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# Preliminary Study on Work-related Musculoskeletal Disorder and Ergonomic Implementation Program among Wood Carvers in Chiang Mai Province, Thailand

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## Abstract

**Purpose:** To survey the work-related risk from wood carving and preliminarily assess the effectiveness of an ergonomic implementation program among wood carvers.
**Methods:** A survey on musculoskeletal disorder (MSD) was conducted by using unstructured conversation, observation, and a focus group. The nature and opinion of the workers, using tools, work station, postures, environment and opinion on adapting to ergonomic factors were investigated and developed for an ergonomic implementation program. Work-related MSD was assessed by the Rapid Upper Limbs Assessment (RULA) at before and after implementation for three weeks. Moreover, the knowledge and, satisfaction on implementation program, and pain sensation were evaluated. Results from the survey result from 25 male wood carvers aged 45.76±8.3 years old showed that. The size, dimension and design of the devices affected to MSD. Most of the wood carvers had low back pain. After ergonomic program was implemented by educated and trained in 14 wood carvers, the knowledge score improved significantly, except total RULA and total pain scores of all regions. But the RULA and pain scores at low back region showed significant improvement.
**Conclusion:** Low back pain was predominantly in wood carvers and a specific ergonomic implementation program can improve posture and reduce pain.
**Keywords:** Ergonomic; Wood carving; Work-related musculoskeletal disorder

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## Introduction

Work-related musculoskeletal disorders (WMSDs) are of interest, and many industries focus on the office [1], with varied prevalence depending on the occupations in each country, such as transport laborers, cooks, storage laborers, shop salespersons, and building structure cleaners in South Korea, [2]. Moreover, some work that needs contact stress, forceful contraction and awkward postures, as in a cashew factory, induces pain at the knee, back and shoulder, respectively [3]. The main problem proposed from WMSDs has been muscle pain from in corrected posture. Upper and lower back pain are still implied, for example, cervical pain was more frequent in tailoring and packing work, whereas lumbar pain was more common in buffing, and press operators [4]. Previous evidence showed that WMSDs was varied and depend on various occupations, for example the frozen food industry in Thailand [5], and low back pain as well as shoulder pain could be detected in Thai women during construction-related work [6]. Unfortunately, whether these problems presented among wood carvers in Chiang Mai had not been surveyed or confirmed. Wood carving is a specific occupation and needs vast experience, especially from its predecessors, as reputable craftsmen produce Thai wood carvings that are famous worldwide, like ceramics, candles, bronze ware, Buddhist sculpture and dragons (Figure 1).

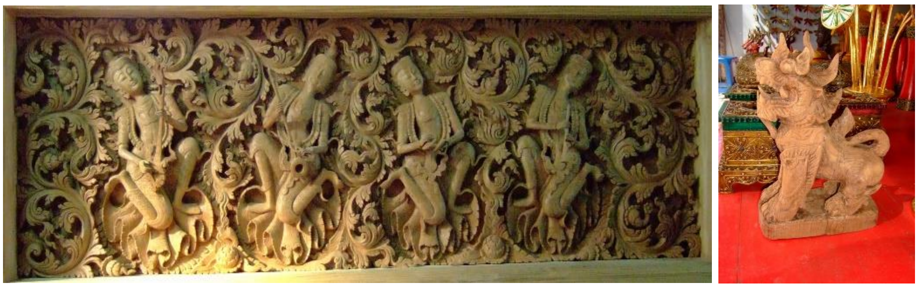

**Figure 1:** Wood carving handicrafts: graving (left) and floating (right).

The traditional wood carving has been performed by low-sitting on the floor. Thus, the posture of wood carvers does not look safe and possibly provokes musculoskeletal disorder. Slumping and prolong static posture with neck, head and lower back flexion increase the WMSDs, especially with pain caused by contradicting the guideline for good posture [7]. Good posture has been proposed to maintain the head, neck and back in a coronal plane, by keeping joints in a neutral position, using suitable tools and distributing weight while sitting. Working postures that should be avoided for long duration were informed by Warren & Sanders [8], as follows: neck flexion at more than 20 degrees, shoulder

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flexion or abduction at more than 30 degrees, shoulder extension and internal rotation, extreme elbow flexion, extreme sup nation and pronation with grasp, extreme wrist flexion or extension, and ulna or radial deviation while grasping tools. Moreover, design of the workstation also is very important for workers and so adjustable tables are used [7]. For example, an adjustable work station was developed for carpet weavers, and results showed that working posture was appropriate, and postural discomfort reduced when the weaving height was adjusted to 20 cm above elbow height and a high seat sloping forward was used [9]. Moreover, hand tools also were shown to influence working posture of the upper limbs of 44 hairstylists [10,11]. Previous evidence proposed that the risk factor from inappropriate posture, either static or dynamic and [8], work environment such as lighting, dust and noise level related to the WMSDs [8]. Finally, previous evidence mentioned that WMSDs such as injuries and pain produced industrial problems, and this was accepted worldwide. Furthermore, poor working postures and movements were the main causes of injuries [12]. Therefore, musculoskeletal injury, pain and fatigue led to a reduction of productivity. Therefore, the aims of study were to survey the WMSDs and risk factors among wood carvers, and evaluate the effectiveness of an ergonomic implementation program after focus group discussion on WMSD problems and satisfaction in posture, pain and knowledge.

