	Answer	Code	Notice
Q1	In what month, year were you born?	Month (write two digits): ….		
		Year (write four digits): ….….		
		Do not remember	99	
Q2	Gender	Male	1	
		Female	2	
Q3	In what your BMI?	Height: …………………. cm		
		Weight: …………………. kg		
		BMI: ………….		
Q4	What is your smoking status?	Never smoke	1	Jump to Q6
		Occasionally smoke	2	
		Smoking daily	3	
		Used to smoke but quit	4	
Q5	How many years did you smoke cigarettes?	.... year(s)		
Q6	How often do you have a drink containing alcohol in the last 12 months?	Never	1	Jump to Q8
		Once per month or less	2	
		2 to 4 times per month	3	
		2 or more times per week	4	
Q7	How many drinks containing alcohol do you have on a typical day when you are drinking? (1 standard cup = 120 ml beer bottle or 30 ml cup of spirit wine)	.... cup(s)		
Q8	Do you exercise or play a sport?	No	1	Jump to Q11
		Yes	2	
Q9	On average, how many days do you exercise a week?	……. day(s)/week		
Q10	What kind of exercise do you have?	Light	1	
		Moderate	2	
		Heavy	3	
Q11	Have you ever had an injury or a surgery in any musculoskeletal area in your body?	No	1	
		Yes Please clarify…..…………	2	

Q12	How long have you worked until now?	……. year(s) ...... month(s)		
Q13	How long have you been working at this factory?	……. year(s) ...... month(s)		

PART 2. ORGANIZATIONAL INFORMATION

No	Question	Answer	Code	Forward
Q14	What is your current department?	Moulder	1	
		Line A	2	
		Line B	3	
		Line C	4	
		Line D	5	
		Line Sofa	6	
		Line Toilet chair	7	
		Line Table top	8	
		Sewing	9	
		Quality control	10	
		Warehouse	11	
		Other,specify:..........................	99	
Q15	What is your main job?	Moulder (Cutter)	1	
		Forming operator	2	
		Sander	3	
		Assembler	4	
		Painter	5	
		Upholsterer	6	
		Finisher (QC)	7	
		Stocker/Loader	8	
		Other,specify:..........................	99	
Q16	What is your average time for performing the main task per day?	.... hour(s)/ day		
Q17	What kind of your working time?	Office hours	1	
		Shift	2	
		Part time	3	
Q18	During the shift, did you get a break in the middle of the time?	No	1	
		Yes	2	
Q19	In an average shift, how many times do you get a break?	…..… time(s) / shift		
Q20	How long is your average per break?	…… minute(s) / time		
Q21	Have you ever taken part in a training course before starting the job?	No	1	
		Yes	2	

PART 3. INVESTIGATION ON PARTS OF THE BODY AFFECTED BY MUSCULOSKELETAL DISORDERS



The body parts	During the last 12 months,				During the last 7 days, did you experience ache, pain, discomfort, numbness in:		Do you know where the cause came from?			If you experienced ache, pain, discomfort, how uncomfortable was this?									
	Did you experience ache, pain, discomfort, numbness in:		If you experienced, did this interfere with your ability that had to stop working for recovery?				At work	Outside work	Not sure	Mild			Moderate			Severe			
	No	Yes	No	Yes	No	Yes				1	2	3	4	5	6	7	8	9	10
Neck	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Shoulders (Right) (Left)	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐	☐	☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
Elbows (Right) (Left)	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐	☐	☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
Wrist/hands (Right) (Left)	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐	☐	☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
Upper back	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Low back	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
One or both Hip/Thighs	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
One or both Knees	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
One or both Ankles/foots	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

PART 4. HAND-ARM VIBRATION SYNDROME QUESTIONNAIRE
(*For employees using hand-held vibrating tools, machines or hand-fed processes)*

No	Question	Answer	Code	Notice
H1	Have any of your fingers gone white* on cold exposure (blanching) while working?	No	1	Jump H3
		Yes	2	
H2	If yes, how often does it occur?	Several times a year	1	
		Several times a month	2	
		Several times a week	3	
		Every day	4	
H3	Do you have any numbness or tingling of the fingers lasting more than 20 minutes after using vibrating equipment?	No	1	
		Yes	2	
H4	Do you have numbness or tingling of the fingers at any other time?	No	1	
		Yes	2	
H5	Do you wake at night with pain, tingling, or numbness in your hand or wrist?	No	1	
		Yes	2	

APPENDIX B
SELF-REPORTED QUESTIONNAIRE

The questionnaire of research "Prevalence and Risk Factors of Work-Related Musculoskeletal Disorders Among Workers in A Wooden Furniture Factory in Binh Duong province, Vietnam". All information provided will be kept privately. The result of research does not contain any information to recognize participants.

Number code: …………………………...

Instruction for answering the questions: Circle or slash '**x**' the number corresponding to the answer is most appropriate.

No	How does the work affect you?	Very disagreement	Disagreement	Agreement	Very agreement
1	My job requires me to work very quickly	□1	□2	□3	□4
2	My job requires me to work hard	□1	□2	□3	□4
3	I'm required to do excessive work	□1	□2	□3	□4
4	I don't have enough time to finish my work	□1	□2	□3	□4
5	I'm exposed to conflicting demands from others	□1	□2	□3	□4
6	My job requires long periods of intense concentration	□1	□2	□3	□4
7	My tasks are often interrupted before completion, which requires me to resume them later	□1	□2	□3	□4
8	I'm always in a hurry in my work	□1	□2	□3	□4
9	Requiring the work of other individuals or other services often slows me	□1	□2	□3	□4
10	My job allows me to make many decisions	□1	□2	□3	□4
11	I have a lot of freedom to decide how I will do my job	□1	□2	□3	□4
12	I have much to say about what happens in my work	□1	□2	□3	□4
13	I can determine the order in which I perform my tasks	□1	□2	□3	□4

