

# Prevention of Occupational Traumas by Developing an Ergonomic Design and Modifying Farmers' Postures in Walnut Gardens of Tuyserkan, Iran

Hassan Sadeghi Naeini, Zahra Kaviani<sup>1</sup>, Karmegam Karupiah<sup>2</sup>, Mohammadreza Sadeghi<sup>3</sup>

Department of Industrial Design, School of Architecture and Urban Studies, Iran University of Science and Technology (IUST), Tehran, Iran, <sup>1</sup>Department of Industrial Design, Pars University, Tehran, Iran, <sup>3</sup>Faculty of Mechanical Engineering, Iran University of Science and Technology(IUST), Tehran, Iran, <sup>2</sup>Faculty of Medicine and Health Science, Universiti Putra Malaysia (UPM), Serdang, Selangor, Malaysia

## ORCID:

Hassan Sadeghi Naeini: <http://orcid.org/0000-0003-4094-0809>

Zahra Kaviani: <http://orcid.org/0000-0002-7809-4508>

Karmegam Karupiah: <http://orcid.org/0000-0002-9488-9335>

Mohammadreza Sadeghi: <http://orcid.org/0000-0002-5790-7151>

## Abstract

**Background and Objectives:** Occupational traumas are known as work-related disorders, associating with some sorts of factors such as repetitive tasks, body postures, workstations, and hand tools. These traumas cause various problems for both workers and employers. Due to occupational hygiene considerations, problems such as cumulative trauma disorders, occupational trauma, low back pain (LBP), and work-related musculoskeletal disorders should be controlled. In this regard, ergonomic interventions can have efficient outcomes toward controlling occupational traumas. In this study, the focus was on working at some walnut gardens in the city of Tuyserkan in Iran, to reach an ergonomic analysis base, in which hand tools were assessed. The main objective was to develop a new ergonomic design for workers using hand tools. **Subjects and Methods:** In this cross-sectional study, 19 workers participated and filled out the Nordic Musculoskeletal Questionnaire (NMQ). Their body postures during harvesting walnuts were evaluated by the Ovako Working Posture Analysis System method. Hand tool analysis was also performed by ergonomic risk assessments. **Results:** The results showed that 15% of the farmers experienced some sorts of trauma during the harvest while using traditional hand tools. The results also emphasized that 61.5% of the workers' body postures should be modified. In addition, according to the NMQ, the most common problems among workers were wrist disorders, LBP, and knees' and shoulders' disorders. **Conclusions:** Considering experimental data, a new device was developed in which the weight, adjustability, and form of hand tools were modified under ergonomic considerations. The benefits of the new design were confirmed by SOLIDWORKS software. Since this new device helps farmers to decrease extra force exertion in awkward postures, it is expected to improve farmers' condition while using it.

**Keywords:** Ergonomics, hand tool, nordic musculoskeletal questionnaire, occupational trauma, ovako working posture analysis system

## INTRODUCTION

Human resources, in agricultural sectors, play a prominent role in farming and related activities. However, most workers in the mentioned fields suffer from several sorts of accident-induced traumas, cumulative trauma disorders, muscle strain and tension, low back pain (LBP) and such, especially in developing countries,<sup>[1-3]</sup> in which some risk factors should be considered, i.e., awkward postures, manual tasks, muscle exertions, and manual material handling. The

**Address for correspondence:** Dr. Hassan Sadeghi Naeini, Department of Industrial Design, School of Architecture and Urban Studies, Iran University of Science and Technology, Narmak 1311461684, Tehran, Iran.  
E-mail: [naeini@iust.ac.ir](mailto:naeini@iust.ac.ir)

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**How to cite this article:** Naeini HS, Kaviani Z, Karupiah K, Sadeghi M. Prevention of occupational traumas by developing an ergonomic design and modifying farmers' postures in walnut gardens of Tuyserkan, Iran. Arch Trauma Res 2020;9:24-9.

