Musculoskeletal Problems in Iranian Hand-Woven Shoe-Sole Making Operation and Developing Guidelines for Workstation Design

H Veisi¹, AR Choobineh², H Ghaem³

Abstract

Background: Musculoskeletal disorders (MSDs) are among important health problems in working population. Because of performing difficult physical activities, hand-woven shoe-sole makers are at risk of developing various types of MSDs.

Objective: To determine the prevalence of musculoskeletal symptoms in different body areas of hand-woven shoe-sole makers, assess workers’ postures and workstations, evaluate ergonomic and individual factors associated with MSDs, and develop guidelines for designing hand-woven shoe-sole making workstation.

Methods: In this cross-sectional study, the prevalence of MSDs symptoms and their risk factors were studied among 240 hand-woven shoe-sole makers. Working posture and workstations were ergonomically assessed as well. The data were collected through interviewing and using Nordic musculoskeletal questionnaire and by direct observation of posture using RULA method. Logistic regression analysis was used to determine risk factors associated with MSDs symptoms.

Results: The prevalence and severity of MSDs symptoms were high among the study population. Ergonomic factors including daily working time, working posture, and force exertion, as well as individual factors, such as age, job tenure, and education were significantly associated with MSDs symptoms.

Conclusion: It seems that the majority of ergonomics shortcomings originate from poorly designed workstation. Some general guidelines for designing shoe-sole making workstation are presented.

Keywords: Musculoskeletal diseases; Human engineering; Occupational diseases; Equipment design

Introduction

Musculoskeletal disorders (MSDs), a highly prevalent and costly health problem among working population, constitute a major cause of occupational injury and physical disability in both developed and developing countries. It is also accounted as a main cause of sickness and absence from work.
in developed world, ie, Western European countries, USA, and Canada. MSDs have substantial effects on millions of people throughout the world, and are one of the most prevalent causes of severe long-term pains and physical disability. Epidemiological studies have shown evidence of a causal relationship between occupational physical activity and work-related MSDs that are associated with repetitive motions, excessive force, sustained and/or poor postures, and prolonged sitting and standing.

In recent decades, prevention of work-related MSDs has become a necessity and a national priority in many countries. In developing countries, the large number of workers in small-scale industries, especially in the informal sector, has caused occupational health programs and safety issues to become a prerequisite. Home-based workshops are a subset of the informal sector of small-scale industries.

Workers employed in small-scale industries usually benefit from low-quality occupational health services and have poorer health conditions compared to those in large-scale enterprises. Informal sectors are in fact unrecorded enterprises with less than 10 workers, which are not supported by formal employment contracts. In addition, in many countries occupational health services either do not exist or are presented at a low level to this sector. Iran's hand-woven shoe industry, which is categorized as a home-based workshop and small-scale industry, has seldom been studied profoundly and scientifically and has been neglected from occupational health point of view. Reduction in MSDs and improvement in working conditions of small-scale industries in developing countries will have a considerable effect on promoting and sustaining the quality of life of workers and will result in higher productivity.

Hand-woven shoe (which is called Giveh in Persian, and Kelash in Kurdish language) is a kind of soft, comfortable, and durable hand-woven shoe that is produced in many districts of Iran, especially in Kermanshah and Kurdistan provinces, West of Iran. Hand-woven shoe making is a kind of handicraft industry where large number of weavers are employed; it comprises a high percentage of handicraft export in these two provinces. Hand-woven shoe making is mainly performed in home-based workshops and, in a few cases, in shoe-weaving complexes where a number of weavers work. Giveh consists of two parts—sole and the upper part. The sole is usually made of cloth and leather, while the upper part is made of woven threads. The sole of the shoes is made using different hand tools by male workers. This is a physically demanding task requiring too much force and sufficient skills and experience. The upper part of the shoe is made by hand in workshops where it then is adjoined to the sole.
Making the shoe sole, which was investigated in the present study, is among the most wearying and tiresome occupations and requires long hours of static work. Hand-woven shoe-sole makers sit on the ground in cross-legged or folded-knee position behind a wooden chump to produce or prepare the shoe sole (Fig 1). In hand-woven shoe-making industry, the risk of MSDs is predicted to be high because of awkward posture, working with poorly designed hand tools, non-ergonomic and repetitive motions, contact pressure, long working time, and no rest pauses.

