Journal of Associated Medical Sciences 2020; 53 (3): 72-77

JAMS
Journal of Associated Medical Sciences

Thai-Journal Citation Index Centre (TCI) & ASEAN Citation Index (ACI)

Journal of Associated Medical Sciences

Journal homepage: https://www.tci-thaijo.org/index.php/bulletinAMS/index

Preliminary Report: Modified and innovative workstation and tools in a male wood carver at Chiang Mai Province, Thailand

Kanokporn Ooneklabh[1] **Jirakrit Leelarungrayub**[2*] **Samatchai Chamnongkich**[2]

[1]*Biomedical Sciences, Faculty of Associated Medical Sciences, Chiang Mai University, Chiang Mai Province, Thailand*
[2]*Department of Physical Therapy, Faculty of Associated Medical Sciences, Chiang Mai University, Chiang Mai Province, Thailand*

ARTICLE INFO

Article history:
Received April 2020
Received in revised form June 2020
Accepted as revised August 2020
Available online August 2020

Keywords:
Ergonomics risk, innovative workstation, wood carver

ABSTRACT

Background: Wood carving is a very well-known occupation in Chiang Mai Province, Thailand. Traditional posture during wood carving with conventional tools has been demonstrated by sitting on the floor. However, work-musculoskeletal disorders (WMSDs) during carving had not been assessed and whether workstation modification could be involved in posture, pain and satisfaction.

Objectives: To evaluate posture and pain during wood carving at before and after workstation modification and to develop an innovative workstation and tools for a wood carver.

Materials and methods: This study was performed preliminarily in a male wood carver aged 28 years, with ten years of carving experience. Before and after 4-weeks when the workstation and tools were modified, the ergonomic risk was evaluated by using the Rapid Upper Limb Assessment (RULA), and pain area and intensity as well as satisfaction were interviewed. Then, the innovative workstation was designed and developed after face to face discussions.

Results: The results of posture in a conventional workstation showed a slumping position on a low stool and use of various unsafe steel carving tools, and the total RULA score was 7, whereas an intense pain located at the neck and lower back regions. When the workstation was modified with marble and wooden chairs, and tools with hammer with rubber wrapped heads, the total RULA score decreased to 6. Additionally, pain intensity at the neck and lower back decreased and the satisfaction improved. Finally, when an innovative workstation was designed and developed, the result showed looked convenient, comfortable and usable for wood carving.

Conclusion: Modification of the workstation and tools for wood carver can reduce pain. Furthermore, an innovative workstation should have developed for wood carver for protecting the WMSD.

Introduction

Current work-related musculoskeletal disorders (WMSDs), especially pain, can occur during work in many occupations, such as cooks, storage laborers, transport laborers and building structure cleaners.[1] Contact stress, forceful contraction and awkward postures can induce pain at various regions of the body such as the knees, back and shoulders.[2] WMSDs also present in various occupations in Thailand, for example, construction-related work,[3] and frozen food manufacturing.[4] Wood carving is a famous and specific occupation that requires vast experience gained from predecessors, who were reputable craftsmen producing famous products worldwide, like ceramics, bronzeware, and Buddhist sculptures and dragons. Unfortunately, traditional wood carving had to be performed on the floor, so poor posture such as a slumped

* **Corresponding author.**
Author's Address: *Department of Physical Therapy, Faculty of Associated Medical Sciences, Chiang Mai University, Chiang Mai Province, Thailand*
** **E-mail address:** : donrawee.leela@cmu.ac.th
doi:
E-ISSN: 2539-6056

posture commonly developed when carving for a long time. Previous data claimed that slumping and prolonged static posture tends to increase WMSDs or pain.[5] Thus, appropriate postures, working environment and workstation adaptation are very important factors for improving tasks in the workplace[6] and preventing injury while working.[7] Interesting evidence showed that an adjustable workstation for carpet weavers, with height and seat adaptation, could reduce discomfort while working,[8] the same as tool adaptation for hairstylists, who reduced fatigue during hairdressing. [9, 10] Therefore, evaluating on WMSDs and modification of table, stool, and tools in the workstation for wood carving are very challenge that should improve work performance and productivity and can be prevented the WMSDs among of wood carvers as same as other occupations. As a consequence, the aim of this preliminary study was to survey the workstation and tools for wood carving and evaluate the benefits of their modification on posture, pain and satisfaction. Finally, the present study also aimed to develop an innovative workstation with a pilot design after face to face discussion.