**Received:** 11-06-2019, **Revised:** 21-09-2019,

**Accepted:** 02-02-2020, **Published:** 27-03-2020.

### Access this article online

#### Quick Response Code:



**Website:**  
[www.archtrauma.com](http://www.archtrauma.com)

**DOI:**  
10.4103/atr.atr\_48\_19

International Labor Organization pointed that around 160 million work-related illnesses and more than 300 million occupational accidents occur per year, in which work-related musculoskeletal disorders (WMSDs) play an important role.<sup>[1,4]</sup> The US Bureau of Labor Statistics reported that 32% of nonfatal injuries and illnesses in 2014 were related to WMSDs.<sup>[5]</sup> Musculoskeletal disorders (MSDs), as the most common disorders among farmers, make some limitations for workers and some negative outcomes for employers.<sup>[6,7]</sup> Health and safety in agricultural sectors play a critical role in terms of human being since these interventions meant to lead to occupational health promotion. Farmers are facing various occupational traumas and MSDs, such as repetitive tasks, awkward postures, force exertion, using hand tools, and not enough rest during working hours. Surely, most of the mentioned work-related problems are anticipated to be solved by suggested ergonomic plans.<sup>[1]</sup> The results of a study conducted by Pinzke and Lavesson showed that the muscle pain and related disorders are decreased among farmers by changing their body postures, from kneeling tasks to standing or walking ones.<sup>[8]</sup> Hildebrandt studied on ergonomic risk factors among 2580 farmers and showed that 51% of workers suffered from LBP, and the prevalence of neck disorders was about 35%.<sup>[9]</sup> According to the findings of an interventional study in Bangladesh, 434 injuries were recorded among farmers. This study showed that hand tools were one of the main factors to make injuries.<sup>[8]</sup> According to Syazwani *et al.*, 61% of workers, who had collected palm oil in Negeri Sembilan, Malaysia, were exposed to high-risk postures.<sup>[10]</sup> In Iran, there is a considerable amount of workers working in agricultural sectors, that is, why occupational ergonomics and industrial hygiene should be considered not only for farmers' health but also for improving productivity. One of the important agriculture sectors in Iran is walnut gardens. The aim of the present study was to determine and evaluate ergonomic problems among workers working in the walnut gardens during the harvest time. Furthermore, this study aimed at developing a new ergonomic hand tool for these workers.

### Objectives and rationale of the study

Two main objectives of this study were to develop a new design of the hand tool for workers hitting the trees to harvest the walnut from trees for preventing the occupational traumas and WMSDs.

In general, agricultural tasks and all sorts of related activities make some negative effects on human health. Certainly, occupational health interventions, especially in terms of WMSDs and traumas' prevention, make conditions for farmers healthy and safe. Ranney *et al.* showed that the prevalence of MSDs among 146 female workers who were working at high repetitive tasks was about 54%.<sup>[11]</sup> Weir *et al.* reported that the average annual cost per patient with trauma was \$75,210 in 69 hospitals in the USA. In this survey,  $\geq 5000$  injured patients were assessed.<sup>[12]</sup> According to a cross-sectional study done on 243 farmers who used pesticides, some side effects such as water blisters,

headache, skin rashes, and dizziness were reported,<sup>[13]</sup> which means that work-related health hazards in agriculture are not limited to MSDs and traumas. Therefore, occupational health studies and interventions in agricultural sectors are inevitable.

### Applied ergonomics in agriculture

Ergonomics is a multidisciplinary science, in which fitting the tasks to the workers and making a better condition for their duties are considered. Ergonomics has five subbranches: "microergonomics," "macroergonomics," "environmental ergonomics," "cognitive ergonomics," and "cultural ergonomics." Microergonomics concerns with workstation design based on anthropometry, work physiology, and so on. Organizational management and sociotechnical aspects of equipment are studied in macroergonomics. Environmental factors, i.e., lighting, noise, and vibration, are assessed in environmental ergonomics. Cognitive and cultural ergonomics concern with perception and social concepts, respectively. Considering the scope of ergonomics, ergonomic interventions might be useful and effective to improve agricultural tasks and prevention of WMSDs.<sup>[1]</sup> Khidiya and Bhardwaj showed that the design of some hand tools such as trowel based on ergonomic considerations makes a better condition for workers.<sup>[14]</sup> The results of Jiang study conducted on designing hand tools showed similar outcomes.<sup>[15]</sup>

