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Original

Ergonomic Evaluation of Risk Factors for Musculoskeletal Disorders in Construction Workers by Key Indicator Method (KIM)

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Abstract

Background: Construction activities are dicey businesses such that the existing peril not only threatens the person's safety, but also has health impacts. Inappropriate work postures, vibration and prolonged standing from using physical workload resources are known to cause musculoskeletal disorders among construction workers. Consequently, the purpose of this study was to evaluate the physical posture of construction workers using key indicator method. **Methods:** In this descriptive-analytical study, 150 construction workers were assessed in Bojnourd city. They included reinforcement workers, plasterers, tile installers, stoneworkers and painters. Thirty individuals from each of these professions were evaluated. This study was conducted using simple randomized sampling and in-person sessions. The prevalence of musculoskeletal discomfort was evaluated using Nordic questionnaire while working postures was assessed using KIM. Data was analyzed by chi-square. with SPSS19 software (*P*-Value =0.05).**Results:** The mean age of the workers was 29.28 (6.329), the average working experience was 4.91 (5.574) years and the mean duration of work was 6.34 (1.16). The Min and Max scores for workers' postural work were 18 and 64, respectively; and the average final score was 40.59 (11.941). There was no significant difference in terms of the relationship between the final score with age and work experience. However, a significant difference was observed in relation to the duration of the work and the type of task. The average final score for the reinforcement workers, stone workers, plasterer, painter and tile installer was 50.67 (8.227), 47.6(6.29), 45 (6.052), 5.188 (38), and 21.7 (3.12), respectively. **Conclusion:** Musculoskeletal disorders are frequent in construction workers. Consequently, appropriate measures should be taken to reduce musculoskeletal disorders among construction workers. These measures include provision of ergonomic guidelines in the design of work stations, tools and training of workers in the field on correct lifting techniques.

Keywords: Ergonomic evaluation; Risk factor; Musculoskeletal disorders; Key indicator method

Introduction

Construction activities are associated with a lot of risks such that the existing risks not only jeopardize the individual's safety, but also have an impact on health. In addition, construction work belongs to a class of work known as non-repetitive work and it is ergonomically

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hazardous. Consequently, musculoskeletal disorders are very common among construction workers[1] and are the most prevalent occupational injuries.[2] Musculoskeletal disorders can be defined as disorders of the muscles and skeleton, tendons, tendon sheath, peripheral nerves, joints, bones, ligaments and blood vessels which are either caused by a repeated hit over time or an immediate or acute hit.[3] According to studies, work-related musculoskeletal disorders are considered to be the most imperative factors in the loss of working time, increase in labor costs and injuries, and one of the biggest health care challenges in the world.[4] According to studies conducted by the World Health Organization (WHO) and the 2013 reports on occupational diseases, musculoskeletal injuries accounted for 48% of all work-related diseases and ranked second in the classification of health challenges, and by extension accounts for 1.2 billion in direct costs and 90 million dollars in indirect costs.[5] Musculoskeletal disorders account for 7% of the total diseases in the community, 14% referral to doctors and 19% of hospital admissions. In addition, 62% of the patients with musculoskeletal disorders have some kind of movement restriction.[6] According to statistics released by the Statistics Center of Iran and the Ministry of Health and Medical Services, 76% of workers suffer from poor physical posture.[7] According to the report of the medical committee of the social security organization of Tehran province, musculoskeletal disorders account for 14.4% of the prevalence of various diseases and disability. According to the U.S. Bureau of Labor Statistics, musculoskeletal disorders accounts for 44% of work-related diseases.[8] In the construction industry, this figure has been reported to be 14.2%.3 Manual materials handling (MMH) means moving or handling things by lifting, lowering, pushing, pulling, carrying, holding, or straining and requires the use of force by the individual.[9] In this study, a Nordic questionnaire was employed to evaluate the prevalence of musculoskeletal disorders; and the Key Indicator Method (KIM) was used to assess the risk of musculoskeletal disorders. In a study on three significant factors for manual handling (lifting height, load weight and handling skill) of the external load on the back, Plummondon et al. discovered that all three factors are important, but the greater focus should be on lifting height and load weight in order to reduce the external load on the back.[10] In a study, Randin et al., found that physical and mental strain of workers can be lessened by designing appropriate resting periods during working hours, adopting job rotation blueprints, correction of physical postures and compliance with the principles of ergonomics.[11] Ergonomic conditions of the work environment can be assessed using a variety of techniques. One of these methods is KIM, which is designed to evaluate exposure to work-related musculoskeletal risks; and has the advantage of differentiating between lifting, holding, pulling and pushing and contains different checklists for assessment of the risk of each of the listed occupations. This technique can provide reliable information for interventions and prioritization.[12,13,14] The high physical strain of construction workers is associated with task such as transportation of building materials, use of tools and related machines. Inappropriate working postures, frequent use of various body parts, vibration and prolonged standing are the causes of physical workloads. Physical workload has been identified as the primary cause of musculoskeletal injuries of construction workers.[15] It should be noted that there are many of our beloved compatriots who are working in the construction industry and most of their activities require high physical capacity. Most of their activities are usually performed in undesirable posture that can induce musculoskeletal disorders in the long run. There are few studies that have been conducted on postural evaluation of workers in this profession in Iran. Hitherto, no study has been conducted on this issue in Bojnurd. Consequently,