To the best of our knowledge, a few studies have so far been conducted on MSDs and their related risk factors among the workers making shoe sole. Therefore, the present study was carried out with the following objectives: (1) to determine the prevalence of musculoskeletal symptoms in different body areas of hand-woven shoe-sole makers, (2) to assess working postures and hand-woven shoe-sole making workstations, (3) to determine the ergonomic and individual risk factors associated with MSDs, (4) to determine the severity and frequency of MSDs in shoe-sole makers, and (5) to develop guidelines for designing hand-woven shoe-sole making workstations. We believe that the results of the present study can be used for planning and implementing ergonomic interventional programs in hand-woven shoe weaving industry.

**Materials and Methods**

This cross-sectional study was conducted in active rural and urban hand-woven shoe-making workshops in Kurdistan and Kermanshah provinces, western Iran. Based on the official records of Iranian Cultural Heritage Organization, in these provinces there were 145 active workshops with 300 hand-woven shoe-sole making male workers. To determine the minimum sample size, a pilot study was conducted on 50 randomly selected shoe-sole makers. Based on the results of the pilot study, with a confidence level of 95%, accuracy of 2.5%, MSDs prevalence of 25%, and a population size of 300, the minimum sample size was calculated to be 239.

In total, 240 hand-woven shoe-sole makers with at least one year of job tenure were randomly selected. The required data related to personal details of studied work-
Statistical analysis was performed by SPSS® for Windows®, ver 21. Logistic regression analysis was applied to determine the independent risk factors associated with MSDs symptoms. In the regression analysis, if the p value of univariate analysis for assessing association between the variables and reported symptoms was ≤0.25, the variable was included in the model.\(^{21}\) Logistic regression analysis was then performed for each outcome retaining the variables in the model to adjust for potential confounders. A p value <0.05 was considered statistically significant.

**Results**

Personal characteristics and working conditions in the study population are presented in Table 1. The participants had a mean age of 34.5 (range 18 to 66) years; their median job tenure was 12 (range 1 to 37) years, thus they can be considered “experienced craftsmen.” Most of sole makers

---

**Table 1:** Some personal details of hand-woven shoe-sole making male workers (n=240). Figures are mean (SD) or percentage unless stated otherwise.

| Variable                  | Value     |
|---------------------------|-----------|
| Age (yrs)                 | 34.5 (9.8) |
| Weight (kg)               | 72.5 (10.5)|
| Height (cm)               | 173.0 (6.0)|
| BMI (kg/m²)               | 24.2 (3.0) |
| Job tenure (yrs)          | 12.0 [7–16]* |
| Daily working time (hrs)  | 9.2 (1.5)  |
| ≤8 hrs                    | 33.3%     |
| >8 hrs                    | 66.7%     |
| Weekly working days (%)   | 6.7 (0.6)  |
| ≤5 days                   | 6.7%      |
| >5 days                   | 93.3%     |
| Handedness (%)            |           |
| Right                     | 96.7%     |
| Left                      | 3.3%      |
| Education (%)             |           |
| Illiterate                | 13.3%     |
| Primary school (the first 5 years of education at school) | 30.4% |
| Guidance and high school (GHS) | 45.4% |
| Diploma and higher        | 10.9%     |
| Workshop (%)              |           |
| Urban                     | 27.9%     |
| Rural                     | 72.1%     |
| Smoking (%)               |           |
| Yes                       | 47.5%     |
| No                        | 52.5%     |
| Regular exercise (%)      |           |
| Yes                       | 21.2%     |
| No                        | 78.8%     |

*Median [IQR]
(93.3%) worked more than five days a week; the majority of them (66.7%) worked more than eight hours a day. The majority of the participants had low education and most of them (72.1%) worked in rural workshops.