Iran is the second country around the world in terms of walnut garden area and has the third rank in walnut producing (450 tons).<sup>[16]</sup> There are some well-known counties in Iran, such as province of Azerbaijan, Khorasan, and Hamedan, in which walnuts have been harvested during fall. There are various tasks for offering the walnut to market; one of the main preliminary parts of harvesting is to remove walnut green hulls from trees in which workers suffer some ergonomic problems. Workers use the long (4–8 m), heavy (3–6 kg) wooden rods for harvesting [Figure 1].

### Ergonomic assessment of body postures

One of the methods to evaluate body postures during



Figure 1: The long heavy rod for walnut removing from trees

work-related activities is the Ovako Working Posture Analysis System (OWAS) method.<sup>[17-19]</sup> In this method, all of the body postures would be observed; then for each posture, a four-digit code would be itemized.<sup>[18]</sup> In this four-digit code, the first digit shows the trunk posture, the second and third ones show the position of arms and legs, respectively, and the fourth code indicates the level of force exertion or lifting [Table 1]. Figure 2 shows some postures' codes, which were assessed in this field study.

According to the OWAS guideline [Table 2], all of the postures get a four-digit code. One of the following action categories (AC) is defined for each code:<sup>[17,20]</sup>

- AC = 1 – The posture is correct and no need to any correction
- AC = 2 – The posture should be corrected in the near future
- AC = 3 – The posture should be corrected as soon as possible
- AC = 4 – The posture should be corrected immediately.

### SUBJECTS AND METHODS

This cross-sectional study was conducted to assess the harvesting process of walnuts in walnut gardens of Tuyserkan city in Hamadan Province. Microergonomic assessment was done to explore risk factors of traumatic events among the farmers during the harvest season at walnut gardens. The assessed farm workers were working

in two conditions: on the ground or on the trees. In fact, based on the height of trees, workers had to climb from trees and did the rest of the harvest and picked the walnuts from the trees. Intended objectives were to assess the body postures of workers and redesigning the hand tools. Data were collected by in-depth observation, interviews, and task analysis. For ergonomic task analysis, all of the body postures of 19 volunteer workers were assessed during walnut harvesting. Workers usually are harvesting at least 4 h/day, and in more than 65% of their tasks, they use the long wooden rod (4–8 m, and 3–6 kg).

In this study, the OWAS method was used to evaluate body postures. The Nordic Musculoskeletal Questionnaire (NMQ)<sup>[21]</sup> was used to assess the psychophysical aspects of disorders among 19 workers with at least 1-year experience in the target task. To develop a new model for hand tools, SOLIDWORKS software (version 2017, Dassault Group, Velizy-Villacoublay, France) was used. As mentioned above, our research design included some parts of in-depth observation, posture analysis, and assessment and design of hand tools.

### RESULTS

The results of postural analysis by the OWAS method showed that 61.5% of the postures should be modified in the near future (AC = 2), and 15% of the cases should be modified as soon as possible (AC = 3).

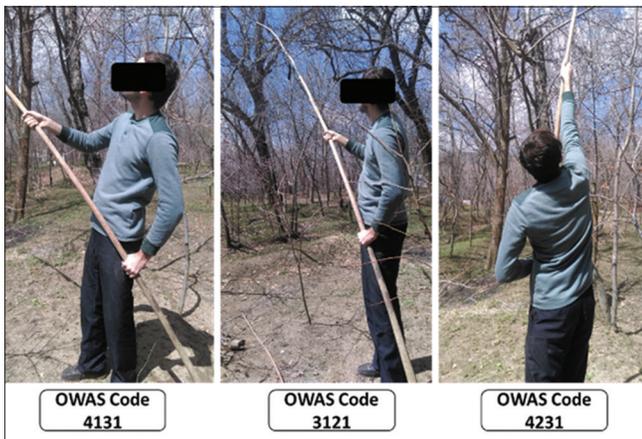


Figure 2: Some of more frequent body postures and the related Ovako Working Posture Analysis System codes