Materials and methods

This case study was performed with a male wood carver aged 28 years, with ten years' experience in wood carving. He worked for seven hours daily at Baan Tawai, Khun Kong sub-district, Hang Dong district, Chiang Mai Province, Thailand. The protocol in this preliminary study was approved under exception review from the Ethical Human Committee at the Faculty of Associated Medical Sciences, Chiang Mai University, Chiang Mai, Thailand. The data was permitted from wood carver by a personal contact. Then, a survey of a conventional workstation and tools was performed before modification of both the table, stool, and tools for a short-term trial. Ergonomic risks and pain were evaluated before and after the wood carving trial. Finally, both the table and stool were designed and developed for an innovative workstation that worked after face to face discussions was completed.

Ergonomic risk and pain assessment

Baseline data of the ergonomic risk while working was assessed according to the Rapid Upper Limb Assessment (RULA) guideline,[11] which was permitted by Professor Alan Hedge of Cornel University (November 2000). RULA is a standardized tool showing the reliably good evaluation of posture,[12] and popularly used to evaluate musculoskeletal disorder relating to overall posture imbalance as the previous standardized protocol.[13] RULA score was determined by viewed the best videos captures which were adjusted to slow the speed of movement for more precise and accuracy during wood carving for 20 minutes at least and summarized the final scores both individual parts and total scores. RULA scores was conducted by a researcher by training and reliability test with two expert ergonomists. Then, the acceptable both intra-rater (ICC 3,2) and high inter tester (ICC 2,2) reliabilities (0.77 & 0.75) was confirmed before data collection. The RULA score can be categorized into four classes depending the number of movements; static muscle work, force, work posture and time worked without a break, and the total score ranges from 1 to 7 points. Total RULA score deals mainly with parts of the body; upper arms, lower arms, wrists, wrist twist, neck, trunk and leg. The priority level of exposure and investigation is classified as; acceptable posture if not maintained or repeated for long periods (1 or 2 points), more investigations are needed and changes may be required (3 or 4 points), investigation and changes are required (5 or 6 points), and investigation and changes are required immediately (7 points).[14] Finally, the areas of most pain intensity were evaluated using the numerical rating scale (NRS) of no pain (scale at 0) to the most intense pain imaginable (score at 10).[15]

Modified workstation and tool protocols

The workstation was modified as previously suggested.[16] Appropriate or good posture should help the muscles in the body to optimal load and relax, and it prevents unnecessary strain and fatigue. In this study, the workstation was modified by using slightly tilted and higher marble chairs in the workplace, in order to keep the body alignment on a vertical plane. The tools for wood carving were modified in order to reduce the risk of occupational injuries to the upper limbs and hands, especially swollen finger joints or neuralgia, as previously suggested,[17] and the handle of hand tools was remodeled with finger grooves for better grip as shown in a previous study.[10] When the modified workstation and tools had been used for 4 weeks without any contact stress, the ergonomic risk, pain intensity and areas of pain were reassessed. Finally, satisfaction of the modified workstation was discussed.

Innovative workstation development

After 4-week modification of the workstation and tools were completed, advantages or disadvantages were performed by the face to face interviewing method[18] for one day meeting in order to design and develop an innovative workstation, with both a table and stool for wood carving. The design of the workstation was followed a previous recommendation, with a tilting adjustable stool and high seat pan that sloped forward by approximately 10-25 degrees, which could provoke anterior pelvic tilt.[8, 16] Moreover, the surface of the table was inclined slightly[5] in order to adjust to 20 cm above elbow height during the carving process.[8] Furthermore, the table was made with spaces in front and by each side for hand tools that could be kept within reach while the wood carver was working. This possibly helped safe body movement. When the innovative workstation was constructed completely, possible ideas for wood carving were discussed.

Statistical analysis

Data of all the parameters were presented with descriptive results.

Results

Conventional and modified workstation and tools

This study was studied in a male wood carver who carving specific the Buddha image on the plate wood for 2 days. Initial survey results showed that conventional wood carving tools were constructed from traditional culture and wisdom with a selection of tough and forced absorbed wood such as that from trees. Furthermore, chisel handles, iron hammer heads, sew Ngon (curved chisel), and iron stamps were unsafe with rough and hard surface. Wood carvers worked in stationary and prolong sitting positions on a low seat (Figure 1.A), that caused a humpback, affected neck and knee flexion and induced dominate pain at the neck and lower back regions.