## Materials and Methods

This study was a survey with a preliminary education study model, divided into two phases: Phase I surveyed the characteristics of wood carving work, tools, workplace environment and perceived WMSDs before developing an ergonomic implementation program from brain storming ideas between wood carvers and researchers.Phase IIinvolved a cross-sectional descriptive study of risk, conductedto evaluate the postures, satisfaction, knowledge and area of pain in wood carving workers after educating and teaching themin a 3-month ergonomic implementation program. This research was carried out at Baan Tawai, Khun Kong sub-district, Hang Dong district, Chiang Mai province, Thailand. Before the survey or data collection, individual personal contact with the wood carvers was made for obtaining their agreement and informed consent.

**Participants:** The approved participants in phase I and II were recruited by purposive sampling and snowballing approach. The inclusion criteria were as follows: 25 healthy male wood carvers inBaan Tawai village,who had at least 3 years' experience in wood carving. Wood carvers who had health problems such as pulmonary or cardiovascular disease (tuberculosis, asthma, chronic obstructive pulmonary disease [COPD], heart failure, etc.,or severe musculoskeletal problems such as fracture, etc.), were excluded from this study.

**Assessments and Procedures:** General information recorded on a form was used initially for the survey, moreover the tools, workstation, environment, and working postures were analyzed from digital photographs. An initial survey questionnaire with related pictures was used for conversations, interviews and probing questions for the wood carving workers and community leaders. Digital camera and voice recorders were used to gather data in this phase. Focus group interviews started 3 months after the initial survey and lasted for 2 days. After data analysis, the overall conclusions were presented to wood carver for agreement in the community. Then, the wood carvers were persuaded to join a health education meeting (Table 2), which was held under the previous criteria [13]. Knowledge of ergonomics was evaluated before starting the health education program and again

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immediately after the meeting had finished. The risks found in phase I were presented to all of the wood carvers for improvement on the ergonomic knowledge and other related topics such as proper working posture, risk of worst posture and a proper workstation and environment. According to a health belief model (HBM) construction [13]. The knowledge from the program was assessed immediately after education, and compared to that before the meeting. Finally, brain storming between the workers and researchers was performed in order to establish ideas on ergonomic factors for designing an ergonomic implementation program that included tools, workstation, work environment, and concept of safety in wood carving work. Baseline data of work, pain during work, knowledge, and satisfaction of the implementation program were assessed in work information questionnaires performed before and after three weeks of ergonomic implementation and in accordance with the Rapid Upper Limb Assessment (RULA), Employee Assessment Worksheet (© Professor Alan Hedge, Cornell University. Nov. 2000). For adherence and control in performing the ergonomic implementation program, a self-recording log book was used.

**Outcomes:** Quantitative and qualitative variables in phase I of this study consisted ofdemographic data (age, duration of working experience,education level, and working condition); unknown in-depth knowledge (reflecting the intelligence of local people regarding wood carving tools);opinion of wood carving workersabout the conditions and situations in a working period, body mechanics, workstation and environment; perceived WMSDs from wood carving and workers' recognition;opinion of wood carving workersabout the effect of tools, workstation, and work environment on working posture, as perceived by experienced workers; information about adjustment of tools, workstation, and work environment. After brainstorming and ergonomic implementation for three weeks, the knowledge and satisfaction scores were questioned.In addition, total RULA scores, individual RULA region scores, and pain scale were analyzed.

**Statistical analysis**: Qualitative data in thissurvey study were analyzed by usingcontent analysis.The data were transcribed from tape recording into text, and then themes were developed to form a base for probing questions. Checking accuracy and rigor in the analysis wascarried out by using methodological triangulation and saturation [14]. Methodological triangulation was performed by checking data using 3 different methods. Data of general information from interviews and observation from the initial survey and two rounds of focus group member checks were analyzed. Whereas quantitative data were represented with frequency, distribution, percentage, mean and standard deviationwhen using ergonomic implementation and demographic data of the participants.Moreover, before and after initiating the ergonomic implementation program, the total RULA, individual RULA region and knowledge, satisfactory and pain scores were evaluated.

## Results

### Characteristics of participants

Twenty-five participants from total 42 malewoodcarvers were interviewed initially in this survey study.Their characteristics aredescribed in Table 1**.** They were aged between 30 and 59 years with the mean and standard deviation of 45.76±8.3 years. Their work experience ranged from 10 to 40 years with the mean and standard deviation of 27.36±9.17 years. Their level of education was high school (1,4%) and lower level (24,96%), and working period ofat least 5 days per week (22,88%) and less than 5 days a week (3,12%).

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| **Table 1:** Demographic data of 25 male woodcarvers who joined the focus group. | |
|---|---|
| **Parameters** | |
| **Age (years)**<br>Range (mean±SD) | 30-59 (45.76±8.3) |
| **Work experience (years)**<br>Range (mean±SD) | 10-40(27.36±9.17) |
| **Education level [n (%)]**<br>High school and lower level<br>Above high school | <br>24 (96%)<br>1(4%) |
| **Work day/ week[ n(%)]**<br>Less than 5 days<br>At least 5 days | <br>3 (12%)<br>22 (88%) |

**Conventional tools and workstation during wood carving**

Initial survey results showed that wood carving tools were designed from traditional culture and wisdom with a selection of tough and forced absorbed wood such as that from lemon, pomelo, guava or tamarind trees for chisel handles (Figure 2). Moreover, the wood carvers worked in stationary and prolong sitting positions on the floor (Figure 3). Therefore, this posture presented a hump back and neck and knee flexion induced back pain. Further more, chisel handles, iron hammer heads, sew Ngon (curved chisel), or iron stamps can be unsafe tools. Wood carvers often used a slouching posture for a low work station, whichrelates to their pain. This survey found that common areas of pain are a result of using a slouching posture, for example,pain and ache at the neck, back, shoulders, scapulars, arms, elbows, wrists, hands, knees and calves; tension at the anterior thighs, numbness in the hands, cramping of the feet, and foot injury due to wood falling on the feet. Moreover, the focus group found all wood carvers preferring work environments thathad a comfortable temperature, good ventilation and atmosphere, and peaceful surroundings.