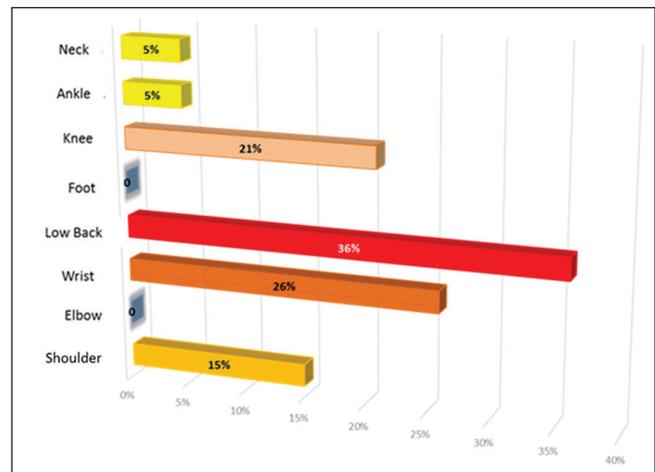


Figure 3: The prevalence of psychophysical disorders based on the Nordic Musculoskeletal Questionnaire (%)

Back	Arms	Legs	Force/lifting
Back straight	Both hands under shoulder level	Sitting	Force exertion and manual lifting less than 10 kg
Forward or backward bent	One hand above shoulder level	Standing (neutral)	Force exertion and manual lifting between 10 and 20 kg
Twist or lateral bending	Both hands above shoulder level	Standing (weight on one leg)	Force exertion and manual lifting more than 20 kg
Twist and bent		Standing with flexed knees (squat)	
		Standing (weight on one bent knee)	
		Kneeling	
		Walking	

Based on OWAS AC, hitting the rod on the trees for walnut harvesting and holding the rod upper than the shoulders' level [Figure 2] were more difficult than other postures.

The results of the NMQ showed that the prevalence rates of pain or traumas on low back, wrists, knees, and shoulders were 36%, 26%, 21%, and 15%, respectively [Figure 3].

According to interviews done, about 15% of the workers pointed to their accidental traumas, based on falling from trees, dropping the heavy hand tools on their toes, extreme trunk bending, and such.

**DISCUSSION**

Considering the related traumas, injury is known as one of the major causes of death and disability worldwide. However, there are various traumas based on age, gender, and job.<sup>[22-24]</sup> Majority of occupational traumas might be controlled and prevented by occupational health and safety measures. Based on the findings of the present study, workers face ergonomic hazards, for example, awkward postures, force exertion, and manual tasks. In this regard, it has been attempted to design and develop a new ergonomic hand tool for harvesting walnut in this study.

This study represents a newly developed ergonomic tool for farmers, helping them to do their job under safer conditions, as well as preventing the occupational traumas. Finalizing the recommended device on SOLIDWORKS shows the effectiveness and efficiency of the design.

There are plenty of tools in agriculture, most likely to cause injuries, potentially traumas and MSDs.<sup>[21]</sup> MSDs are known as one of the important disorders around the world according to the Finnish Institute of Occupational Health. These disorders are known as one of the most common work-related problems.<sup>[19]</sup> In most working cases in agriculture, numerous musculoskeletal problems occur according to the physical demands on the body, awkward postures, prolonged standing and kneeling, stooping, bending, and repetitive

muscle activities; assuredly, these postures will result in fatigue, illness, and accidents. In addition, inadequate knowledge of workers about agricultural health and safety could lead to the most life-threatening situations. Scientific reports and published articles confirm the significance of work-related diseases in agriculture. Therefore, to provide better conditions, ergonomic considerations are required for the related workers.<sup>[1]</sup> In this regard, an ergonomic design prepares a proper condition throughout ergonomic-based design of hand tools. In addition, ergonomics as a human-centered science concerns the quality of life, whether at working spaces or in daily life. Undoubtedly,

