



Understanding musculoskeletal disorders among Iranian apple harvesting laborers: Ergonomic and stop watch time studies



Ehsan Houshyar^{a,*}, In-Ju Kim^b

^a Department of Mechanical Engineering of Biosystems, Faculty of Agriculture, Jahrom University, PO BOX 74135-111, Jahrom, Iran

^b Department of Industrial Engineering and Engineering Management, College of Engineering, University of Sharjah, PO Box 27272, Sharjah, United Arab Emirates

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ABSTRACT

Background: Musculoskeletal disorders (MSDs) are usually caused by bad working postures and habits. There is a great demand to correctly estimate laborers' work-related musculoskeletal disorders (WMSDs) during physically intensive works. This study aimed to suggest a practical solution with ergonomic principles and time studies on the reduction of WMSDs for the apple harvesting laborers in Sepidan gardens at the Fars Province, Islamic Republic of Iran (Iran).

Methods: Prevalence of MSDs was evaluated by the Nordic Standard Questionnaire surveys and the laborers' workload was assessed by the rapid entire body assessment postural analysis tool. A stop watch time study method was employed to estimate rest time allowances. Data from the time study was also recorded by a questionnaire validated from a panel of experts. Thirty laborers from two age groups: a young (20–35 years of old) and old (36–55 years old) were sampled from 10 gardens.

Results: The stop watch time study revealed that the frequencies of apple harvesting works were 95 vs. 119 times for the old group and young one, respectively. The prevalent disorders were related to specific body regions such as the lumber, knee, neck and shoulder areas. The percentages of disorders were significantly reduced when ergonomically corrected postures were applied with suitable rest time allowances.

Conclusion: Fruit harvesting works may need to improve their work-rest time intervals to prevent WMSD developments and productivities with time managements. With a correct estimation of the desired number of laborers, apple harvesting jobs can be performed on time, and by implementing appropriate ergonomic postures, occupational health and safety problems can be lessened in the apple harvesting workers.

1. Introduction

Agriculture is regarded as a job containing high risks in many countries (Fathallah et al., 2010). Human resources are one of the most crucial capitals and the main production factors in the agriculture industry. Its management is a major determinant for higher productivities. However, farmers and agricultural laborers are exposed to various diseases and hurt such as musculoskeletal disorders (MSDs) (Amitabha and Robendranaz, 1992). Work-related musculoskeletal disorders (WMSDs) are one of the main causes of working time losses and employee injuries around the world (Bon and Daim, 2010). Thus, control and reduction of WMSDs amongst laborers represent a major ergonomic problem. This issue is so critical that the prevention of WMSDs is considered as a national priority in many countries (Hosseini et al., 2010).

Poor awareness on WMSDs is a major problem amongst the farm workers who use inappropriate postures during their agricultural works

including harvesting. It is well documented that WMSDs can be avoided by providing continuous educations (intervention) and utilizing proper ergonomic methods (Krystosik-Gromadzińska, 2017; Subramanian, 2017). Effective applications of ergonomic principles and tools in working environments can result in the balance between worker protections and task demands (Petit et al., 2014). To increase productivity and prevent work-related injury problems, the workers need to complete their work in a reasonable time. WMSD's can be lowered by the perception of work types and employment of an appropriate number of workers depending on the workload.

The workload is usually measured by three methods: “activity sampling”, “work sampling”, and “time study” (Zahedi and Najjari, 2008). Amongst the three methods, it is suggested that the time study method is most suited to those jobs which are repetitive in nature and required to be performed according to a clearly definable method (Nair, 2004). Time study is the development of a standard time by observing a task and analyzing it with the use of a stop watch (Russell and Taylor,

* Corresponding author.

E-mail addresses: Houshyar.e@Jahromu.ac.ir, Houshyar.e@gmail.com (E. Houshyar), dr.injukim@gmail.com (I.-J. Kim).

2005). A stop watch time study measures how long an average worker takes to complete a task at a normal pace (Yusoff et al., 2012). A “normal” operator is defined as a qualified and thoroughly experienced operator who is working under conditions as they customarily perform the workstation at a pace that is neither fast nor slow, but representative of an average (Nakayama, 2002).

Although time study and work measurement are useful tools for the enhancement of work efficiency, they are not widely used in the agriculture study and even within the industry (Zain and Rajamony, 2014). Amitabha and Robendranaz (1992) studied a relationship between a work speed and a heart pulse in rice production farms. They reported that the average speed of workers was 1.39 m/sec., which was higher than the expected value. Many other studies have focused on ergonomics interventions to reduce WMSDs (Krystosik-Gromadzińska, 2017; Petit et al., 2014; Guan et al., 2013), but no study has been found on estimating the best working time durations to reduce WMSDs. In this sense, the present study seems to be the first trial to measure the best working times with the consideration of environmental and caring conditions under a given time interval whilst WMSDs are mitigated.