**Figure 2:** Wood carving tools; chisel handle (A), iron hammer head covered with rubber (B), Sew Ngon (curved chisel ) (C), iron stamps (D).

**Figure 3:** Sitting posture of wood carvers.

**Preliminaryeducation and theergonomic implementation program**

From the survey, brain storming and ideas from previous data, education under the health belief model construction (Table 2) and the ergonomic implementation program (Table 3) were designed and performed.

The program for education was divided into six constructed items; perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy (Table 2). Firstly, in order to perceive susceptibility, a one and half hour lecture and practice were performed, with the main

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objective of finding the risk factors of wood carving work, proper postures and relationship between poor working postures and musculoskeletal disability. Secondly, perceived severity of functional impairment and disability was carried out by a lecture and shared views for 20 minutes. Thirdly, perceived benefits showed how to improve work safety, proper working conditions and benefit of risk reduction by discussion, lecture, and one-hour of practice. Fourthly, the types of perceived barriers and how to get rid of those barriers were dealt with in a 20-minute brain storming session, discussion and advice. Fifthly, cues for action were activated by two hours of facilitating and sharing ideas in order to design a preliminary ergonomic implementation program. A three-week preliminary ergonomic implementation program (Table 3) applied to 14 wood carvers. Finally, 30 minutes of self-efficacy was constructed among the wood carvers.

The ergonomic implementation program was designed (Table 3) and consisted of 4 domains; (1) tool adaptation with hammer handles having grooves for fitting fingers or the hammer head wrapped in rubber (Figure 4), (2) workstation management by designing a tilting adjustable desk and stool for individual carvers (Figure 5), andthe desk should be cleaned every time after use and the wood chips kept in a separate area (Figure 6), (3) work guideline for instruction on the basicseven stretching patterns and two strengthening patterns (Figure 7), and a cooling down exercise program, and (4) self-massage as an individual activity for anyone who has an area of pain and prefers tomassage using traditional thai wooden instruments.

**Efficacy of education and the ergonomic implementation program**

After the 14 wood carvers had completed their education and the ergonomic implementation program, the knowledge score increased significantly from 3.21±1.05 to 4.07±0.83 after one month of implementation, but there was no immediate statistical difference ineducation (3.42±1.40) (Table 4). In addition, the satisfaction score on implementation wasthe highest (5 out of 5) in all items: education and brainstorming, work guideline, total adjustment, workstation adjustment, environmental adjustment and stretching and strength exercise program.

**Table 4:** Knowledge score (pre- and post-tests) after recent implementation (1st post-test), at the end of the 1st and 4th week of ergonomic implementation (n=14).

| **Knowledge score** | **Mean** | **Standard deviation** | **Range (Total 5)** |
|---|---|---|---|
| Pre-test | 3.21 | 1.05 | 1-5 |
| 1st Post-test | 3.43 | 1.40 | 1-5 |
| 2nd Post-test*/** | 4.07 | 0.83 | 2-5 |
| 3rd Post-test*/** | 4.21 | 0.89 | 2-5 |

* Wilcoxon Signed Ranks Test; significant difference from pretest ($p<0.05$)
** Wilcoxon Signed Ranks Test; significant difference from 1st posttest ($p<0.05$)

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**Table 2:** Education program following the health belief model constructs, health education objectives, topics, activities and duration [13].

| **Constructs** (“definitions”) | **Objectives of learning** | **Topics** | **Activities** | **Duration** |
|---|---|---|---|---|
| Perceived susceptibility (“Belief about the chances of experiencing a risk or getting a condition or disease”) | Toknow the risk factors of wood carving work | 1. Risk factors of wood carving found from phase I and RULA assessment<br>2. Concepts of proper postures<br>3. Relationship between work-related musculoskeletal disorders (WMSDs) and poor working postures | Lecture and practice | 1 hour 30 minutes |
| Perceived severity (“Belief about how serious a condition is and its sequelae are”) | Toknow severity of functional impairment and disabilities resulting from WMSDs | Functional impairment and disabilities resulting from WMSDs | Lecture and sharing views | 20 minutes |
| Perceived benefits (“Belief in efficacy of the advised action to reduce risk or seriousness of impact”) | To know how to improve work safety, proper working situations and benefit of risk reduction | 1. How to improve work safety | 1. Brainstorming or discussion and lecture (share and learn) | 1 hours |
| | | 2. Proper working situation (working posture, appropriate hand tools, workstation, environment and work pace/breaks) | 2. Lecture and practice | |
| | | 3. Expected positive results of using the proper working situation | 3. Brainstorming or discussion and lecture (share and learn) | |
| Perceived barriers (“Belief about the tangible and psychological cost of the advised action”) | To know barriers | What are the barriers?<br>How do we get rid of the barriers? | Brainstorming or discussion and advice (share and learn) | 20 minutes |
| Cues to action (“Strategies to activate readiness”) | To activate readiness | 1. Guidelines and brainstorming ideas | 1. Facilitation and brainstorming ideas | 2 hours |
| | | 2. Ergonomic implementation program in Phase III | 2. Implementation of the program design | 3 months |
| Self-efficacy (“Confidence in one’s ability to take action”) | To construct self-confidence of workers in implementation | Conclusion and making scenario of the ergonomic implementation program | Lecture and practice | 30 minutes |