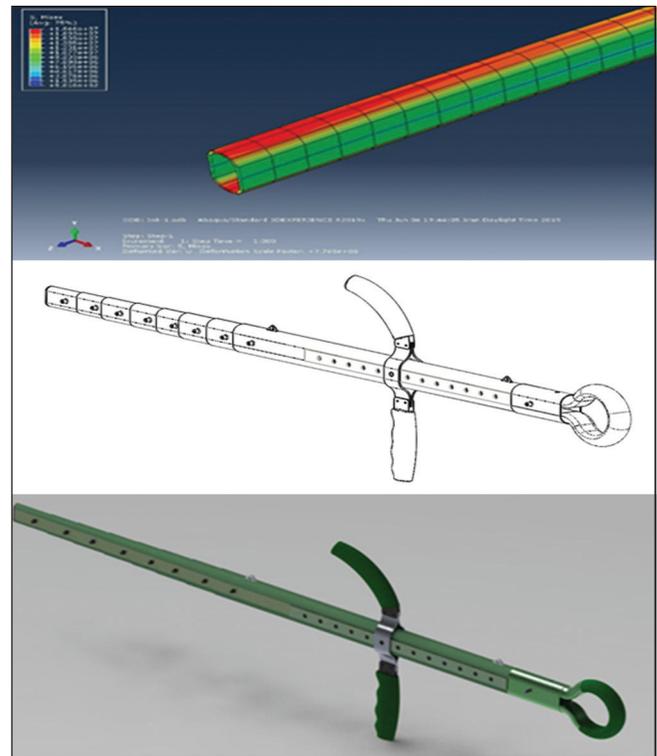


Figure 4: The design of the new hand tool and its characteristics

**Table 2 : Action Categories (AC) in OWAS**

Back	Arms	1			2			3			4			5			6			7			Legs Load
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	1
	2	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	1
	3	1	1	1	1	1	1	1	1	1	2	2	3	2	2	3	1	1	1	1	1	1	2
2	1	2	2	3	2	2	3	2	2	3	3	3	3	3	3	3	2	2	2	2	3	3	3
	2	2	2	3	2	2	3	2	3	3	3	4	4	3	4	4	3	3	4	2	3	4	4
	3	3	3	4	2	2	3	3	3	3	3	4	4	4	4	4	4	4	4	2	3	4	4
3	1	1	1	1	1	1	1	1	1	2	3	3	3	4	4	4	1	1	1	1	1	1	1
	2	2	2	3	1	1	1	1	1	2	4	4	4	4	4	4	3	3	3	1	1	1	1
	3	2	2	3	1	1	1	2	3	3	4	4	4	4	4	4	4	4	4	1	1	1	1
4	1	2	3	3	2	2	3	2	2	3	4	4	4	4	4	4	4	4	4	2	3	4	4
	2	3	3	4	2	3	4	3	3	4	4	4	4	4	4	4	4	4	4	2	3	4	4
	3	4	4	4	2	3	4	3	3	4	4	4	4	4	4	4	4	4	4	2	3	4	4

the integration between ergonomics and the concept of sustainability might culminate in higher levels of quality of life.<sup>[25]</sup> Surely, the prevalence and incidence of traumas resulting in physical disorders make a negative effect on human health and quality of life. In addition, job satisfaction has a firm association with safety and health;<sup>[26]</sup> regarding this fact, farmers' tasks should be modified in terms of occupational ergonomics. In addition, making a proper connection between ergonomics and economics would result in improved productivity;<sup>[27-32]</sup> undoubtedly, effectiveness and efficiency are known as prominent factors in agriculture. However, other related factors should not be ignored such as environmental agents which are conceded by environmental ergonomics. For instance, air temperature is known as one of the mentioned factors is in related to increase in the probability of falling.<sup>[33]</sup>