14	I can determine when to work	□1	□2	□3	□4
15	I can easily leave work for short periods	□1	□2	□3	□4
16	I set break times myself	□1	□2	□3	□4
17	I can determine my own work pace	□1	□2	□3	□4
18	My work includes some repetitive tasks	□1	□2	□3	□4
19	I can set the time when I start and finish my work	□1	□2	□3	□4
20	I can interrupt my work as I wish	□1	□2	□3	□4
21	I determine days off myself	□1	□2	□3	□4
22	I know my work procedure at least one month in advance	□1	□2	□3	□4
23	My job requires me to assimilate new knowledge	□1	□2	□3	□4
24	My job requires me to be creative	□1	□2	□3	□4
25	My work involves a high level of qualification	□1	□2	□3	□4
26	My work includes many activities	□1	□2	□3	□4
27	I have the opportunity to develop skills	□1	□2	□3	□4
28	The atmosphere in the workplace is good	□1	□2	□3	□4
29	Aggressiveness is rare among my colleagues and me	□1	□2	□3	□4
30	If I want, I can get help from one or more colleagues	□1	□2	□3	□4
31	I have a good relationship with my immediate supervisor	□1	□2	□3	□4
32	Immediate supervisor takes my ideas into account sufficiently	□1	□2	□3	□4
33	Immediate supervisor has a clear picture of how I work	□1	□2	□3	□4
34	Immediate supervisor gives me enough support in my work	□1	□2	□3	□4
35	I am sufficiently informed of what’s happening at work	□1	□2	□3	□4

APPENDIX C

PHYSCIAL RISK FACTORS CHECKLIST

Evaluator:		**Date:**	
Department:		**ID:**	

No	Question	Answer	Code
Awkward posture			
1	Raising or working with the hand(s) above the head or the elbow(s) above the shoulder(s) more than 2 hours total per day.	No Yes	1 2
2	Repeatedly raising or working with the hand(s) above the head or the elbow(s) above the shoulder(s) more than 2 hours total per day.	No Yes	1 2
3	Working with the **neck** bent (without support and the chance to vary posture) more than 2 hours total per day.	No Yes	1 2
4	Working with the **back** bent forward (without support and the chance to vary posture) more than 2 hours total per day.	No Yes	1 2
5	Kneeling more than 2 hours total per day.	No Yes	1 2
6	Squatting more than 2 hours total per day.	No Yes	1 2
7	Prolonged standing more than 2 hours total per day.	No Yes	1 2
8	Prolonged sitting more than 2 hours total per day.	No Yes	1 2
Manual material handling			
9	Lifting the heavy load more than 2 hours total per day.	No Yes	1 2
10	Carrying the heavy load more than 2 hours total per day.	No Yes	1 2
11	Pushing or pulling the heavy load more than 2 hours total per day.	No Yes	1 2
12	Pinching an unsupported object weight 1 kg or more per hand; or using a force of 2 kg or more per hand total per day.	No Yes	1 2
13	Gripping an unsupported object weight 5 kg or more per hand; or using a force of 5 kg or more per hand total per day.	No Yes	1 2
14	The average weight of loading with the most strenuous activity for manual handling of heavy loads when performing the main task.	(……………… kg)	
Repetitive motion			
15	Repeating the same motion or small range actions (more than 4 times per minute)	No Yes	1 2
Hand-transmitted vibration exposure			
16	Daily exposure duration	No Yes	1 2
17	The average time of exposure for performing the 1st hand-held tool (Clarify the device :…………………….…)	(………… hours)	
18	The average time performing the 2nd vibratory machine or tool (Clarify the device :…………………….…)	(………… hours)	
19	The average time performing the other vibratory machine or tools (Clarify the device :…………………….…)	(………… hours)	

APPENDIX D
OBSERVATION FORM

REBA Tool

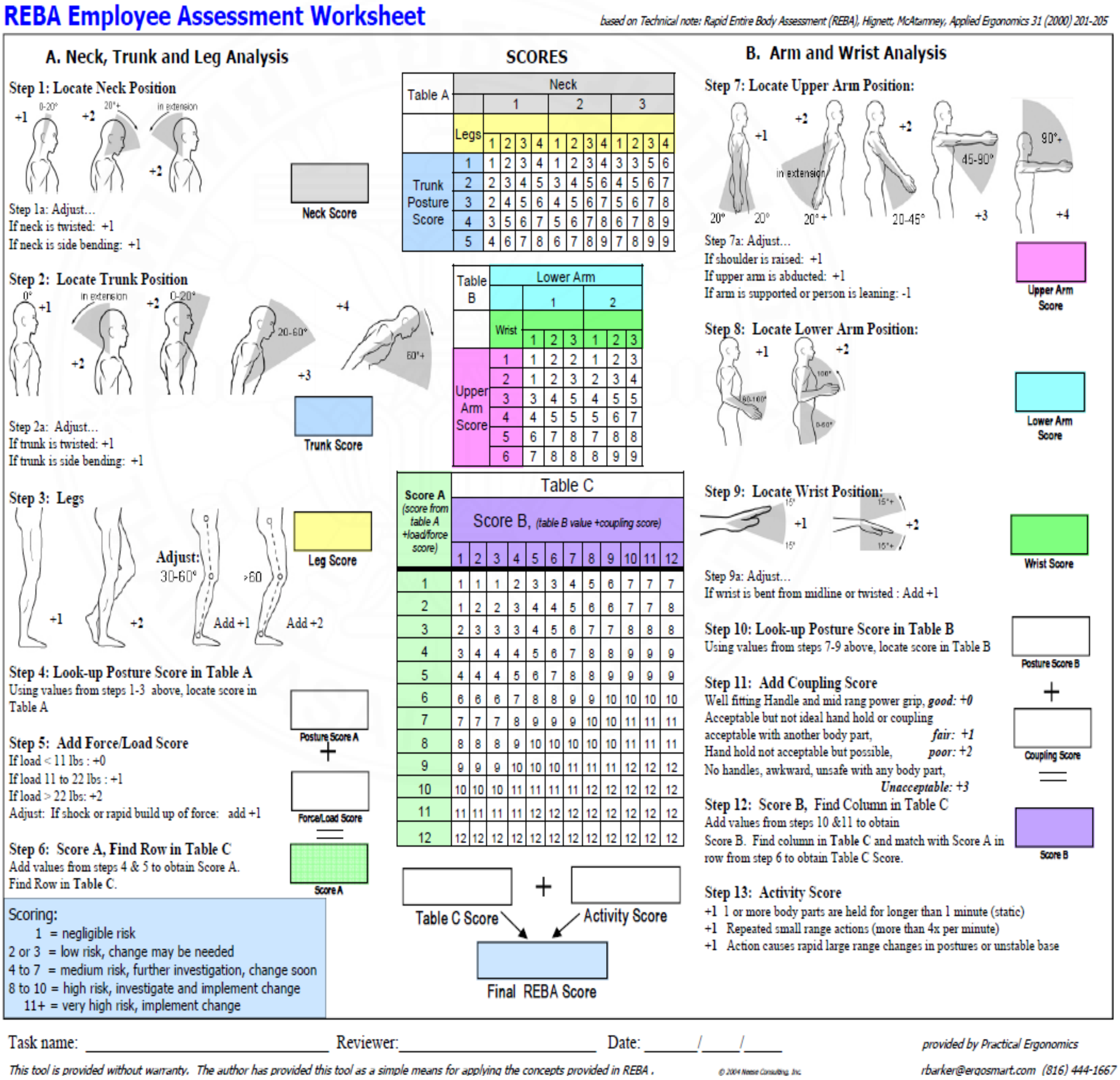
Full name of the participant: ……………………………………