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**Table 3:** Ideas about the ergonomic implementation program frombrainstorming.

| No. | Ergonomic factors and examples | Ideas |
|---|---|---|
| 1 | Tool | - Hammer handle with grooves forfitting fingers<br>- Rubber wrapped around thehammer head |
| 2 | Workstation<br><br>Examples;<br>- tilted adjustable desk and stool prototype | - Tilted adjustable desk and stool forone woodcarver, who works with a flat and small piece of wood<br>- Desk and tilted adjustable stool for one woodcarver, who works with flat and small piece of wood<br>-Two pieces of wood to support the workpiece and tilted adjustable stool for one woodcarver, who works with a flat and big piece of wood<br>- Height adjustable desk and tilted adjustable chair for one woodcarver who works with varied styles of work pieces<br>- Shelf provided by the wood carvers for placing tools that are used frequently<br>- “กุ๋ม” old style of woodcarving workstation composed of rain tree logand bench,1-2 m. wide, but this one has an added backrest and traditional Thai wooden massager for self-massage |
| 3 | Environment | - Cleaned every time after work<br>- Dividing workplace from areafor wood chip storage |
| 4 | Work guideline | - Taking a rest by standing and doing curved up back exercise or other physical activity<br>- Stretching before and after work and during rest period<br>- Other exercisesuch as back stabilization exercise<br>- Program poster created by researchers for warning of exercise: 5 minutes stretching exercisewith itsbenefit |
| 5 | Self-massage | Individual activity for anyone who has area of pain and prefers tomassage such as using a traditional Thai wooden massager for self-massage (provided by the workers) |

RULA was used to investigate effectiveness of the ergonomic implementation program. After the ergonomic implementation program, the total RULA score from risk assessment in 14 wood carvers was equal to 6.5 (range 5-7). Although this score indicated poor working posture with risk of injury, but there was no statistical difference between after and the ergonomic implementation However, when the individual RULA score for each region, was reassessed after the ergonomic implementation, the score of upper limbs (median=4.0), neck (median=3.0) and lower limbs(median=1.0) was not statistically different from before implementation (4.0, 3.0 and 1.0), except the trunk scores (median=3.0 and 3.6) (p=0.034) (Table 5).

**Table 5:** The RULA scores of upper limb, neck, trunk, and lower limb between pre- and post-implementation (n=14).

| Areas | Pre-implementation | Post-implementation | P |
|---|---|---|---|
| Upper limb | 4.00 (3.75-4.0) | 4.0 (4.0-4.0) | 0.257 |
| Neck | 3.0 (2.0-3.0) | 3.0 (3.0-4.0) | 0.160 |
| Trunk | 3.6 (7.0-5.0) | 3.0 (3.0-4.0) | 0.034 |
| Lower limb | 1.0 (1.0-1.0) | 1.0 (1.0-1.0) | 1.000 |

**Note:** Data presents with median (ranges), P value was analyzed statistically with the Wilcoxon Signed Ranks Test. RULA=Rapid Upper Limb Assessment.

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The results of total pain score for all regions at baseline and at the end of implementation showed no significant difference (3.93□1.98 and 3.43□2.28). However, when regions were separated, 9 of the 14wood carvers presented pain at the lower back (9,64%), when compared to other regions such as the shoulder (3, 21%), knee (3.21%), neck (2,14.28%), wrist (2, 14.28%), and claves (2, 14.28%). Other areas such as the elbow, hand and thigh also presented pain (1, 7.14%). After three weeks of the ergonomic implementation program, the pain scale showed that only the lower back had significantly less pain than before implementation ($p< 0.05$).

**Figure 4:** Hammer handle with grooves for fitting fingers (left) and rubber wrapped around hammer head and/ or handle and chisel handle (right).


**Figure 5:** The original or conventional workstation with sloping work surface (A) and a tilting adjustable desk and stool prototype (B).

**Figure 6:** Environmental adjusted (left) and tilting adjustable tasks (right) are provided.


**Figure 7:** Seven stretching exercise programs composed of abdominal and thigh stretching (A), upper thoracic stretching in long sitting (B), lateral trunk and forearm stretching in standing (C), scapular stretching (D), lateral neck and shoulder stretching (E), pectoralis with neck stretching (F), and elbow and wrist stretching (G).Strengthening exercise with standing and stretching arm against the wall (H) and standing and bending the knee (I). Each pattern performedis repeated 10 times and held for 10 seconds.(The photos were presented by co-author, MsKanokporn who haspermitted them for academic publication in this study).

## Discussion

This was a preliminary study of wood carvers in Chiang Mai province, Thailand. Previous data showed some WMSDs among wood carvers at Baan Tawai, which is the most famous work place for handicraft and souvenirs in Chiang Mai [15,16]. Previous survey results showed that wood carving tools, work posture, workstations and environment are the same as the sequence of action for jobs related to WMSDs [12]. In practical theory, complex repetitive tasks are associated with upper extremity disorder [17], especially from bad posture such as crossed-legged and heel sitting, which induce slow back pain among handicraft workers [18]. This preliminary study also found that wood carving tools derive from cultural wisdom, and are made from the wood of lemon, pommel, guava and tamarind trees. Moreover, most wood carvers work sitting on the floor or in a stationary sitting position during prolonged carving sessions, therefore, back pain was presented in this survey. Furthermore, common pain areas at the neck, back, shoulders scapulars, arms, elbows, wrists, hands and calves; tension at the anterior thighs, numbness in the hands and