Figure 1. *Conventional (A) and modified workstation (B) during wood carving. (Photos were permitted by wood carver for academic publication without conflict of interest).*

The workstation was modified by using wooden and marble chairs with a higher level (Figure 1.B). In addition, hammers were adapted for safe handling with grooves in the handle for fingers to fit and rubber wrapped around the hammer head and handle (Figure 2). The total RULA scores during use of the conventional and modified workstation are shown in Table 1, the total RULA scores were 7 and 6, respectively. The RULA scores for each part of the body did not change in the upper arm position, wrist position, wrist twist or legs, except the lower arm, neck, and trunk position. Results for areas of pain and intensity at the neck and lower back regions decreased from intense (scale=6) to comfortable (scale=2) sensation. Moreover, the satisfaction of wood carver on the modified workstation was excellence.

Figure 2. *Conventional (Left) and modified tools (right). Hammer adapted for safe handling with grooves in the handle for fingers to fit and rubber wrapped around the hammer head and handle.*

Table 1 Rapid Upper Limb Assessment (RULA) scores between carving with conventional and modified workstations

RULA part	Conventional workstation	Modified workstation
Individual body part;		
- Upper arm postition	3	3
- Lower arm position	2	3
- Wrist postition	3	3
- Wrist twist	1	1
- Neck position	2	3
- Trunk position	4	3
- Legs	1	1
Total score	7	6

Innovative workstation design and development

From the face to face discussions on the modified workstation with the fourteen-wood carvers, an innovative workstation with table and stool was designed and developed, comprising a wooden tilted table and stool. The general characteristics of the innovated workstation were agreed upon, with their low cost, and tailor-made and small flat designs. Figure 3 shows the innovative workstation with adjustable sloping surface was made at an appropriate height at elbow level in a sitting position. Moreover, the table was developed with spaces in the front and at both sides for hand tools and free space for legs under the table. The height stool was designed appropriate to popliteal level and a width of seat pan with a round ridge can be adjustable tilt, in order to avoid contact stress. Finally, the result of discussions claimed that the innovative workstation was convenient, comfortable and usable for wood carving.

Figure 3. *The innovative workstation with both table and stool for wood carving. Table is wooden and tilted with hand tool spaces in the front and on both sides. Stool was designed with an appropriate popliteal height and seat pan of appropriate width with a round ridge, and special adjustable tilt, in order to avoided contact stress.*

Discussion

This preliminary study showed that a wood carver in a conventional workstation worked traditionally in a slumping posture on a low, flat seat. A previous report showed that prolonged slumping in a sitting position for one hour reduced abdominal muscle strength and induced muscle fatigue.[19] In addition, pressure was loaded at the cervico-thoracic and lumbosacral joints.[20] Therefore, slumping posture directly affects the cervico-thoracic and lower back regions that reflect WMSDs.

In this study, ergonomic risk during wood carving was assessed with a standardized tool and Rapid Upper Limb Assessment (RULA), which has good reliability in evaluating posture[12] or overall posture imbalance.[13] RULA has been a tool for evaluation in many previous occupations, such as carpet hand-weaving,[8, 16] the ceramic industry,[21] warehouse working,[22] etc. A high RULA score reflects the high risk of WMSDs, which requires immediate change in posture.[14] The total RULA scores when wood carving as the figure 1 (A) before modification of the workstation was 7, which can be interpreted as action level 4, meaning that the wood carver has the worst posture with the risk of sudden injury and the need to change posture immediately.[23] Although the total RULA score of the modified workstation as the figure 1 (B) was 6, it can be interpreted as action level 3, which means that the wood carver has an awkward posture and risk of injury, and needs to investigate the posture and change it quickly.[23] Although the total RULA scores were not dominantly different, either before or after modification of the workstation, scores for many parts of the body part were not reduced, but increased, however, the score of trunk position decreased from 4 to 3. These results can be explained by modification of the workstation with marble chairs that can correct lower back alignment. Sitting on a low seat involves the posterior pelvic tilt position and lumbar flexion or reversed lumbar curve.