Workstation/ Department: ……………………...........................

Picture code: ………………………….……………………………

Task number 1: ………………………………………………….

Task number 2: ………………………………………………….



REBA Employee Assessment Worksheet

based on Technical note: Rapid Entire Body Assessment (REBA), Hignett, McAtamney, Applied Ergonomics 31 (2000) 201-205

A. Neck, Trunk and Leg Analysis

Step 1: Locate Neck Position

+1 (0-20°), +2 (20°+), +2 (in extension)

Step 1a: Adjust…
If neck is twisted: +1
If neck is side bending: +1

Neck Score

Step 2: Locate Trunk Position

+1 (0°), +2 (in extension), +2 (0-20°), +3 (20-60°), +4 (60°+)

Step 2a: Adjust…
If trunk is twisted: +1
If trunk is side bending: +1

Trunk Score

Step 3: Legs

+1, +2, Adjust: 30-60° Add +1, >60 Add +2

Leg Score

Step 4: Look-up Posture Score in Table A
Using values from steps 1-3 above, locate score in Table A

Posture Score A

+

Step 5: Add Force/Load Score
If load < 11 lbs : +0
If load 11 to 22 lbs : +1
If load > 22 lbs: +2
Adjust: If shock or rapid build up of force: add +1

Force/Load Score

=

Step 6: Score A, Find Row in Table C
Add values from steps 4 & 5 to obtain Score A.
Find Row in Table C.

Score A

Scoring:
1 = negligible risk
2 or 3 = low risk, change may be needed
4 to 7 = medium risk, further investigation, change soon
8 to 10 = high risk, investigate and implement change
11+ = very high risk, implement change

SCORES

Table A

Table A	Neck 1				Neck 2				Neck 3			
Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk Posture Score 1	1	2	3	4	1	2	3	4	3	3	5	6
2	2	3	4	5	3	4	5	6	4	5	6	7
3	2	4	5	6	4	5	6	7	5	6	7	8
4	3	5	6	7	5	6	7	8	6	7	8	9
5	4	6	7	8	6	7	8	9	7	8	9	9

Table B

Table B	Lower Arm 1			Lower Arm 2		
Wrist	1	2	3	1	2	3
Upper Arm Score 1	1	2	2	1	2	3
2	1	2	3	2	3	4
3	3	4	5	4	5	5
4	4	5	5	5	6	7
5	6	7	8	7	8	8
6	7	8	8	8	9	9

Table C

Score A (score from table A +load/force score)	Score B (table B value +coupling score) 1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

Table C Score + Activity Score

Final REBA Score

B. Arm and Wrist Analysis

Step 7: Locate Upper Arm Position:

+1 (20°, 20°), +2 (in extension, 20°+), +2 (20-45°), +3 (45-90°), +4 (90°+)

Step 7a: Adjust…
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Upper Arm Score

Step 8: Locate Lower Arm Position:

+1 (60-100°), +2 (100°+, 0-60°)

Lower Arm Score

Step 9: Locate Wrist Position:

+1 (15°), +2 (15°+)

Step 9a: Adjust…
If wrist is bent from midline or twisted : Add +1

Wrist Score

Step 10: Look-up Posture Score in Table B
Using values from steps 7-9 above, locate score in Table B

Posture Score B

+

Step 11: Add Coupling Score
Well fitting Handle and mid rang power grip, *good: +0*
Acceptable but not ideal hand hold or coupling acceptable with another body part, *fair: +1*
Hand hold not acceptable but possible, *poor: +2*
No handles, awkward, unsafe with any body part, *Unacceptable: +3*

Coupling Score

=

Step 12: Score B, Find Column in Table C
Add values from steps 10 &11 to obtain Score B. Find column in Table C and match with Score A in row from step 6 to obtain Table C Score.