The prevalence rates of MSDs symptoms in different body areas in shoe-sole makers during the last 12 months are shown in Table 2. The highest rates were related to lower back followed by knees, shoulders, neck, wrists, and upper back.

The severity of pain in the nine different body parts on a 10-point scale (0: “no pain” and 9: “worst possible pain”) is presented in Table 3. The most affected body regions were lower back, shoulders, upper back, neck, wrists/hands, and knees.

A high percentage of the observed upper arm, neck, and trunk postures were deviated from the neutral posture (Table 4). In all cases, leg posture obtained score 2, demonstrating awkward legs position. Moreover, the mean RULA grand score was 6.83 (SD 0.37) indicating prompt attention was necessary for correction of workers' postures. Overall, RULA assessment showed that neck, trunk, and leg postures of most of the study participants had deviations from the neutral position.

Results of regression analysis of ergonomic and individual risk factors affecting different body areas are presented in Table 5. The significant factors were the result of a logistic regression analysis performed to adjust for potential confounding variables (e.g., working posture, exerted force, and daily working time). Daily working time (OR 1.66; ranging from 1.25 to 2.20) was an independent risk for MSDs symptoms in all body areas. Other factors such as trunk and neck postures, and exerted force, were also significant independent ergonomic factors in occurrence of these symptoms. Among the demographic factors, age, job tenure, and education remained in the regression model. Other factors, including weekly working time, BMI, handedness, workshop place, smoking habits, and regular exercise each week, were not significantly associated with the reported symptoms.

**Discussion**

This study was one of the first studies conducted on assessment of working conditions in hand-woven shoe-sole making workshops with particular attention to occurrence of musculoskeletal symptoms and their associated risk factors. We found several important observations:

**Prevalence of MSDs**

The prevalence of MSDs was high among the study population. The mean severity of low back, shoulder and upper back pain was higher than in other parts of the body. During the last 12 months, 92.5% of the studied workers had experienced musculoskeletal symptoms in at least one body area. Therefore, their work can be considered a job with a high risk of MSDs. Moreover, lower back, knees, shoulders, neck, wrists, and upper back were at a

---

**Table 2:** Prevalence of reported musculoskeletal symptoms among hand-woven shoe-sole makers during 12 months prior to the study (n=240)

| Body area            | n (%)   | 95% CI          |
|----------------------|---------|-----------------|
| Neck                 | 93 (38.8) | 32.6 to 44.9   |
| Shoulders            | 124 (51.7) | 45.3 to 58.0   |
| Elbows               | 51 (21.3)  | 16.1 to 26.5   |
| Wrist/hands          | 86 (35.8)  | 29.7 to 41.9   |
| Upper back           | 76 (31.7)  | 25.8 to 37.6   |
| Lower back           | 181 (75.4) | 69.9 to 80.9   |
| Hip/thighs/buttocks  | 73 (30.4)  | 24.6 to 36.3   |
| Knees                | 162 (67.5) | 61.5 to 73.5   |
| Ankles/feet          | 32 (13.3)  | 9.0 to 17.7    |
Factors Associated with Musculoskeletal Symptoms

Occurrence of MSDs in different body areas of hand-woven shoe-sole makers were significantly associated with age, job tenure, daily working time, educational level, working postures, and force exerted. The major ergonomic and individual factors will be discussed with the ultimate goal of developing guidelines for designing ergonomic workstations to improve working posture. Although no similar studies have been conducted on the issue to compare the results, our findings were consistent with those of the previous studies investigating MSDs among relatively similar occupations such as weaving the upper part of hand-woven shoes, sewing machines, and hand-woven carpet.