It is possible that non-dominantly changed RULA scores on other parts of the body, especially the upper and middle thoracic position, can refer to loss of voluntary trunk control from prolonged muscle fatigue, characterized by an extended cervical spine, a long C-shaped kyphotic thoracolumbar spine and posteriorly tilted pelvic region, which is consistent with a previous report.[24] In addition, pain was located at the lower back in this study, which is similar to previous evidence that reported on either crossed-leg or heel sitting posture affecting the lumbar multifidus muscles during work, and the center of gravity shifted anteriorly, thus, muscle fatigue and pain could be presented.[25] The results of RULA scores of the upper arm position, wrist position, wrist twist, and legs did not change, whereas those of the lower arm and neck position increased because of higher of table height when compared to before modification. This can be explained possibly by the height of the workstation being insufficient or unadaptable for wood carving. Moreover, strength of the back and neck muscles were not evaluated, therefore, posture analysis with the RULA sheet at the back region from muscle weakness, including work efficacy after modification of the workstation during different wood carvings, should be studied in the future.

Not only the workstation was modified in this study, but also the hand tools because they are very important for ergonomic risk factors in all of the wood carvers. Previous data showed a strong relationship between occupational musculoskeletal disorders (MSDs) and the use of hand tools[26] that may result in traumatic events.[27] In addition, inappropriate hand tools have influence on musculoskeletal disorder during work, for example, those in the study of hairstylists.[9, 10] Carving tools were modified by rubber wrapping in order to reduce stress on the palm of the hand and improve grip. Unfortunately, this study did not evaluate the efficiency of tool modification, while the RULA scores of wrist position and twist did not improve. However, it has been suggested that a tool handle should be coated with soft material and a non-slip surface.[10] Thus, the force and safety of hand tools during wood carving should be studied and confirmed in the future. In addition, the size or cross-sectional shapes of the tools may affect contact pressures. A previous study found that cross-sectional shapes of tools caused variations in distribution of contact-pressure, especially in the palm region close to the index finger, which induces a comfortable grip during work.[28]

When the face to face discussions and RULA scores were completed and after the 4-week working trial with the modified workstation, many weak points needed to be corrected. An innovative workstation was designed and developed from the ideas discussed and some evidence in a previous report that evaluated the appropriate posture for weaving.[8] A good workstation should correct the posture of the wood carver to a neutral one (sitting upright), with symmetry according to the sagittal plane, looking straight ahead horizontally, arms hanging down beside the trunk, and forearms perpendicular to the upper arms. In theory, good posture during work has been recommended as neck flexion of less than 20 degrees, shoulder flexion or abduction of less than 30 degrees, shoulder extension and internal rotation, slight elbow flexion, supination and pronation with grasp, the same as wrist flexion or extension, and ulnar or radial deviation while grasping tools, which can prevent musculoskeletal injury.[29]

In addition, the innovative workstation was finally developed with an adjustable tilting stool for the individual wood carver. It had a high seat pan that sloped forward by approximately 10 degrees, thus provoking an anterior pelvic tilt as previously suggested[8, 16] for industrial carpenters.[10] Furthermore, the design of a table with a tilted surface and adjustable stool is very important for wood carving and consistent with a previous recommendation 5 and previous study on carpet weavers, which found that postural discomfort reduced when the weaving height was adjusted to 20 cm above elbow height and a high seat pan sloping forward was used.[8] It is interesting that the wood carvers suggested design of the hand tool spaces in front and at both sides of the table, so that tools can be kept within reach while working with no need to drag, push or pull heavy hammers during carving. A previous study showed that exposure to both 'fatigue-inducing or painful posture' and 'dragging, pushing, or moving heavy objects' related to work-related low back pain.[30] Thus, the development of spaces for keeping

tools reachable possibly helps safe body movement and protects from muscle overload.

Therefore, the innovative workstation in this study should have more benefits for wood carvers such as allowing changes in leg position and helping to decrease neck bending forward when carving. Furthermore, the seat pan of the stool can be tilted together with the wood carver's body movement, possibly promoting a straight low back (lumbar lordosis) and avoiding a slumping position. Moreover, the good posture with neutrality alignment of head, neck, back, trunk, and lower extremities is not only direct clinical effect on neuromuscular function, but it also promotes the diaphragmatic function and breathing efficiency that possibly prevents the respiratory dyspnea during working. Whether an innovative workstation can correct the posture or characteristics of all parts of the body should be studied in the future. Finally, satisfaction with the innovative workstation and adjustable tilted table was discussed completely and immediately considered excellent for wood carving. However, efficiency of wood carving and ergonomic risk should be studied and confirmed in the future.