Score B

Step 13: Activity Score
+1 1 or more body parts are held for longer than 1 minute (static)
+1 Repeated small range actions (more than 4x per minute)
+1 Action causes rapid large range changes in postures or unstable base

Task name: ____________________ Reviewer: ____________________ Date: ___/___/___

provided by Practical Ergonomics
rbarker@ergosmart.com (816) 444-1667

APPENDIX E
HAND-ARM VIBRATION RESULT

Machine/ Operation: 1. Orbital sander						
No	a_{hwx} (m/s^2)	a_{hwy} (m/s^2)	a_{hwz} (m/s^2)	a_{hv} (m/s^2)	Statistics	
					$\overline{a_{hv}}$ (m/s^2)	s_{n-1}
1	3.045	4.335	3.443	6.318	6.446	0.11
2	3.572	3.931	3.782	6.52		
3	3.449	4.02	3.766	6.499		

Machine/ Operation: 2. Edge sander						
No	a_{hwx} (m/s^2)	a_{hwy} (m/s^2)	a_{hwz} (m/s^2)	a_{hv} (m/s^2)	Statistics	
					$\overline{a_{hv}}$ (m/s^2)	s_{n-1}
1	2.419	1.495	1.776	3.353	3.042	0.32
2	1.655	1.624	1.993	3.058		
3	1.311	1.188	2.056	2.713		

Machine/ Operation: 3. Pistol drill machine						
No	a_{hwx} (m/s^2)	a_{hwy} (m/s^2)	a_{hwz} (m/s^2)	a_{hv} (m/s^2)	Statistics	
					$\overline{a_{hv}}$ (m/s^2)	s_{n-1}
1	4.572	4.403	4.625	7.853	8.151	0.506
2	4.900	2.947	5.396	7.863		
3	6.055	2.558	5.753	8.735		

Machine/ Operation: 4. Screwdriver						
No	a_{hwx} (m/s^2)	a_{hwy} (m/s^2)	a_{hwz} (m/s^2)	a_{hv} (m/s^2)	Statistics	
					$\overline{a_{hv}}$ (m/s^2)	s_{n-1}
1	2.257	1.596	2.525	3.744	4.776	0.949
2	3.065	2.389	3.102	4.972		
3	3.068	1.689	4.385	5.613		

Machine/ Operation: 5. Upholstery stapler						
No	a_{hwx} (m/s^2)	a_{hwy} (m/s^2)	a_{hwz} (m/s^2)	a_{hv} (m/s^2)	Statistics	
					$\overline{a_{hv}}$ (m/s^2)	s_{n-1}
1	0.442	0.501	0.456	0.809	0.909	0.163
2	0.441	0.531	0.445	0.821		
3	0.544	0.742	0.599	1.098		

Machine/ Operation: 6. Paint spray gun						
No	a_{hwx} (m/s^2)	a_{hwy} (m/s^2)	a_{hwz} (m/s^2)	a_{hv} (m/s^2)	Statistics	
					$\overline{a_{hv}}$ (m/s^2)	s_{n-1}
1	1.054	0.704	0.652	1.426	1.527	0.118
2	1.063	0.791	0.698	1.497		
3	0.559	1.142	1.063	1.657		

Note: $\overline{a_{hv}}$ = *the average of total acceleration value, in m/s*^{2}

s_{n-1}= *the standard deviation value*

APPENDIX F

CERTIFICATE OF CALIBRATION

TECHMASTER
ELECTRONICS J.S.C
Global Leader in Test Equipment Solutions

707 Street 7, Lot A An Phu - An Khanh, An Phu Ward
District 2, Ho Chi Minh City, Vietnam
Tel.: (028) 6266 2333 - Fax: (028) 6266 1333
www.techmaster.com.vn - info@techmaster.com.vn

ANAB ACCREDITED ISO/IEC 17025 CALIBRATION LABORATORY Cert. #: AC-1868

ilac-MRA

M.S.D.N: 0312668882 - C.T.C.P CÔNG TY CỔ PHẦN ĐIỆN TỬ TECHMASTER QUẬN 2-T.P HỒ CHÍ MINH

CERTIFICATE OF CALIBRATION

Certificate Number (Giấy Chứng Nhận Số)
TSG-0-18804

Customer: / **Tên Khách Hàng**	**VIỆN Y TẾ CÔNG CỘNG TPHCM** **159 Hưng Phú, Phường 8,** **Quận 8, TPHCM.**		
Manufacturer: / **Nhà sản xuất:**	**Svantek**	*Report Number:* / **Giấy chứng nhận số :**	TSG-0-18804
Description: / **Tên thiết bị**	*Human Vibration Meter & Analyser* / ***Máy đo rung phân tích dải tần***	*Calibration Date:* / **Ngày hiệu chuẩn :**	01/Apr/2019
Model: / **Kiểu**	SV106A	*Recommended Due:* / **Ngày hiệu chuẩn sắp tới (đề nghị) :**	01/Apr/2020
Size / Range: / **Khoảng sử dụng**		*Calibration Location:* / **Nơi hiệu chuẩn**	*In-Laboratory* / **Tại phòng Lab**
Serial Number: / **Số hiệu**	**69135**	*Condition Received:* / **Điều kiện khi nhận**	*In Tolerance* / **Trong Sai Số Cho Phép**
Asset Number: / **Số quản lý**	**U01/CD/2017**	*Condition Returned:* / **Điều kiện khi trả**	*In Tolerance* / **Trong Sai Số Cho Phép**
P.O. Number: / **Số P.O**	**TEV-YTCC190123**	*Procedure:* / **Quy trình hiệu chuẩn**	ĐLVN 264 : 2014
Accessories : / **Phụ kiện kèm theo**	***N/A***	*Environment:* / **Điều kiện môi trường**	23°C ± 2°C/52%RH ± 3%RH

This certifies that the above instrument was calibrated in compliance with the Calibration Systems Requirement of ISO/IEC 17025:2005 in accordance with referenced procedures. Standards used to perform this calibration are traceable to SI units;, their source of traceability derives from a National Metrology Institute such as NIST, CENAM, NPL, DIN, VMI..., from natural physical constants, consensus standards procedures or derived by the ratio type of calibrations. Estimated statements of uncertainty are determined as required with a distribution that corresponds to a probability of approximately 95% (k=2), no sampling plan or other process was used for this calibration, the results reported herein apply only to the calibration of the item describe above .All calibrations are performed to manufacturer's specifications, unless otherwise noted. Customer has been contacted concerning re-certification interval and documentation has been received and is on file. This form shall not be reproduced, except in full, without the expressed written consent of Techmaster Electronics. If the manufacturer has a specified tolerance for this item, then the calibration results, with our uncertainty value added, are compared to this tolerance, and the combined value.