Working Postures

In this part, working posture refers to neck, trunk, and legs postures while working. The results of the present study demonstrated that working posture had a significant influence on occurrence of MSDs in neck, shoulders, upper back, and lower back. There was a significant association between neck posture and occurrence of MSDs in neck (OR 2.35). A significant association was also observed between trunk posture and occurrence of MSDs in neck (OR 2.41), shoulders (OR 2.47), upper back (OR 3.04), and lower back (OR 3.93). This implies that high deviation of trunk and neck from neutral position can increase the risk of MSDs in the above-mentioned areas. Some previous studies also found positive associations between deviant working postures and musculoskeletal symptoms.19,22

Table 3: Severity of musculoskeletal pain in hand-woven shoe-sole making male workers (n=240).

| Body area            | Mean (SD) pain severity score (Scale 0–9) |
|---------------------|-------------------------------------------|
| Neck                | 6.05 (2.01)                                |
| ≤5                  | 27.1%                                     |
| >5                  | 72.9%                                     |
| Shoulders           | 6.42 (1.47)                                |
| ≤5                  | 27.9%                                     |
| >5                  | 72.1%                                     |
| Elbows              | 3.45 (1.82)                                |
| ≤5                  | 90.4%                                     |
| >5                  | 9.6%                                      |
| Wrists/hands        | 5.84 (2.06)                                |
| ≤5                  | 38.3%                                     |
| >5                  | 61.7%                                     |
| Upper back          | 6.29 (1.65)                                |
| ≤5                  | 23.3%                                     |
| >5                  | 76.7%                                     |
| Lower back          | 7.48 (1.44)                                |
| ≤5                  | 15%                                       |
| >5                  | 85%                                       |
| Hip/thighs/buttocks | 5.30 (1.84)                                |
| ≤5                  | 47.5%                                     |
| >5                  | 52.5%                                     |
| Knees               | 5.52 (1.68)                                |
| ≤5                  | 46.3%                                     |
| >5                  | 53.7%                                     |
| Ankle/feet          | 3.80 (2.06)                                |
| ≤5                  | 76.3%                                     |
| >5                  | 23.7%                                     |
| Whole body pain     | 50.19 (5.91)                               |
| Range               | 32 to 65                                   |
Force Exertion
Occurrence of musculoskeletal symptoms in some body areas was associated with force exertion. A significant association was observed between the exerted force and occurrence of MSDs in shoulders (OR 1.87), wrists (OR 2.28), and back (OR 1.68). This showed that force exertion imposes a high postural stress on the body during work and could increase the risk of disorders in the aforementioned areas.

Daily Working Time
Daily working time is not usually fixed in hand-woven shoe-sole making workshops, varying depending on the situation and workload. Moreover, motivation towards earning more money causes workers to work longer. Because of no scheduled working time, workers usually work continuously for a long period without a rest pause. This causes prolonged exposure to MSDs risk factors and an increased risk of MSDs. Daily working time was found to be a significant factor in musculoskeletal symptoms in all body areas (Table 5). In the same line, the studies performed on hand-woven carpet and weaving the upper part of hand-woven shoes revealed an association between long daily working hours and musculoskeletal symptoms.\cite{18,19}

Age and Job Tenure
We found a significant positive association between age and job tenure, and the prevalence of musculoskeletal symptoms in all body areas. This finding was in agreement with the results of the previous studies on similar operation.\cite{19,22,23}

Education
We found a significant association between level of education and occurrence of MSDs in neck, shoulders, wrists, and lower back. Higher education led to a reduction in the risk of MSDs. These results were in agreement with the findings of the study by Dianat and Salimi on weavers of upper part of hand-woven shoes\cite{19} and Wang on sewing machine operations.\cite{23}

Workstation Design Guidelines
Based on the results obtained from this study, most of ergonomic drawbacks and factors associated with occurrence of MSDs were originated from poor design of hand-woven shoe-sole maker workstations. Therefore, any plan for improving working conditions in this industry must focus on ergonomic design of workstations. In this respect, for improving working posture and providing ergonomically appropriate workstations, the following