the aim of this study wasto evaluate the physical condition of construction workers in Bojnurd city using KIM.

Methods

In this descriptive-analytical study, 150 construction workers were assessed in Bojnurd city. The categories of construction workers assessed include reinforcement workers, plasterers, tile installers, stoneworkers and painters. Thirty individuals were evaluated from each of these professions. This study was conducted using simple randomized sampling and in-person sessions. The prevalence of musculoskeletal discomfort was evaluated using Nordic questionnaire while working postures was assessed using KIM. The Nordic questionnaire consists of two parts viz: a) a general questionnaire; b) a specific questionnaire. The general questionnaire seeks general examination information, in which symptoms of disorders are experienced in the whole body, while the specific questionnaire deeply analyzes these symptoms in specific areas of the body, such as the waist, neck and shoulders. In general, these questionnaires were designed to achieve two goals: A) As a tool for screening musculoskeletal disorders b) for utilization by healthcare services.

These questionnaires were designed to answer the general question of whether musculoskeletal problems are peculiar to a specific population, and if so, in which of the body organs are these disorders concentrated.

The KIM method was presented by the German Federal Agency for Occupational Safety and Health in 2001-2007 and is one of the most valid and comprehensive methods for assessing manual handling of tasks. It has three parts viz:

A) KIM-MHO: To evaluate and analyze manual activities (hands, arms and shoulders)

B) KIM-LHC: To assess and analyze activities related to the lifting, holding and carrying of things (trunk)

C) KIM-PP: To evaluate and analyze activities related to pushing and pulling of things (trunk)

1) Calculating the risk rating in the KIM-MHO method

2) Calculating the risk rating in the KIM-LAKK method

3) Calculating the risk rating in the KIM-PAP method

Finally, checklist related to the task was coded after the extraction activities and determination of the means and materials to be carried and the type of tools to be used. After determining the risk rating for each activity and task according to its method, the risk level was computed and the tasks were grouped at risk levels ranging from 1 to 4 using the relevant tables. According to the KIM, preventive measures can be classified as unnecessary, necessary and mandatory and are required at risk levels 1, 2, 3 and 4. It should be noted that this technique is able to evaluate the overall working conditions during manual carrying and handling of loads. It can also identify and classify critical tasks in terms of physical stress. Table 1

Research findings

In this research, 150 construction workers including reinforcement workers, plasterers, tile installers, stoneworkers and painters (30 individuals from each occupation) were selected and their postural status was assessed using the checklist of KIM. The Min and Max age of workers was 22 and 55 years, respectively; with an average age of 29.28 (6.329), a minimum working experience of one year and a maximum working experience of 25 years as well as an average working experience of 4.91 (5.574) years. The duration of the work was at least 4 hours, and a maximum of 8 hours and an average of 6.34 (1.16). The Min and Max score for workers' posture was 18 and 64, respectively and the average score was 40.59 (11.941) Table 2.