Calibration Accuracy: Base on Manufacturer's Specifications or Customer's Specifications.
Sai số của thiết bị được hiệu chuẩn: *Dựa trên thông số kỹ thuật của nhà sản xuất hoặc của Khách Hàng đưa ra.*
Remark **(Ghi chú):**

Standards Used **(Các thiết bị chuẩn được sử dụng)**

Standard Number / *Số hiệu t.bị chuẩn*	**Manufacturer** / *Nhà Sản Xuất*	**Model** / *Kiểu*	**Due Date** / *Hạn hiệu chuẩn*	**Report Number** / *Giấy C.N. Số*	**Traceability** / *Liên kết chuẩn*
TEV- ME0370	VMI INTERNATIONAL AB	CA200	25/Aug/2019	TME-105399	NMI

Certified By Technician: ***(Được hiệu chuẩn bởi)*** T E 121 V — Doan Huu Duc

Inspected By Auditor: ***(Được kiểm tra bởi)*** TEV 44 — Nguyen Van Tien

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District 2, Ho Chi Minh City, Vietnam
Tel.: (028) 6266 2333 - Fax: (028) 6266 1333
www.techmaster.com.vn - info@techmaster.com.vn

CALIBRATION REPORT

Report Number (Giấy chứng nhận số): TSG-0-18804

Manufacturer: *Svantek* ***Model:*** *SV106A* ***Asset No. / Serial No.:*** *U01/CD/2017 / 69135*
Nhà sản xuất *Kiểu* *Số quản lý / Số seri*

1 Acceleration Accuracy Test (Kiểm tra độ chính xác gia tốc)

Frequency Tần số	**Standard Value** *Giá trị chuẩn*	**As Found** *Giá trị trước khi chỉnh*	**As Left** *Giá trị sau khi chỉnh*	**Correction** *Số hiệu chỉnh*	**Expanded Uncertainty** *Độ không đảm bảo đo mở rộng*
31.5 Hz	2.700 m/s^2_{rms}	2.711	2.711	-0.011	0.017
63 Hz	5.400 m/s^2_{rms}	5.423	5.423	-0.023	0.017
125 Hz	10.700 m/s^2_{rms}	10.735	10.735	-0.035	0.017
250 Hz	21.300 m/s^2_{rms}	21.356	21.356	-0.056	0.017
500 Hz	42.500 m/s^2_{rms}	42.562	42.562	-0.062	0.058
1000 Hz	85.000 m/s^2_{rms}	85.061	85.061	-0.061	0.058

*** Note (Ghi chú):**
• The reported uncertainty of measurement was based on a standard uncertainty multiplied by a coverage factor k = 2.00, providing a level of confidence of approximately 95 %.
Báo cáo về độ không đảm bảo đo dựa trên độ không đảm bảo đo chuẩn nhân với hệ số phủ k = 2, với độ tin cậy 95%.

*** Explanation (Diễn giải):**
• *As Found: value before adjust*
Giá trị đo được trước khi điều chỉnh
• *As Left: value after adjusted*
Giá trị đo được sau khi điều chỉnh
• *Correction: The result of a measurement in which the instrument gave a reading is obtained by adding the correction to the reading*
Hệ số hiệu chỉnh: giá trị được cộng thêm vào chỉ số đọc của thiết bị để thu được kết quả đo chính xác

Certified By Technician: Được hiệu chuẩn bởi — Doan Huu Duc

Inspected By Auditor: Được phê duyệt bởi — Nguyen Van Tien

APPENDIX G
CERTIFICATION OF VALIDITY EVALUATION FOR RESEARCH TOOL

Name of experts

1. Dr. Ngoc Dang Tran Ph. D – Lecturer of Ho Chi Minh City Medicine and Pharmacy University, Ho Chi Minh City, Vietnam
2. Dr. Nguyen Bich Ha - Occupational disease physician. - Head of Occupational Disease Clinic – Instutite of Public Health HCM City, Minister of Health, Vietnam.

Letters for validated the research tools and questionnaire

DANG NGOC TRAN	THIEN THUC TRAN
Vice Director, Grant and Innovation Center Lecturer, Environmental and Occupational Health Department University of Medicine and Pharmacy at HCMC Mobile: +84-985137435 Email: tranngocdang@ump.edu.vn Research gate: https://www.researchgate.net/profile/Ngoc-Dang-Tran	Master student of Occupational and Environmental Health, Faculty of Public Health, Thammasat University

Date February 10th 2020

Dear Thien Thuc Tran,

According to your letter on "Inviting to be an expert to perform Tool Validity", from my background on Public Health, I am happy to give comments on thesis topic named "PREVALENCE AND RISK FACTORS OF WORK-RELATED MUSCULOSKELETAL DISORDERS AMONG WORKERS IN A WOODEN FURNITURE FACTORY AT BINH DUONG PROVINCE, VIETNAM".

The questionnaire consists of 4 parts: General information, Organizational information, Investigation on parts of body affected by Musculoskeletal disorders and Hand-arm vibration syndrome information. The checklist is for assessing the physical factors in workplace. Overall, your research tools is consistent with research's objectives, clear lay-out and content. The questionnaire is carefully designed, suitable for interviewing furniture workers in Binh Duong province, Vietnam.

The both questionnaire and instruments need to be used carefully when conducting onsite.

Finally, I am fully agreed to employ the research tools for your thesis.

Sincerely,

TRAN NGOC DANG

NGUYEN BICH HA

Head of Occupational Disease Clinic
Deputy Dean of Labor Health and Occupational Disease Department
Institute of Public Health Ho Chi Minh City
Mobile: (+84)090.88.77.820
Email: nguyenbichha@iph.org.vn

THIEN THUC TRAN

Master student of Occupational and Environmental Health, Faculty of Public Health, Thammasat University

Date .... 2020.