### Table 4: RULA working posture assessment for the study participants (n=240)

| Part of body | RULA score | Mean (SD) |
|--------------|------------|-----------|
|              | 1          | 2          | 3          | 4 | 5 | 6 | 7 |              |
| Upper arms (%) | 2          | 92.8       | 5.2        | — | — | — | — | 2.03 (0.26) |
| Lower arms (%) | 5.2        | 92.8       | 2          | — | — | — | — | 1.96 (0.26) |
| Wrist (%)    | 3.9        | 90.1       | 6          | — | — | — | — | 2.01 (0.31) |
| Neck (%)     | 6.6        | 13.8       | 79.6       | — | — | — | — | 2.73 (0.51) |
| Trunk (%)    | 0.7        | 31.6       | 67.7       | — | — | — | — | 2.67 (0.48) |
| Leg (%)      | —          | 100        | —          | — | — | — | — |              |
| Grand score (%) | —        | —          | —          | — | — | — | — | 16.4 83.6 6.83 (0.37) |
| Body area     | Ergonomic factors | OR*(95% CI)       | Individual factors | OR (95% CI)       |
|--------------|-------------------|------------------|-------------------|------------------|
| Neck         | Daily working time | 1.34 (1.15 to 1.62) | Age               | 1.04 (1.01 to 1.07) |
|              | Trunk posture     | 2.41 (1.22 to 4.77) | Job tenure        | 1.08 (1.04 to 1.12) |
|              | Neck posture      | 2.35 (1.24 to 4.43) | Education         |                  |
|              |                   |                  | Illiterate        | 1.00             |
|              |                   |                  | Primary School (GHS or higher) | 0.53 (0.23 to 1.21) |
|              |                   |                  |                   | 0.47 (0.25 to 0.87) |
| Shoulders    | Daily working time | 1.64 (1.33 to 2.02) | Age               | 1.04 (1.01 to 1.07) |
|              | Trunk posture     | 2.47 (1.21 to 5.04) | Job tenure        | 1.10 (1.06 to 1.15) |
|              | Force/load        | 1.87 (1.22 to 2.87) | Education         | 1.00             |
|              |                   |                  | Illiterate        | 0.47 (0.21 to 1.03) |
|              |                   |                  | Primary School (GHS or higher) | 0.50 (0.28 to 0.90) |
| Elbows       | Daily working time | 1.30 (1.05 to 1.61) | Age               | 1.05 (1.02 to 1.08) |
|              |                   |                  | Job tenure        | 1.08 (1.03 to 1.12) |
| Wrists       | Daily working time | 1.46 (1.20 to 1.78) | Age               | 1.04 (1.05 to 1.14) |
|              |                   |                  | Job tenure        | 1.10 (1.02 to 1.07) |
|              | Force/load        | 2.28 (1.49 to 3.51) | Education         | 1.00             |
|              |                   |                  | Illiterate        | 0.53 (0.23 to 1.24) |
|              |                   |                  | Primary School (GHS or higher) | 0.51 (0.27 to 0.95) |
| Upper back   | Daily working time | 1.70 (1.36 to 2.13) | Age               | 1.05 (1.02 to 1.08) |
|              | Trunk posture     | 3.04 (1.46 to 6.34) | Job tenure        | 1.11 (1.07 to 1.16) |
|              | Force/load        | 1.68 (1.11 to 2.55) | Age               | 1.05 (1.02 to 1.13) |
| Lower back   | Daily working time | 2.20 (1.67 to 2.89) | Job tenure        | 1.19 (1.11 to 1.27) |
|              | Trunk posture     | 3.93 (1.26 to 12.28) | Education         | 1.00             |
|              |                   |                  | Illiterate        | 1.21 (0.38 to 3.84) |
|              |                   |                  | Primary School (GHS or higher) | 0.18 (0.09 to 0.36) |
| Thighs       | Daily working time | 1.25 (1.03 to 1.51) | Age               | 1.03 (1.01 to 1.06) |
|              |                   |                  | Job tenure        | 1.06 (1.02 to 1.10) |
| Knees        | Daily working time | 1.49 (1.21 to 1.84) | Age               | 1.04 (1.01 to 1.07) |
|              |                   |                  | Job tenure        | 1.09 (1.05 to 1.14) |
| Legs         | Daily working time | 1.32 (1.03 to 1.70) | Age               | 1.06 (1.02 to 1.10) |
|              |                   |                  | Job tenure        | 1.08 (1.03 to 1.12) |

*Odds ratio calculated by logistic regression analysis
general guidelines have been developed. These guidelines are oriented towards eliminating awkward and fixed postures and improving working conditions.