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cramping of the feet also were shown because of prolonged sitting in a slouching posture. This result of pain at lower back region was consistent with a previous study that showed significant increase of backache from prolong low-sitting in people who worked with furniture in school [19]. On the other hand, sitting on heels or on the floor with the lower back in a slouching posture is similar to the standing posture of rice farmers in the field [20], which presents predominate pain in the lower back area, as in a previous study on sitting postures of handicraft workers that showed fatigue of lumbar multifidus and internal oblique muscles when working while sitting on their heels [18]. In addition, the results also are consistent with previous data that found risk factors of low back pain in movements such as dragging, pushing or moving objects, and repetitive hand or arm movements [21]. In addition, work time is one of the main risk factors in WMSDs, which is the same as in a previous study that presented prolonged working hours exceeding physical capacity in welders, causing fatigue, joint pain, and swelling, strain and sprain of ligaments and soft tissue [22]. When this survey study was evaluated completely, an education program was performed by dividing it into six constructions: perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy. Details of the education program comprised risk factors, proper posture and musculoskeletal disability from wood carving. Furthermore, the perceived benefits of work safety, proper working conditions and risk reduction, and perceived barriers were then discussed in order to activate readiness for cues to act in developing the ergonomic implementation program, although there was no previous evidence of an education program for wood carvers. The ergonomic implementation program in this study developed a hammer adapted for safe handling with grooves in the handle for fingers to fit and rubber wrapped around the hammer head. However, a workplace safety sheet reported that a good hammer has a rubber handle with pinch grip, which is generally more comfortable to use and produces greater force with the lower strain on the forearm, wrist and hand muscles, and ligaments and joints [23]. Furthermore, it has been proposed that handle length and grip size also affect pain in the hand among carpenters [24]. In addition, the workstation was managed by developing a tilting adjustable desk and stool for individual carvers, as a previous report showed a work station designed with a high seat that sloped forward by approximately 10 degrees in order to provoke anterior pelvic tilt [9,25] in industrial carpenters [11]. Furthermore, a prolonged static working day can induce muscle fatigue and tightness [8], and this might be the main cause of less wood carving productivity. Moreover, intervention with tool adjustment and workstation management for all wood carvers was consistent with previous suggestions for performing stone carving for handicraft workers [26]. In addition, the education program included knowledge of the environment; for example, clean, comfortable and safe surroundings, especially regarding all devices being kept in shelved cabinets, which was consistent with another report [27]. Furthermore, this study included the work guideline protocol, especially the basic stretching and strengthening exercise for the 14 wood carvers in this study. Previous study found that the stretching exercise program on the back, shoulder and neck joints was easy to learn and perform [28]. This study performed the stretching exercise program, which was taught with seven patterns of back, leg, shoulder and neck regions, before strengthening the shoulder, arm and hand muscles. The stretching exercise in this program was adapted from a previous study [28] that was designed with thirteen exercises from McKenzie [29] and Whilliam [30], and guidelines of the American College of Sport Medicine (ACSM) [31]. Instruction in constant and controlled stretching of each pattern was

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performed, and tension slowly applied to the muscle at the end of the joint's range of motion (ROM). Moreover, the program included a strengthening exercise of the arms and lower limbs by pushing against a wall and bending the knee or performing a dumb gesture for improving strength of the upper and lower limbs, especially in wood carvers. Although the strengthening exercise did not implement weight training, bodyweight was used. The set of stretching and strengthening exercises was designed for performance once a day/3 times a week, with each session lasting approximately 10-15 min. Each individual strengthening exercises was performed 10 repetitions of 3 sets (with a rest of 60-120 s between sets). All of the exercise sessions took place at the worksites of the wood carvers at any time during the working day. Finally, the ergonomic implementation program included self-massage for anyone who had pain. Although there is no evidence supporting immediate benefits of self-massage on wood carvers, self-myofascial release on a latent trigger point on the lateral gastrocnemius muscles [32] could reduce the sensitivity of pain significantly. Interesting results showed higher knowledge and satisfaction scores in all 14 wood carvers when all of the education and ergonomic implementation program were presented. However, knowledge in preventing musculoskeletal disorder among wood carvers must be of concern because a previous study claimed that lack of knowledge on ergonomics in 102 hospital personnel, whose primary job was on computers, affected job performance [33]. Moreover, appropriate postures, work environment and workstation design were important factors for improving on the job designs in the workplace [34]. Unfortunately, this study could not conclude that job performance involved knowledge and satisfaction in education, and this should be studied in the future.

Finally, the interesting results of clinical improvement on posture in this study was evaluated by using the RULA sheet. Previous studies found that RULA is standardized and reliably good for evaluating posture in various populations, such as computer posture in children [35]. In addition, the RULA is a better assessor in presenting musculoskeletal disorders in the lower back and neck area, when compared to assessments from the Rapid Office Strain Assessment (ROSA) [36], Novel Ergonomic Postural Assessment (NERPA) and Rapid Entire Body Assessment (REBA) [37]. In addition, it has been used for health-risk assessment of musculoskeletal disorders and is related to overall posture disorder [38]. It also can be used to evaluate postures (arms, forearms, wrists, neck, trunk, and legs), number of movements, and static muscle work and force [39]. The procedures are composed of scoring and recording the postures by using a scoring sheet, body-part diagrams, and tables. Then, the scores are converted to one of the four action levels, which indicate the time frame needed for risk control to be initiated (posture acceptable to changes is required immediately) [40]. The RULA is used to assess tasks including computer work, manufacturing, or jobs that entail sitting or standing without moving about [40]. It plays different roles in many studies such as investigation of work-related disorders [41], ergonomic indicators [42-44], risk factors [45-47], risk levels [48] and physical demands [49], and was used for evaluation in this study, as the intra- and inter-testers of RULA were rechecked and acceptable with an ICC of 0.7. Thus, good assessment with good reliability was confirmed, as in previous studies in children [35] and adults [50]. In this study, the median RULA score, with 5-7 ranges, was 6.5, indicating very high risk and a need to implement change with consistency now for low back pain in both sites (64.28%) [40], but not in other regions such as the neck, shoulder or knee. In addition, the ergonomic implementation program also includes management of environments and workstation adjustment to see whether these issues can