Dear Thien Thuc Tran,

According to your letter on "Invitation to act as a Translation expert to evaluate the content validity of the research tool", I am happy to be the validity contributor for your study titled "PREVALENCE AND RISK FACTORS OF WORK-RELATED MUSCULOSKELETAL DISORDERS AMONG WORKERS IN A WOODEN FURNITURE FACTORY AT BINH DUONG PROVINCE, VIETNAM".

The interview questionnaire consists of 4 parts: General information, Organizational information, Investigation on parts of body affected by Musculoskeletal disorders and Hand-arm vibration syndrome information. The self-reported questionnaire includes 35 questions about psychosocial factor with the 4-point Likert scale. Overall, your both questionnaires are well designed, cover all relevant parts of research's objectives, clear lay-out and suitable content for interview. After our previous discussions, the questionnaires were translated into Vietnamese language, including nuances of particular words, the nature of different contexts, and so on, until agreement was reached about the Vietnamese translations matching with the original questionnaires.

From my background of occupational physician, I am totally agreed with your translation into Vietnamese version, and encourage to employ these research tools for your study.

Kindest regards,

NGUYEN BICH HA

APPENDIX H
CERTIFICATE OF APPROVAL

ScF 03_01 (Eng)

The Ethical Review Sub-Committee Board for Human Research Involving Sciences, Thammasat University, No. 3

Room No. 110, Piyachart Building, 1st Floor, Thammasat University Rangsit Campus, Prathumthani 12121, Thailand, Tel: 0-2986-9213 ext.7358 E-mail: ecsctu3@nurse.tu.ac.th

COA No. 062/2563

Certificate of Approval

Project No.	:	029/2563
Title of Project	:	Prevalence and risk factor of Work-related Musculoskeletal disorders among workers in a wooden furniture factory in Binh Duong province, Vietnam
Principle Investigator	:	MR. THIEN THUC TRAN

Place of Proposed Study/Institution: Faculty of Public Health, Thammasart University

The Ethical Review Sub-Committee Board for Human Research Involving Sciences, Thammasat University, No. 3, Thailand, has approved the above study project, in accordance with the compliance to the Declaration of Helsinki, the Belmont report, CIOMS guidelines and the International practice (ICH-GCP).

Signature:...............................
(Assoc. Prof. Jinda Wangboonskul, Ph.D.)
Chairman of the Human Ethics
Sub-Committee of Thammasat University, No. 3

Signature: ....
(Assoc. Prof.Laksana Laokiat, Ph.D.)
Secretary of the Human Ethics Sub-Committee of
Thammasat University, No. 3

Date of Approval : 14 June 2020
Progressing Report Due : 13 June 2021

Approval Expire date : 13 June 2021

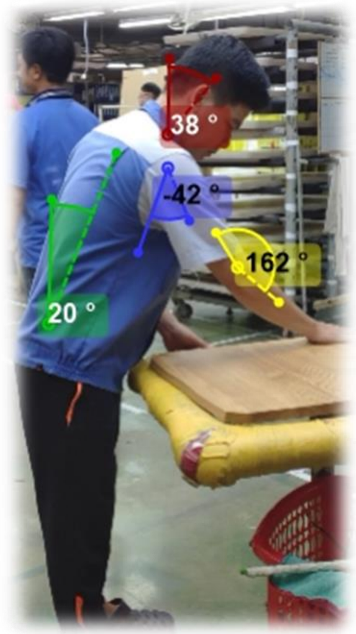
The approval documents including

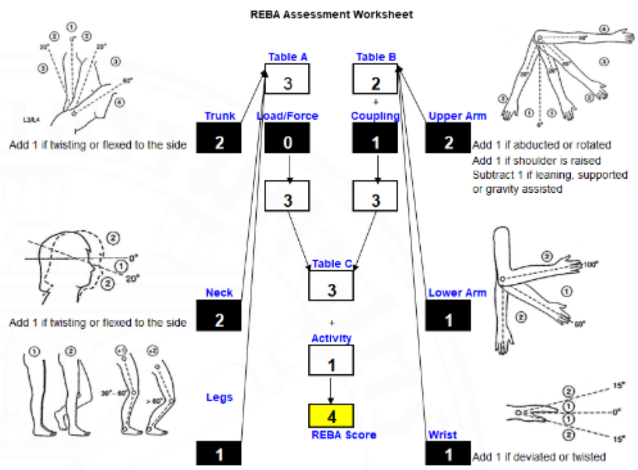
1) Research proposal
2) Patient/Participant Information Sheet and Informed Consent Form
3) Principal investigator's Curriculum Vitae
4) Questionnaire for Interview
5) Self-Reported Questionnaire
6) Physical Risk Factors Checklist
7) Observation Form
8) Hand-Arm Vibration Form