Weakness, limitation and suggestion

The results of this preliminary study were specific to the wood carver, represented with descriptive data without a statistical method, which possibly makes the data weakness. Moreover, modification and development of the innovative workstation had specificity that limited this study from other specific types of carving and possibly all wood carvers or different occupations. However, studying larger sample sizes, with adjustable seats and workstations for preventing musculoskeletal injury or disorder in various wood carvers, is very interesting for future research. Moreover, other factors in wood carving, especially environments, size of tools, and duration of carving, should be concerned and evaluated in the future. Because previous evidence proposed that risk factors came from inappropriate posture, either prolonged static or dynamic posture, and working environment such as lighting, dust and noise level related to WMSDs[29] should be studied in the future. In addition, multifactorial ergonomic intervention and exercise training should be introduced into the program as recommended in a previous report.[31]

Conclusion

Modification of the workstation and seat for wood carver can correct posture and reduce pain. Furthermore, the innovative workstation with reachable spaces for hand tools in front and at both sides and adjustable tilted table, which possibly could correct low back alignment. This workstation should have more potential benefits for wood carvers, especially protecting the musculoskeletal disorder when compared to original workstation.

Conflict of interest

No potential conflict of interest was reported by the authors.

References

[1] Choi HW, Kim YK, Kang DM, Kim JE, Jang BY. Characteristics of occupational musculoskeletal disorders of five sections in service industry between 2004 and 2013. Ann Occup Environ Med 2017; 29: 41. doi 10.1186/s40557-017-0198-4.

[2] Girish N, Ramachandra K, Arun GM, Asha K. Prevalence of musculoskeletal disorders among cashew factory workers. Arch Environ Occup Health 2012; 67(1): 37-42.

[3] Hanklang S, Kaewboonchoo O, Silpasuwan P, Mungarndee SS. Musculoskeletal disorders among Thai women in construction-related work. Asia Pac J Public Health 2014; 26(2): 196-202.

[4] Thetkathuek A, Meepradit P, Jaidee W. Factors affecting the musculoskeletal disorders of workers in the frozen food manufacturing factory in Thailand. Int J Occup Saf Ergon 2016; 22(1): 49-56.

[5] Khalil TM, Moty EM, Rosomoff RS, Rosomoff HL. Ergonomics in back pain: a guide to prevention and rehabilitation. New York: Van Nostrand Reinhold; 1993.

[6] Khattak SA . Role of ergonomics in re-designing job design in call centers. Int J Occup Saf Ergon 2019: 1-10.

[7] White J. Health and safety management: an alternative approach to reducing accidents, injury and illness at work. 1st edition. Boca Raton (FL): CRC Press; 2019.

[8] Choobineh A, Hosseini M, Lahmi M, Jazani RK, Shahnavaz H. Musculoskeletal problems in Iranian hand-woven carpet industry: Guidelines for workstation design. Appl Ergon 2007; 38(5): 617-24.

[9] Boyles JL, Yearout RD, Rys MJ. Ergonomic scissors for hairdressing. Int J Ind Ergon 2003; 32(3): 199-207.

[10] Motamedzade M, Choobineh A, Mououdi MA, Arghami S. Ergonomic design of carpet weaving hand tools. Int J Ind Ergon 2007; 37(7): 581-7.

[11] Hedge A. Quantifying office productivity: an ergonomic framework. Proc Hum Factors Ergon Soc Annu Meet. 1998; https;//doi.org/10.1177/154193129804201306.

[12] Dockrell S, O'Grady E, Bennett K, Mullarkey C, Mc Connell R, Ruddy R, et al. An investigation of the reliability of Rapid Upper Limb Assessment (RULA) as a method of assessment of children's computing posture. Appl Ergon 2012; 43(3): 632-6.