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reduce musculoskeletal disorder, which still needs to be confirmed. However, this study proposed that poor postures, bad workstations and environment are the main risk factors in wood carving work. Appropriate postures, work environment and workstation design are important factors for improving job designs in the workplace [34], especially regarding adaptive workstations that ideally should be supported yearly, as suggested previously [19]. However, the ergonomic implementation program was designed after the wood carver participants had trained for a short period of time, but this was consistent with a previous pilot study, which confirmed awareness of physical stains and workplace interventions, including physical exercise having significant benefits on stressful trunk postures in 6 nursing homes [51]. However, non-significant results in this study are possibly from the short period of intervention, when compared to a six-month study by Kozak.

## Innovation from this research and Conclusion

The innovated tool and workstation from this research were formed from participatory development between woodcarvers and researchers using low cost technology, which was appropriated for small and flat woodcarving designs. Therefore, there were some limitations in using a variety of woodcarving designs. If the funding and technology are available, a fixed wooden desk that is easily adjustable should be developed. In this study, a tilting adjustable desk was designed from an old workstation with a comfortable lower back and leg position. Furthermore, the stand stools on both sides were for easy management that should be safe for woodcarvers. Whereas, the arm support was not designed by following a previous study, which preferred sitting with pivotal transfer [52], because of the need for wood carvers to move freely during working hours. Interesting results in a previous study proposed that stand stools are a good alternative for workers who change frequently from sitting to standing while working [53]. Whereas, in this study, most of the wood carvers worked sitting on a seat. Therefore, an adaptable seat should be more preferable for those workers than a stand seat. Moreover, improving occupational health and safety has been suggested in a participatory model, and as in this study, participatory approaches to preliminary assessment, observation of informal practices, group discussion and [54]. However, this study can conclude that musculoskeletal disorder, especially pain, is presented predominately at the lower back in wood carvers, and specially implemented in the ergonomic implementation program with education. Management of instruments, environments and seating during carving work can reduce musculoskeletal problems, especially pain severity, which is consistent with previous evidence of102 hospital personnel, who received education intervention that showed a significant decrease in pain intensity [33].Therefore, the results of this preliminary study combined education and implementation with ergonomic knowledge and adjustment on devices and equipment for wood carvers. They also showed health benefits that protect wood carvers in Chiang Mai province, Thailand, from musculoskeletal disorder.

## Limitation of study and suggestions

Due to the small sample size of woodcarvers in the local area of Chiang Mai province, the results in this study showed non-significant changes.There also were carving jobs at a low- and high-floor work-status, and the varied results must be repeated for evaluation in the future, especially adaptation of a specific work station, which must be considered for individual work.