APPENDIX I

SEVERAL IMAGES FOR REBA ANALYSIS

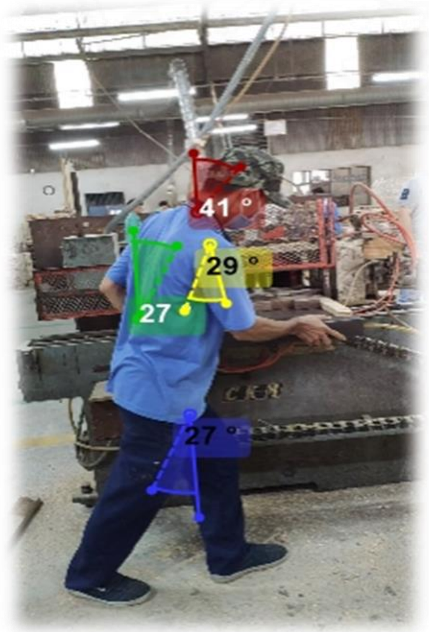
1. Quality Controller

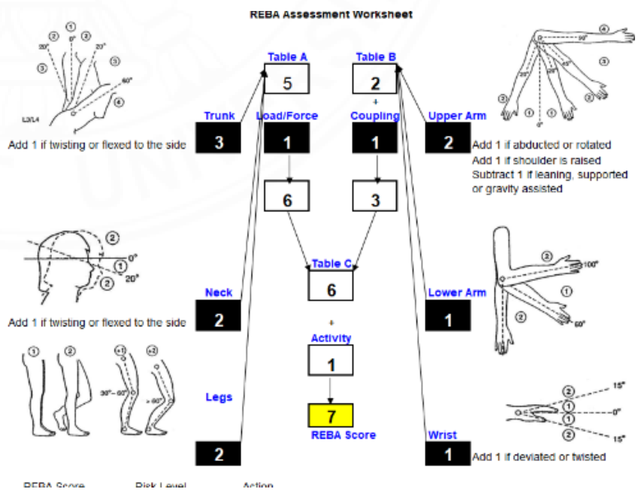




5. ID 223 – REBA score 4

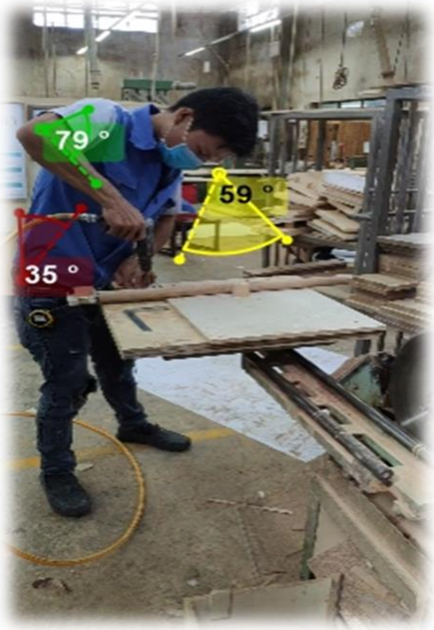
2. Moulder

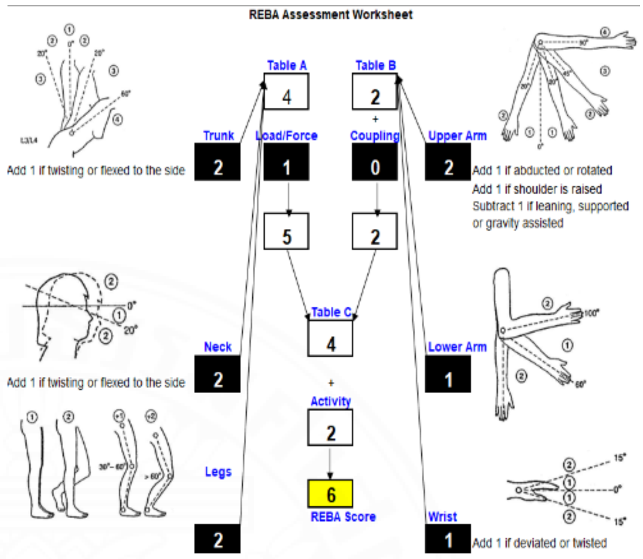




8. ID 12 – REBA score 7

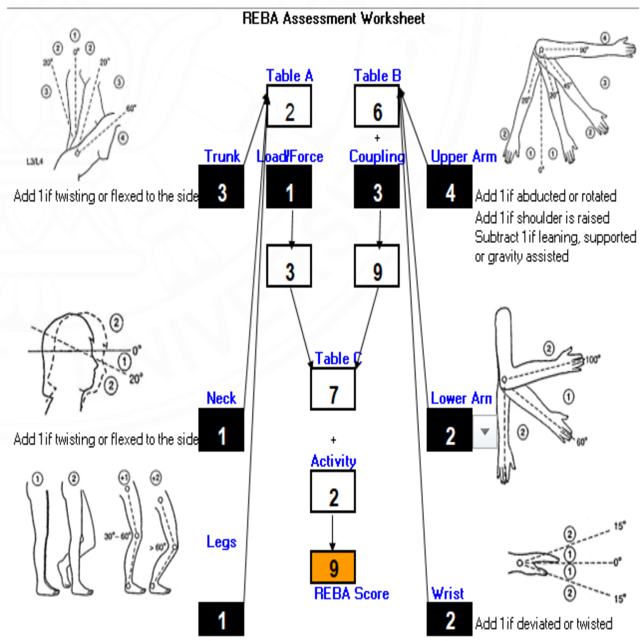
3. Forming Operator





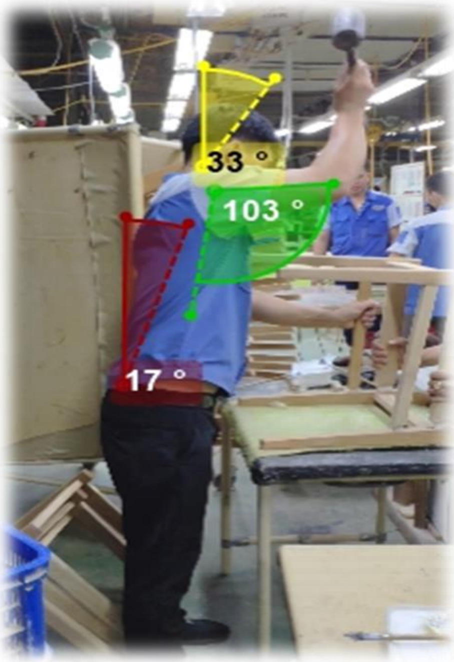
11. ID 101 – REBA score 6

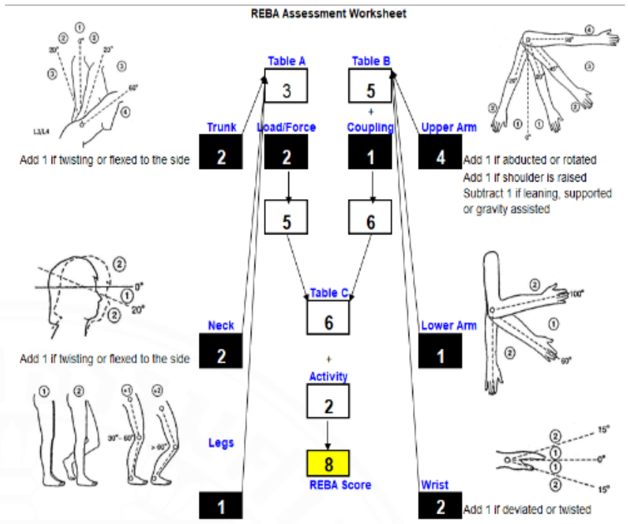
4. Sander



14. ID 138 – REBA score 9

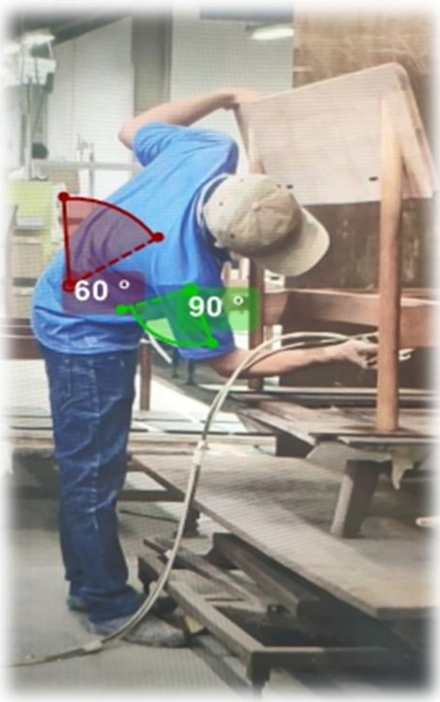
5. Assembler

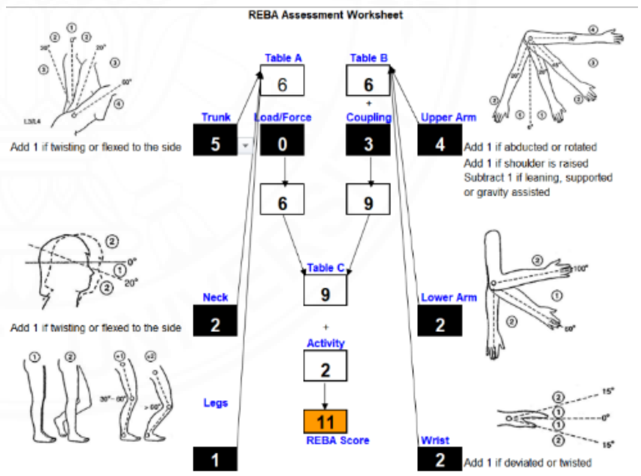




17. ID 138 – REBA score 8

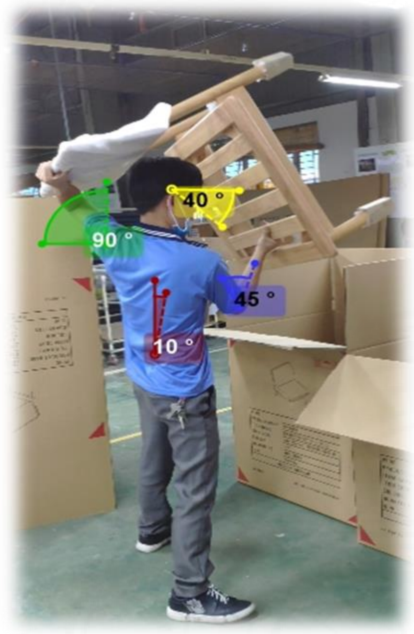
6. Painter

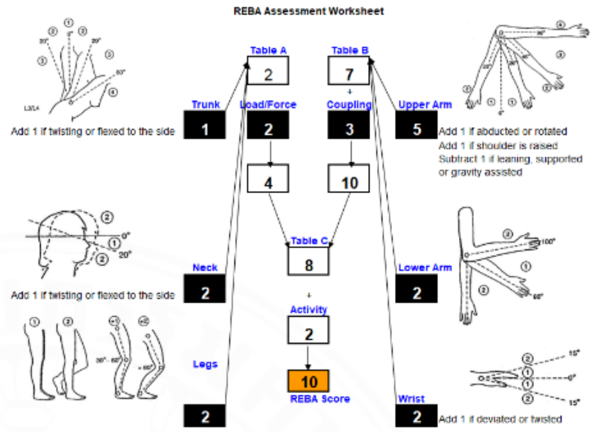