[13] Cremasco MM, Giustetto A, Caffaro F, Colantoni A, Cavallo E, Grigolato S. Risk assessment for musculoskeletal disorders in Forestry: A comparison between RULA and REBA in the manual feeding of a wood-chipper. Int J Environ Res Public Health 2019; 16(5): 793. doi: 10.3390/ijerph16050793.

[14] Mokkink LB, Terwee CB, Patrick DL, Alonso J, Stratford PW, Knol DL, et al. The COSMIN checklist for assessing the methodological quality of studies on measurement properties of health status measurement instruments: an international Delphi study. Qual Life Res 2010; 19(4): 539–49.

[15] Fillingim RB, Loeser JD, Baron R, Edwards RR. Assessment of chronic pain: domains, methods, and mechanisms. J Pain 2016; 17(9 Suppl): T10-T20.

[16] Choobineh A, Tosian R, Alhamdi Z, Davarzanie M. Ergonomic intervention in carpet mending operation. Appl Ergon 2004; 35(5): 493-6.

[17] Radjahi A. Carpets, hand-woven. In: Encyclopedia of Occupational health and Safety. Third edition. ILO: Geneva. 1983. pp. 416-8.

[18] Lavrakas PJ. Face-to Face Interviewing. In: Encyclopedia of Survey Research Methods. 2008. doi: https;// dx.doi.org/10.4135/9781412963947.n174.

[19] Waongenngarm P, Rajaratnam BS, Janwantanakul P. Internal oblique and transversus abdominis muscle fatigue induced by slumped sitting posture after 1 hour of sitting in office workers. Saf Health Work 2016; 7(1): 46-54. doi: 10.1016/j.shaw.2015.08.001

[20] Kwon Y, Kim JW, Heo JH, Jeon HM, Choi EB, Eom GM. The effect of sitting posture on the loads at cervico-thoracic and lumbosacral joints. Technol Health Care 2018; 26(S1): 409-18.

[21] Rahman CM. Study and analysis of work postures of workers working in a ceramic industry through rapid upper limb assessment (RULA). Inter J Eng Appl Sci 2014; 5(3). 14-20.

[22] Basahel AM. Investigation of work-related musculoskeletal disorders (MSDs) in warehouse workers in Saudi Arabia. Procedia Manufact 2015; 3: 4643-9.

[23] McAtamney L, Corlett, EN. RULA: a survey method for the investigation of work-related upper limb disorders. Appl Ergon 1993; 24(2): 91-9. doi: 10.1016/0003-6870(93)90080-s.

[24] Hobson DA, Tooms RE. Seated lumbar/pelvic alignment. A comparison between spinal cord-injured and noninjured groups. Spine 1992;17(3): 293-8.

[25] Areeudomwong P, Puntumetakul R, Kaber DB, Wanpen S, Leelayuwat N, Chatchawan U. Effects of handicraft sitting postures on lower trunk muscle fatigue. Ergonomics 2012; 55(6), 693-703. doi: 10.1080/00140139.2012.658086.

[26] Aghazadeh A, Mital A. Injuries due to hand tools: results of a questionnaire. Appl Ergon 1987; 18(4): 273-8. doi: 10.1016/0003-6870(87)90134-7.

[27] Armstrong T. Ergonomics and cumulative trauma disorders. Hand Clin 1986; 2(3): 553-65.

[28] Hokari K, Pramudita JA, Ito M, Noda S, Tanabe Y. The relationships of gripping comfort to contact pressure and hand posture during gripping. In J Ind Ergon 2019; 70: 84-91.

[29] Warren N, Sanders MJ. Biomechanical risk factors. In M.J. Sanders (Ed). Ergonomics and the management of musculoskeletal disorders. 2nd Edition. St. Louise: Butterworth Heinemann. 2004; pp. 191-229.

[30] Kim JY, Shin JS, Lim MS, Choi HG, Kim SK, Kang HT, et al. Relationship between simultaneous exposure to ergonomic risk factors and work-related low back pain: a cross-sectional study based on the fourth Korean working conditions survey. Ann Occup Environ Med 2018; 30:58. doi: 10.1186/ s40557-018-0269-1.

[31] Marshall L, Villeneuve J, Grenier S. Effectiveness of a multifactorial ergonomic intervention and exercise conditioning kinesiology program for subsequent work-related musculoskeletal disorder prevention. Work 2018; 61(1): 81-9. doi: 10.3233/WOR-182782.