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## References


1. Yasobant S, Rajkumar P. 2014. Workt-related musculoskeletal disorders among health car professionals: a cross-sectional assessment of risk factors in a Tertiary hospital, Indal. Indian J Occup Environ Med. 18: 75-81. Ref.: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4280781/
2. Choi HW, KimYK, Kang DM, et al. 2017. Characteristics of occupationsl musculoskeletal disorders of five sections in service industry between 2004 and 2013. Ann Occup Environ Med. 29: 41. Ref.: https://bit.ly/2w4k7XU
3. Girish N, Ramachandra K, Arun GM, et al. 2012. Prevalence of musculoskeletal disordrers among cashew factory workers. Arch Envrion Occupa Health. 67: 37-42. Ref.: https://bit.ly/3bISWkM
4. Joshi TK, Mennon KK, Kishore J. 2001. Musculoskeletal disorders in industrial workers of Delhi. Int J Occupa Environ Health. 7: 217-721. Ref.: https://bit.ly/2UzXUdI
5. Thetkathuek A, Meepradit P, Jaidee W. 2016. Factors affecting the musculoskeletal disorders of workers in the frozen food manufacturing factory in Thailand. Int J Occup Saf Ergon. 22: 49-56. Ref.: https://bit.ly/2UzGUUR
6. Hanklang S, Kaewboonchoo O, Silpasuwan P, et al. 2014. Musculoskeletal disorders among Thai women in construction-realted work. Asia Pac J Public Health. 26: 196-202. Ref.: https://bit.ly/3aAH7gg
7. Khalil TM, Abdel-Moty EM, Rosomoff RS, et al. Ergonomics in back pain: a guide to prevention and rehabilitation. 1993: New York: Van Nostrand Reinhold.
8. Warren N, Sanders MJ. 2004. Biomechanical risk factors . In M.J. Sanders (Ed). Ergonomics and the management of musculoskeletal disorders. 2nd Edition. St. Louise: Butterworth Heinemann. 191-229.
9. Choobineh A, Hosseini M, Lahmi M, et al. 2007. Musculoskeletal problems in Iranian hand-woven carpet industry: Guidelines for workstation design. Appl Ergon. 38: 617-624. Ref.: https://bit.ly/343Heyc
10. Boyles JL, Yearout RD, Rys MJ. 2003. Ergonomic scissors for hairdressing. Int J Indus Ergon. 32: 199-207. Ref.: https://bit.ly/39FI4Tn
11. Motamedzade M, Choobineh A, Mououdi MA, et al. 2007. Ergonomic design of carpet weaving hand tools. Int J Indus Ergon. 37: 581-587. Ref.: https://bit.ly/2UR2YJM
12. Delleman NJ, Haslegrave CM, Chaffin DB. 2004. Introduction. InDelleman NJ, Haslegrave CM, Chaffin DB, (Eds). Working postures and movements: tools for evaluation and engineering (pp.1-5). Boca Raton: CRC Press.
13. Glanz K, RimerBK, ViswanathK. 2008. Health behavior and health education: theory, research, and practice. 45-65. Ref.: https://bit.ly/2Uwgeo6
14. Bureekul T, Pongsaksri M. 2007. Focus group interview: technology of participation and data collection for research (Thai). 2nd edition. Bangkok: Ngandee Creation.
15. Yimyam S, Jirapattarapimol B. 2007. Work conditions and health problems among wood carving workers. J Nurs Meas. 22: 79-100.
16. Chairat W. 2008. Erogomics evaluation in problems and risk factors of the wood crafting workers in Ban Tawai (Term Paper). Available from Term Perper database. Faculty of Associated Medical Sciences, Chaing Mai University, Chiang Mai. Thailand.
17. Pritchard SE, Tse CTE, Mc Donald AC, et al. 2019. Postural and muscular adaptations to repetitive simulated work. Ergonomics. 18: 1-13. Ref.: https://bit.ly/3bG6tJz
18. Areeudomwong P, Puntumetakul R, Kaber DB, et al. 2012. Effects of handicraft sitting postures on lower trunk muscle fatigue. Ergonomics. 55: 693-703. Ref.: https://bit.ly/2X1Rp5g
19. Guelfi R, Conti M, Zanfrini S, et al. 2019. Postural disorders produced by school furniture on a population. ArchItal Biol. 157: 15-23. Ref.: https://bit.ly/2UwSIr8
20. Puntumetakul R, Yodchaisarn W, Emasithi A, et al. 2015. Prevalence and individual risk factors assocated with clinical lumber instability in rice farmers with low back pain. Patient Prefer Adherence. 9: 1-7. Ref.: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4274132/
21. Kim JY, Shin JS, Lim MS, et al. 2018. Relationship between simutaneous exposure ergonomic risk factors and work-related lower back pain: a cross-sectional study based on the fourth Korean working conditions surveyAnn

DOI: https://doi.org/10.36811/gjpr.2020.110005 GJPR: April-2020: Page No: 01-16

Occup Environ Med. 30-58. Ref.: https://bit.ly/3bLmHRZ
22. Suman D, Debamalva B, Shankaraskis M. 2018. A Report Based on Analysis of Posture and Occupational Health of Welders in Different Welding Units. Univers J Public Health. 6: 127-134.
23. WSN Ergonomic Safety Talk #4. Hand Toolds. Workplace Safety North. Avalible from:work place safety north.
24. Haque MT. 2018. Ergonomic design of hammer handle to reduce musculoskeletal disorders of carpenters. Int J Res AdvEng Technol. 4: 78-83. Ref.: https://bit.ly/3dL4Tbo
25. Choobineh A, Tosian R, Alhamdi Z, et al.2004.Ergonomic intervention in carpet mending operation. Appl Ergon. 35: 493-496. Ref.: https://bit.ly/39DcipQ
26. Meena ML, Dangayach GS, Bhardwa A. 2011. Impact of Ergonomic Factors in Handicraft Industries. International Conference on Mechanical, Production and Automobile Engineering. Pattaya. Thailand.
27. Cantley LF, Taiwo OA, Galusha D, et al. 2014. Effect of systematic ergonomic hazard identification and control implementation on musculoskeletal disorder and injury risk. Scand J Work Environ Health. 40: 57-66. Ref.: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4096997/
28. Shariat A, Cleland JA, Danaee M, et al. 2018. Effects of stretching exercise training and ergonomic modifications on musuloskeletal discomforts of office workers: a randomized controlled trial. Braz J Phys Ther. 22: 144-153. Ref.: https://bit.ly/39Ab66P
29. Garcia AN, Costa Lda C, Hancock MO, et al. 2015. Efficacy of the McKenzie method in pathients with chronic nonspecific low back pain: a protcocol of randomized placebo-controlled trial. Phys Ther. 95: 267-273. Ref.: https://bit.ly/3bJunnK
30. Sihawong R, Janwantanakul P, Sitthipornvorakul E, et al. 2011. Exercise therapy for office workers with nonspecific neck pain: a systematic review. J Manipulative Physiol Ther. 34: 62-71. Ref.: https://bit.ly/2WY8qNy
31. Thompson PD, Arena R, Eiebe D, et al. 2013. ACSM's new preparicipation health screening recommendations from ACSM's guidelines for exercise testing and prescription. Curr Sports Med Rep. 12: 215-217. Ref.:https://bit.ly/39wg1FD
32. Wike J, Vogt L, Banzer W. 2018. Immediate effects of self-myofascial release on latent trigger point sensitivity; a randomized, placebo-controlled trial. Biol Sport. 35: 349-354. Ref.: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6358529/
33. Sanaeinasab H, Saffari M, Valipour F, et al. 2018. The effectiveness of a model-based health education intervention in office computer workers; a randomized controlled trial. Int Arch Occup Environ Health. 91: 951-962. Ref.: https://bit.ly/2JxX7nn
34. Sanaeinasab H, Saffari M, Valipour F, et al. 2018. The effectiveness of a model-based health education intervention in office computer workers; a randomized controlled trial. Int Arch Occup Environ Health. 91: 951-962. Ref.: https://bit.ly/2JxOHw6
35. Dockrell S, O'Grady E, Bennett K, et al. 2012. An investigation of the reliability of Reapid Upper Limb Assessment (RULA) as a method of assessment of children's computing posture. Appl Ergon. 43: 632-636. Ref.: https://bit.ly/2w5X6UD
36. Mohammadipour F, Pourranjbar M, Naderi S, 2018. Work-related musculosketal disorders in Iranian office workers; prevalence and risk factors. J Med Life. 11: 328-333. Ref.: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6418332/
37. Yazdanirad S, Khoshakhlagh AH, Habibi E, et al. 2018. Comparing the Effectiveness of Three Erognomic Risk Assessment Methods-RULA, LUBA, and NERPA-to Predict the Upper Extremity Musculoskeletal Disorders. Indian J Occup Environ Med. 22: 17-21. Ref.: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5932905/
38. Micheletti-Cremasco M, Giustetto A, Caffaro F, et al. 2019. Risk assessment for musculoskeletal disorders in Forestry: A comparision between RULA and REBA in the manual feeding of a wood-chipper. Int J Environ Resear Public Health. 16: 793. Ref.: https://bit.ly/3bG9iKF