1. Workstation must be equipped with a seat with adjustable height providing natural posture for lower limbs. Besides, the seating surface must be covered with soft materials and rotational to reduce cervical and lumbar twist around the vertical axis. Foot rest must be available in the workstation, as well.

2. Making the sole of hand-woven shoes is a dynamic task and workers need to exert force and move their hands and arms continuously. Therefore, use of high seats (popliteal height + 15 cm) with 10° forward slope is advisable.

3. Wooden chump and table heights should be adjustable to improve neck, lower back, upper back, shoulders, and arms working posture. Additionally, there must be sufficient clearance for movement of legs under the table.

4. Hand tools should be placed in occasional access zone.

5. The adjusting mechanisms for physical dimensions of the workstation should be easy to handle.

6. High seat causes slightly less trunk inclination, increased trunk-thigh angle and consequently increased lordosis in the table region.

Figure 2 displays the guidelines. Taking into account the developed guideline and after a thorough study on the hand-woven shoe-sole making workshops, a prototype workstation was designed and constructed (Fig 3).

The most important feature of the workstation is its adjustability. The height of the wooden chump and the seat is adjustable so that hand-woven shoe-sole makers can adjust work level height according to their preferences.

An experimental test was conducted in the laboratory to assess workers’ perception about
the new workstation and working posture. In this preliminary usability test, we attempt to measure the impact of the new workstation on the subjects’ performance. Further field trials are needed to study efficiency under real condition.

Considering the cross-sectional design of the current study and data collection through self-report, the results of the study should be interpreted with caution. Self-report method might have problems with recall, denial, or deception. Additionally, since the analysis was limited to currently working employees, the workers who had left jobs due to MSDs symptoms might have been excluded from the study, resulting in “healthy worker effect bias.” Therefore, the reported rates might be underestimated.

In conclusion, the present study showed that MSDs were highly prevalent in hand-woven shoe-sole making operation. The results also revealed a significant relationship between the prevalence of MSDs symptoms and neck and trunk awkward postures, force exertion, and daily working time. Collectively, based on the finding, any ergonomic interventional and preventive programs in this operation have to focus on designing ergonomics-oriented workstations. It is believed that the recommended guidelines for workstation design will be effective in prevention of MSDs in hand-woven shoe-sole makers through improving their working postures.

Acknowledgments

This article was extracted from the thesis of Mr. Hemmat Veisi, MSc, student of Occupational Hygiene Engineering and was financially supported by Shiraz University of Medical Science (Project No. 94-7471). Hereby, the authors wish to thank Ms. H. Maghami, Mr. Sh. Ebrahim-Zadeh, and Mr. E. Sedighi for their assistance in data collection.

Conflicts of Interest: None declared.

References

1. McDonald M, DiBonaventura MD, Ullman S. Musculoskeletal pain in the workforce: the effects of back, arthritis, and fibromyalgia pain on quality of life and work productivity. *J Occup Environ Med* 2011;53:765-70.

2. Choobineh A, Tabatabaei SH, Tozihian M, Ghadami F. Musculoskeletal problems among workers of an Iranian communication company. *Indian J Occup Environ Med* 2007;11:32-6.

3. Choobineh A, Daneshmandi H, Aghabeigi M, Haghayegh A. Prevalence of Musculoskeletal Symptoms among Employees of Iranian Petrochemical Industries: October 2009 to December 2012. *Int J Occup Environ Med* 2013;4:195-204.

4. Maul I, Laubli T, K lipstein A, Krueger H. Course of low back pain among nurses: a longitudinal study across eight years. *Occup Environ Med* 2003;60:497-503.

5. Choobineh A, Rajaeefard A, Neghab M. Association between perceived demands and musculoskeletal disorders among hospital nurses of Shiraz University of Medical Sciences: a questionnaire survey. *Int J Occup Saf Ergon* 2006;12:409-16.