Fruit harvesting in Iran is highly dependent on human resources due to lack of mechanized fruit harvesting machines. Fig. 1 shows an example of apple harvesting works from a laborer using a traditional apple bucket (or bag) and container. As shown in Fig. 1, typical harvesting jobs include picking apples, carrying a full apple bucket, transferring an apple container, and unloading an apple container for sorting. These activities require the laborer to perform a number of awkward postures, ranging from leaning far to one side whilst standing to hold both hands over the head for prolonged periods, which increase the likelihood of muscle and joint strain injuries.

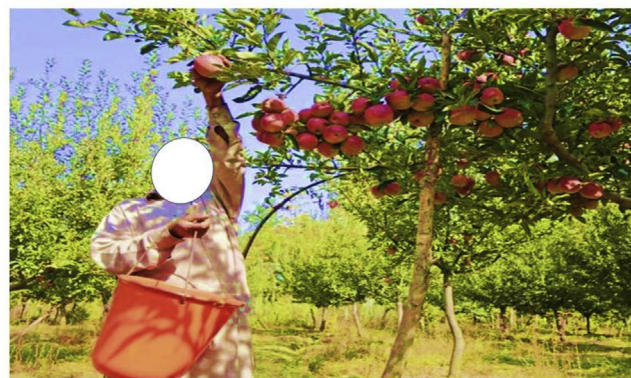
The demand for laborers to reap fruits during the harvesting period forces the gardeners to pay higher salaries, especially when enough laborers are not available. On the other hand, in some cases, the lack of enough laborers imposes extra costs such as fruit damages and wastes due to the difficulty of rapid harvesting. Moreover, laborers are sometimes compelled (or even pressured) to work harder and faster to meet tight time schedules and/or insufficient workforces. Such working conditions may cause to further developments of MSDs and other injury symptoms such as mental stress and fatigue. Therefore, this study had three main goals to investigate laborers' MSD prevalence:

- 1) The first goal was to estimate required working times for traditional apple harvesting practices and find an optimal number of laborers for on-time apple harvesting. A stop watch time study technique was employed to estimate correct working times for each task.
- 2) The second goal was to assess the current working poses for apple harvesting works from an ergonomic point of view and identify corrective worker postures. The Nordic Standard Questionnaire (NSQ) assessment tool was used to evaluate the prevalence of MSDs in various body areas of laborers. The laborers' workload was also assessed by the rapid entire body assessment (REBA) postural analysis tool. Based on the assessment results, an ergonomically principled postural method was suggested to training the harvesting laborers.
- 3) The third goal was to validate the effect of combining ergonomic principles and time study on the reduction of WMSDs.

By the accurate estimation of the needed number of laborers, apple harvesting works will be performed on time, and by implementing appropriate ergonomic postures, occupational health and safety problems will be reduced. Findings from this study may provide a conceivable solution to prevent MSD developments for the labor-intensive industries such as fruit harvesting and farming business.

2. Materials and methods

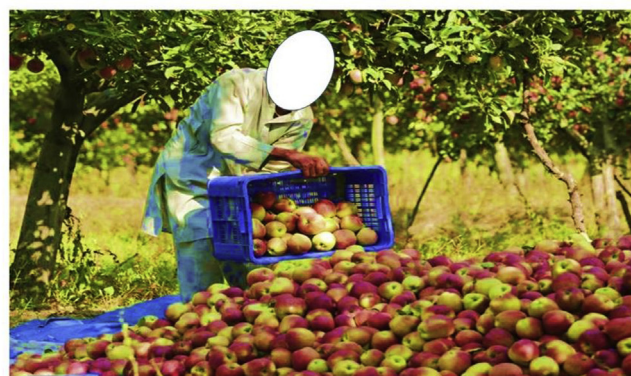
This study was carried out during 45 days of apple harvesting times



(a) Picking apples and put in a basket



(b) Transporting picked apples in a plastic container



(c) Unloading apples in a plastic container

Fig. 1. Photographic images for three main apple harvesting works from various angles and steps: (a) picking apples from an apple tree and put them in a carrying basket, (b) carrying a filled apple box to a garden, and (c) placing the box down and unloading apples for sorting, respectively (Waseem Andrabi/HT Photo, 2017).

in Sepidan town at Fars Province in Iran. The Sepidan town is the main city for apple growing in the province and within the country. The highest record of apple yield per hectare is around 152 tons/ha (Ministry of Jihad-e-Agriculture, 2016). Many laborers work to harvest apples in the gardens without any machinery aid. Thus, correct working posture is one of the essential concerns which may, in turn, reduce MSDs. To collect data for the study, ten out of 43 apple gardens were randomly selected using random sampling method without replacement.

Three laborers from each garden were invited for the study. Totally 30 laborers were tested in the time study and ergonomic experiments. To consider age effects, the laborers were divided into two groups: a

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