DOI: https://doi.org/10.36811/gjpr.2020.110005 GJPR: April-2020: Page No: 01-16


39. Santos J, Sarriegi JM, Serrano N, et al. 2007. Using ergonomic software in non-repetitive manufacturing processes: A case study. Int J Indus Ergon. 37: 267-275. Ref.: https://bit.ly/2JuE3qb
40. McAtamney L, Corlett EN. 1993. RULA: a survey method for the investigation of work-related upper limb disorders. Appl Ergon. 24: 91-99. Ref.: https://bit.ly/2UxEupO
41. McAtamney L, Corlett EN. 2004. Rapid Upper Limb Assessment (RULA). InStanton N,Hedge A,Brookhuis K, Salas E,Hendrick H. (Eds). Handbook of human factors and ergonomics methods. Boca Raton: CRC Press. 1-11. Ref.: https://bit.ly/2UzaUAj
42. Choobineh A, Lahmi M, Hosseini M, et al. 2004.Workstation design in carpet hand-weaving operation: guidelines for prevention of musculoskeletal disorders. Int Occup Saf Ergon. 10: 411-424. Ref.: https://bit.ly/2ylhxNT
43. Gonzalez BA, Adenoso-Diaz B, Torre PG. 2003. Ergonomic performance and quality relationship: an empirical evidence case. Int J Indust Ergon. 31: 33-40. Ref.: https://bit.ly/2UBapWt
44. Kilroy N, Dockrell S. 2000. Ergonomic intervention: Its effect on working posture and musculoskeletal symptoms in female biomedical scientists. Br J Biomed Sci. 57: 199-206. Ref.: https://bit.ly/2UycIcH
45. Hoy J, Mubarak N, Nelson S, et al. 2005. Whole body vibration and posture as risk factors for low back pain among fork lift truck drivers. J Sound Vib. 284: 933-946. Ref.: https://bit.ly/2Uyd2Ir
46. Sundstrup E, Jakobsen MD, Andersen CH, et al. 2013. Participatory ergonomic intervention versus strength training on chronic pain and work disability in slaughterhouse workers: study protocol for a single-blind, randomized controlled trial. BMC Musculoskelet Disord. 14: 67. Ref.: https://bit.ly/2R1Jocm
47. Labbafinejad Y, Imanizade Z, Danesh H. 2016. Ergonomic risk factors and their association with low back and neck pain among pharmaceutical employees in Iran. Workplace Health Saf. 64: 586-595. Ref.: https://bit.ly/2UTO7yc
48. Keester DL, Sommerich CM. 2017. Investigation of musculoskeletal discomfort, work postures, and muscle activation among practicing tattoo artists. Appl Ergon. 58: 137-143. Ref.: https://bit.ly/3bKvWS6
49. Jones T, Strickfaden M, Kumar S. 2005. Physical demands analysis of occupational tasks in neighborhood pubs. Appl Ergon.36: 535-545. Ref.: https://bit.ly/3dOdwli
50. Levanon Y, Lerman Y, Gefen A, et al. 2014. Validity of the modified RULA for computer workers and reliability of one observation compared to six. Ergonomics. 57: 1856-1863. Ref.: https://bit.ly/3bA89o6
51. Kozak A, Freitag S, Nienhaus A. 2017. Evalualtion of a training program to reduce stressful trunk postures in the nursing professoions: a pilot study. Ann Work Expo Health. 61: 22-32. Ref.: https://bit.ly/2WZF15B
52. Kim SS, Her JG, Ko TS. 2015. Effect of different hand positions on trunk and shoulder kinematics and reaction forces in sitting pivot transfer. J Phys Ther Sci. 27: 2307-2311. Ref.: https://bit.ly/2UwxJEG
53. Arborelius UP, Wretenberg P, Lindberg F. 1992. The effects of armrests and high seat heights on lower-limb joint load and muscular activity during stiing and rising. Ergonomics. 35: 1377-1391. Ref.: https://bit.ly/2ytgFXT
54. Manothum A, Rukijkanpanich J, Thawsaengskulthai D, et al. 2009. Arphorn S.A participatory model for improving occupationl health and safety; improving informal sector working conditions in Thailand. Int J Occup Environ Health. 15: 305-314. Ref.: https://bit.ly/3aGbCBC