20. ID 196 – REBA score 11

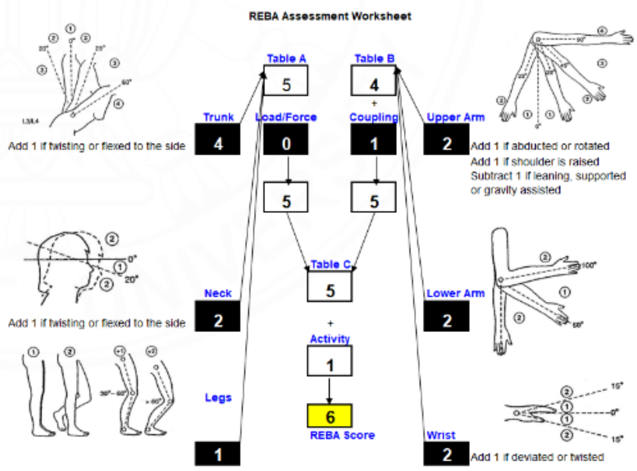
7. Packager





23. ID 195– REBA score 10

8. Upholster



26. ID 176 – REBA score 6

BIOGRAPHY

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Educational Attainment	Academic Year 2010: Bachelor of Public Health, University of Medicine and Pharmacy at Ho Chi Minh City, Vietnam
Scholarship	Year 2018: Occupational and Environmental Health Program for Master degree
Publications	Social Determinants Affecting Immigrant Labourer's Health in Binh Hoa Village, Binh Duong province, 2011. *Le Hoang Ninh*, Trinh Hong Lan* and Tran Thuc Thien** Institute of Public Health, Vietnam (Ho Chi Minh City Medicine Journal ,2012, Episode 16, No.3)
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