6. Bernal D, Campos-Serna J, Tobias A, et al. Work-related psychosocial risk factors and musculoskeletal disorders in hospital nurses and nursing aides: A systematic review and meta-analysis. *Int J Nurs Stud* 2015;52:635-48.

7. Woolf AD, Pfleger B. Burden of major musculoskeletal conditions. *Bull World Health Organ* 2003;81:646-56.

8. Choobineh A, Tabatabaei SH, Behzadi M. Musculoskeletal problems among workers of an Iranian sugar-producing factory. *Int J Occup Saf Ergon* 2009;15:419-24.

9. da Costa BR, Vieira ER. Risk factors for work-related musculoskeletal disorders: a systematic review of recent longitudinal studies. *Am J Ind Med* 2010;53:285-323.

10. Spielholz P, Silverstein B, Morgan M, et al. Comparison of self-report, video observation and direct measurement methods for upper extremity musculoskeletal disorder physical risk factors. *Ergonomics* 2001;44:588-613.

11. Cocker F, Martin A, Scott J, et al. Psychological
distress, related work attendance, and productivity loss in small-to-medium enterprise owner/managers. *Int J Environ Res Public Health* 2013;10:5062-82.

12. Meena M, Dangayach G, Bharadwaj A. Occupational risk factor of workers in the handicraft industry: a short review. *Int J Res Engine Technol (IJRET)* 2012;1:194-6.

13. Gerxhani K. The informal sector in developed and less developed countries: a literature survey. *Public Choice* 2004;120:267-300.

14. Choobineh A, Shahnaz H, Lahmi M. Major health risk factors in Iranian hand-woven carpet industry. *Int J Occup Saf Ergon* 2004;10:65-78.

15. Moriguchi J, Ikeda M, Sakuragi S, et al. Activities of occupational physicians for occupational health services in small-scale enterprises in Japan and in the Netherlands. *Int Arch Occup Environ Health* 2010;83:389-98.

16. Loewenson R. Occupational hazards in the informal sector: A global perspective. In: Isaksson K, ed. *Health Effects of the New Labour Market*. Klumer/Plenum, New York, 2000:329-42.

17. Meena M, Dangayach G, Bharadwaj A. Impact of ergonomic factors in Handicraft Industries. Proceedings of the International conference of Mechanical, production and Automobile Engineering. 2011.

18. Choobineh A, Lahmi M, Shahnaz H, et al. Musculoskeletal symptoms as related to ergonomic factors in Iranian hand-woven carpet industry and general guidelines for workstation design. *Int J Occup Saf Ergon* 2004;10:157-68.

19. Dianat I, Salimi A. Working conditions of Iranian hand-sewn shoe workers and associations with musculoskeletal symptoms. *Ergonomics* 2014;57:602-11.

20. McAtamney L, Corlett EN. RULA: a survey method for the investigation of work-related upper limb disorders. *Appl Ergon* 1993;24:91-9.

21. Kleinbaum DG, Kupper LL, Morgenstern H. *Epidemiologic research: Principles and quantitative methods*. 1st ed. New York, Van Nostrand Reinhold, 1982.

22. Choobineh A, Hosseini M, Lahmi M, et al. Musculoskeletal problems in Iranian hand-woven carpet industry: Guidelines for workstation design. *Appl Ergon* 2007;38:617-24.

23. Wang P-C, Rempel DM, Harrison RJ, et al. Work-organisational and personal factors associated with upper body musculoskeletal disorders among sewing machine operators. *Occup Environ Med* 2007;64:806-13.

24. Choobineh A, Lahmi M, Hosseini M, et al. Workstation design in carpet hand-weaving operation: guidelines for prevention of musculoskeletal disorders. *Int J Occup Saf Ergon* 2004;10:411-24.

25. Choobineh A, Tosian R, Alhamdi Z, Davarzanie M. Ergonomic intervention in carpet mending operation. *Appl Ergon* 2004;35:493-6.