## CONCLUSIONS

Gardening and harvesting as main duties in agriculture may cause various health problems for farmers. Workers in walnut harvesting procedure suffer from several severe traumas based on their physical activities, awkward postures, and force exertions. Considering the number of walnut gardens and their workers in Iran, work-related traumas and MSDs should be noted in terms of occupational health and safety rules. Based on the findings, it has been attempted to develop a new design for developing a hand tool to shake walnut tree branches to pick walnuts. This new device is an ergonomic hand tool which gets the harvesting task easier and makes workers able to shake trees with less force and less extreme muscle tensions. Traditional rods were entirely made from wooden material, but this new rod has been made from aluminum offering lower density, and its geometry can minimize rod deflections. According to SOLIDWORKS simulations, the minimum and maximum deflections of this new rod are between 2 and 9 cm, while traditional rods' deflections were  $\geq 35$  cm. Figure 4 shows the new rod design and its characteristics. Ergonomic participatory programs, ergonomic assessments of hand tools, and workstations offer remarkable benefits toward work-related quality of life. Decreasing the rate of traumas and occupational injuries is known as the effective outcome of ergonomic measures. Undoubtedly, appropriate ergonomic interventions will lead to improved condition in terms of occupational ergonomics and prevention of work-related traumas.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

## REFERENCES

- Sadeghi Naeini H, Karmegam K, Dalal K. Ergonomics in agriculture: An approach in prevention of work-related musculoskeletal disorders (WMSDs). *J Agric Environ Sci* 2014;3:33-51.
- Villarejo D, Baron SL. The occupational health status of hired farm workers. *Occup Med* 1999;14:613-35.
- Xiang H, Stallones L, Keefe TJ. Back pain and agricultural work among farmers: An analysis of the Colorado Farm Family Health and Hazard Surveillance Survey. *Am J Ind Med* 1999;35:310-6.
- Niu S. Ergonomics and occupational safety and health: An ILO perspective. *Appl Ergon* 2010;41:744-53.
- National Institute for Occupational Safety and Health (NIOSH). *Musculoskeletal Disorders*. Vol. 2011. National Institute for Occupational Safety and Health (NIOSH); 2009.
- Kee D, Haslam R. Prevalence of work-related musculoskeletal disorders in agriculture workers in Korea and preventative interventions. *Work* 2019;64:763-75.
- Hossain MD, Aftab A, Al Imam MH, Mahmud I, Chowdhury IA, Kabir RI, *et al*. Prevalence of work related musculoskeletal disorders (WMSDs) and ergonomic risk assessment among readymade garment workers of Bangladesh: A cross sectional study. *PLoS One* 2018;13:e0200122.
- Pinzke S, Lavesson L. Ergonomic conditions in manual harvesting in Swedish outdoor cultivation. *Ann Agric Environ Med* 2018;25:481-7.
- Hildebrandt V. Musculoskeletal symptoms and workload in 12 branches of Dutch agriculture. *Ergonomics* 1995;12:2576-87.
- Syazwani MN, Baba MD, Mohd Nizam AR, Ezrin Hani S, Norani N, Shamsul Bahri MT, *et al*. Ergonomic risk assessment of manual handling tools by oil palm collectors and loaders. *Malay J Public Health Med* 2016;16:56-60.
- Ranney D, Wells R, Moore A. Upper limb musculoskeletal disorders in highly repetitive industries: Precise anatomical physical findings. *Ergonomics* 1995;38:1408-23.
- Weir S, Salkever DS, Rivara FP, Jurkovich GJ, Nathens AB, Mackenzie EJ. One-year treatment costs of trauma care in the USA. *Expert Rev Pharmacoecon Outcomes Res* 2010;10:187-97.
- Nankongnab N, Kongtip P, Tipayamongkholgul M, Bunngamchairat A, Sitthisak S, Woskie S. Difference in Accidents, Health Symptoms, and Ergonomic Problems between Conventional Farmers Using Pesticides and Organic Farmers. *J Agromedicine*, Published online 2019. p. 1-8.
- Khidiya MS, Bhardwaj A. An ergonomic approach to design hand tool for agricultural production. *Work* 2012;41 Suppl 1:1335-41.
- Jiang CY. Ergonomic improvement on the farm/garden hoe. California Polytechnic State University San Luis Obispo. Bachelor of Science Industrial Engineering thesis, 2011. p. 4-39.
- Available from: <https://www.amar.org.ir/english>. [Last accessed on 2019 Sep 01].
- Wahyudi A, Dania W, Silalahi R. Work Posture Analysis of Manual Material Handling Using OWAS Method. *Agric Agric Sci Proc* 2015;3:195-9.
- Herzog N, Buchmeister B. The Review of Ergonomics Analysis for Body Postures Assessment. Ch. 14. Vienna: DAAAM Int. Scientific Book; 2015. p. 153-64.
- Gómez-Galán M, Pérez-Alonso J, Callejón-Ferre AJ, López-Martínez J. Musculoskeletal disorders: OWAS review. *Ind Health* 2017;55:314-37.
- Berlin C, Adams C. *Production Ergonomics: Designing Work Systems to Support Optimal Human Performance*. London: Ubiquity Press; 2017. p. 139-60.
- Parvez MS, Shahriar MM. Agricultural Farm-Related Injuries in Bangladesh and Convenient Design of Working Hand Tools. *J Healthc Eng* 2018;2018:1-10.
- Fazel MR, Fakharian E, Razi E, Abedzadeh-Kalahroudi M, Mahdian M, Mohammadzadeh M, *et al*. Epidemiology of home-related injuries during a six-year period in Kashan, Iran. *Arch Trauma Res* 2012;1:118-22.
- Honarpisheh H. A comprehensive model for trauma research design. *Arch Trauma Res* 2012;1:3-13.
- Talari H, Moussavi N, Abedzadeh-Kalahroudi M, Atoof F, Abedini A. Correlation Between Intra-Abdominal Free Fluid and Solid Organ Injury in Blunt Abdominal Trauma. *Arch Trauma Res* 2015;4:e29184.
- Naeini SH. Towards Quality of Life through the "Ergosustainability" Approach. Proceedings of the 20<sup>th</sup> Congress of the International Ergonomics Association; 2018. p. 662-8.
- Huang YH, Lee J, McFadden AC, Murphy LA, Robertson MM, Cheung JH, *et al*. Beyond safety outcomes: An investigation of the