Table 1. Risk rating and risk level for each activity and task

Description	Risk rating	Risk level
Low-load situation, health risk caused by physical overload is unlikely.	Less than 10	1
Moderate load status, the possibility of an increase in physical load for less flexible people. Redesigning the workplace is beneficial.	10 - 25	2
Increased load status, the possibility of physical overload, even for people with normal flexibility. Workplace design must be reconsidered.	25 -50	3
The high load status, the possibility of a physical overload is too much. Redesigning the workplace is imperative.	More than 50	4

Data was analyzed by chi-square with SPSS19 software.

Table 2. Demographic and occupational characteristics of individuals

Title	Minimum	Maximum	Mean	Standard deviation
Age	22	55	29.28	6.33
work experience	1	25	4.91	5.57
Duration of work	4	8	6.34	1.16
KIM final score	18	64	40.59	11.94

The incidence of discomfort, pain and numbness in the neck, right shoulder, left shoulder, both shoulders, right elbow, left elbow, both elbows, left wrist,, right wrist, both wrists, back, waist, hip-thigh, knee, leg and ankle in the last 12 months were 38.7%,18%, 12.7%, 19.3%, 4.7%, 8%, 3.3% 21.3%, 6.7%,18%, 56%, 67.3%, 20%, 60% and 45.3%, respectively Table 3.

Table 3. The incidence of discomfort, pain and numbness in different parts of the body in the last 12 months

Body part	The incidence of discomfort, pain and numbness in the last 12 months
Neck	58 persons (38.70%)
Right shoulder	27 persons (18%)
Left shoulder	19 persons (12.70%)
Both shoulders	29 persons (19.30%)
Right elbow	7 persons (4.70%)
Left elbow	12 persons (8%)
Both elbows	5 persons (3.30%)
Right wrist	32 persons (21.30%)
Left wrist	10 persons (6.70%)
Both wrists	27 persons (18%)
Back	84 persons (56%)
Waist	101 persons (67.30%)
Hip-thigh	30 persons (20%)
Knee	90 persons (60%)
Leg and ankle	68 persons (45.30%)

The incidence of discomfort, pain and numbness in the neck, right shoulder, left shoulder, both shoulders, right elbow, left elbow, both elbows, left wrist, right wrist, both wrists, back, waist, hip-thigh, knee, leg and ankle in the last 7 days were 24%,8.7%, 9.3%, 7.3%, 2.7%, 2.7%, 4.7% 16%, 6.7%,12%, 42%, 57.3%, 14.7%, 46% and 42.7%, respectively Table 4.

Table 4. The incidence of discomfort, pain and numbness in different parts of the body in the last 7 days

Body part	The incidence of discomfort, pain and numbness in the last 7days
Neck	Person 36 persons (24%)
Right shoulder	Person13 persons (8.70%)
Left shoulder	Person14 persons (9.30%)
Both shoulders	Person11persons (7.30%)
Right elbow	Person4 persons (2.70%)
Left elbow	Person4 persons (2.70%)
Both elbows	Person7 persons (4.70%)
Right wrist	Person24 persons (16%)
Left wrist	Person10 persons (6.70%)
Both wrists	Person18 persons (12%)
Back	Person63 persons (42%)
Waist	Person86 persons (57.30%)
Hip-thigh	Person22 persons (14.70%)
Knee	Person69 persons (46%)
Leg and ankle	Person64 persons (42.70%)

There was no significant difference between the final KIM score with age (p= 0.181) and work experience (p= 0.141) by chi-square Test. As well there was a significant difference between the duration of work (p<0.001) and the type of task (p<0.001000) by chi-square Test. The duration of the work and the type of task were efficacious based on the final KIM score. The average final KIM score for the reinforcement workers, stoneworkers, plasterers, painters and tile installers was 50.67 (8.227), 47.6 (6.29), 45 (6.052), 5,188 and 21.7 (3.12), respectively.

Discussion

The maximum and minimum KIM score was observed among reinforcement workers with an average score of 50.67(8.227) and tile workers with an average score of 21.7(3.12), respectively.This result is consistent with the results obtained by Hokmabadi and Fallah,6 Buchholz16 and Haj Aghazadeh et al.[17] Taking into cognizance the fact that one of the tasks of the reinforcement workers is to reinforce the rebar, which is part of repetitive work, and by extension, this exposes the workers to inappropriate physical posture (including sitting, squatting and trunk bending).From the foregoing, it appears that the reinforcement task has the highest score among existing construction occupations. According to the results, the highest prevalence of discomfort was observed in the lumbar region. The inappropriate trunk posture had a significant impact on the incidence of musculoskeletal disorders in the lumbar region due to manual handling of heavy materials and improper postures during the work. This was consistent with the results obtained by Hokmabadi and Fallah, Richardon,[18] Nesel Seraj et al. 15Pirmand et al.[19] Memarian, et al.[20] and Poomma[21] and inconsistent with the results of the studies conducted on construction buildings by Abdul-rahman et al.[22] and Bushman et al.[23] In relation to the tiling and stone work, there was enormous burden on the spine and the muscular system due to improper postures of hands and the weight of working tools and materials. This is due to the fact that most of the work were carried out over the head. Consequently, it is recommended that lightweight tools be used or the elevation should be increased so that the elbow is placed below the height of the shoulder to lower pressure imposed on the person's skeletal system. The results of previous studies revealed that occupations which involve inappropriate conditions and static loads on the muscles of the shoulder and neck region significantly increased the musculoskeletal disorders of the shoulder and neck region. It should be said that the improper use of manual and electric tools, especially when performingtasks in an inappropriate posture causes musculoskeletal disorders as well as back and neck discomfort.[24] There was no significant difference between the KIM final score with age (p= 0.181) and work experience (p= 0.141), but there was a significant difference between the duration of the work (p= 0.000) and the type of task (p= 0.000). In other words, there was a significant difference between the different work stages and occupations in terms of time of exposure to the musculoskeletal risk factors. This difference could be due to the occupational requirements and the layout of the workplace. This findings were in consonance with studies conducted by Habibi and Fallah,[6] Buchholz16 and HajAghazadeh et al.[17] Average load condition was observed in working conditions of 17.3% of the individuals studied. In view of this, redesigning of the workplace would be beneficial. In addition, increased load condition was observed in working conditions of 62.7% of the individuals studied. From the foregoing, redesigning of the workplace is imperative. High load condition was observed in working conditions of 20% of the individuals studied thereby making the redesigning of the workplace necessary. The foregoing show that inappropriate postures of the trunk and hands, as well as carrying and lifting of objects and heavy tools using wrong techniques can have a significant effect on the musculoskeletal system of construction workers. Additionally, one of the limitations of the study was that the other construction procedures, including excavation, implementation of the column and ceiling of the floors and facade were considered. Therefore, it is recommended that more research on the country's construction industry that will involve more workers, different work stages and occupations be conducted so that the risk of musculoskeletal disorders among construction workers is reduced using the results of these studies. Also, the effect of these factors in reducing the amount of

musculoskeletal disorders among workers should be investigated. Workers should be trained on the correct ways of doing work and the working conditions of construction workers should be modified. Various tools and materials are used in different countries in construction activities; as such, it is necessary to conduct further research on the country's construction industry using other countries' research as a reference source.

Conclusion

The results of this study showed that musculoskeletal disorders are highly prevalent among construction workers and that appropriate measures should be taken to reduce musculoskeletal disorders among workers, including a more in-depth examination of work situations, tools, techniques used for lifting and carrying construction material and workers' postures in order to reduce the prevalence of musculoskeletal disorders among construction workers. One of such measures include the provisionof ergonomic guidelineson the design of work stations, designing of tools and training of workers in the area of proper lifting techniques.

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