- impact of safety climate on job satisfaction, employee engagement and turnover using social exchange theory as the theoretical framework. *Appl Ergon* 2016;55:248-57.
27. Muanah T, Syuaib MF, Liyantono S, Economic Ergonomic Approach to Design an Optimal Manpower and Mechanization in Rice Production. *IOP Conf. Series: Earth and Environmental Science* 2018;147:1-8.
  28. Sadeghi Naeini H, Dalal K, Mosaddad H, Karuppiah K. Economic effectiveness of Ergonomics interventions. *Int J Ind Eng Product Res* 2018;29:261-76.
  29. Burgess-Limerick R. Participatory ergonomics: Evidence and implementation lessons. *Appl Ergon* 2018;68:289-93.
  30. Abeysekera J, Illankoon P. The demands and benefits of ergonomics in Sri Lankan apparel industry: A case study at MAS holdings. *Work* 2016;55:255-61.
  31. Sanjog J, Patel T, Karmakar S. Occupational ergonomics research and applied contextual design implementation for an industrial shop-floor workstation. *Int J Ind Ergon* 2019;72:188-98.
  32. Beevis D, Slade IM. Ergonomics – Costs and benefits. *Appl Ergon* 2003;34:413-8.
  33. Khazaei S, Jenabi E, Zobdeh Z, Biglari M, Afshari M, Gholamaliece B, *et al.* Pattern of trauma related to falling from walnut tree as an occupational injury: A cross-sectional study in the west of Iran. *Arch Trauma Res* 2019;8:99-103.