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ORIGINAL ARTICLE

Ergonomic Evaluation of Musculoskeletal Disorders in Construction Workers Using Posture, Activity, Tools, Handling (PATH) Method

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ABSTRACT

Introduction: Musculoskeletal disorders are the major causes of occupational diseases in the work places and they are the most important cause of disability and absenteeism. For the prevention of these disorders and improvement of working, it is necessary to use ergonomics assessment techniques. This study aimed to assess ergonomic risk factors for musculoskeletal disorders in construction workers in Gonabad, Iran, using Postur, Activity, Tools, Handling (PATH) method.

Materials and Methods: This was a descriptive– analytical study conducted on 72 construction workers in three groups of jobs including brickwork, joinery and foundation in Gonabad, Iran. Sampling was done randomly. Workplace ergonomic assessment was conducted using PATH method and data analysis was performed by SPSS 20 statistical software and presented with descriptive statics.

Results: The mean age of participants was 30.44± 10.21 yr, and the average work experience was 9.26 ±7.20 yr. Legs status assessment showed that neutral state labors make up about 46% of the time. In most jobs, about 39% of labors work in a neutral position and about 50% of labors bear more than 15 kg weight during their work, and about 96% of labors spent their time working with elbows above their shoulder.

Conclusion: Mostly, in time of working, trunk state of construction workers was in a non-neutral posture and construction workers are exposed to musculoskeletal disorders. Thus, it is necessary to conduct more studies on these topics in order to prevent musculoskeletal disorders.

KEYWORDS: *Ergonomic, Musculoskeletal disorders, Construction workers*

INTRODUCTION

Today, the prevalence of musculoskeletal disorders is the major health concern in all societies. Musculoskeletal disorder occurs due to a severe blow or as the result of repetitive movements in the musculoskeletal system over time. Disorders appear in the spine, upper and lower limbs and they include tearing, trapped nerves, blood vessels or bone fractures. Musculoskeletal disorders were attributed to numerous risk factors including prolonged static posture, repetitive movements, suboptimal lighting, poor positioning, physical conditioning[1].

Work activities and tasks including repetition, contact stress, forceful contraction, awkward postures, and sustained position were associated with high risk of work related musculoskeletal disorders, such as lifting [2]. The symptoms include discomfort, pain, swelling, sensory disturbances, tingling, movement limitation and reduction of movement control. When work condition and working environment and works

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develop the musculoskeletal disorder, this is called work-related musculoskeletal disorder which is a work-related musculoskeletal disorder which is the most significant factor in the loss of work time, increase of costs and human force damage and it is considered as the biggest occupational health problem in developed countries [3-6]. The prevalence of musculoskeletal disorders reduces work quality, increases medical expenses and lost work time and causes early disabilities. Ergonomics science helps to design living environment and required equipment and facilities by abilities, and characteristics of human body to prevent musculoskeletal disorders [7].

Work-related musculoskeletal disorder is an important issue with many implications. These disorders vary greatly in people based on types of work. These disorders are common causes of occupational injuries and disabilities in developed and developing countries. This has led to lots of studies on disorders and their methods of evaluation [8-9]. People suffering from musculoskeletal disorders constitute 7% of all diseases in the society, 14% of patients who referred to physicians' offices, and 19% of hospitalized patients. Moreover, 62% of patients with musculoskeletal disorders have movement limitations [10-11]. Based on the statistics provided by the Statistical Center of Iran and the Ministry of Health, 76% of workers have poor physical status [11-12]. Working in hard situations can cause discomfort in the whole body, and if a person stays for a long time in this situation, it may lead to other discomforts in musculoskeletal tissue and eventually may cause disabilities. People who constantly work in standing position always complain about pain in their legs and lower back [11-13]. Poor physical status during work is the most important factor in musculoskeletal disorders. These disorders range from the less important problems to the most serious ones; i.e. from back pain to most severe side effects. If nothing is done to reduce musculoskeletal disorders, the effects of these inappropriate position of working will constantly continue [14]. Nowadays, much of the activities of workers in Iran is carrying products manually, either accidentally or as a part of their jobs (repeatedly) [15-16]. Musculoskeletal disorder is one of the harmful effects of carrying products manually. To prevent musculoskeletal disorders, it is necessary to identify affecting factors and problems on musculoskeletal system to provide solutions [15]. Musculoskeletal diseases are very common in workers [15-17]. These damages are more seen in jobs in which there is more manual material handling, and this is one of the most important occupational problems in a way that 19.1 percent of occupational injuries is due to occupational injuries and lifting heavy loads manually [15-18]. Construction is one of these jobs. Several methods have been proposed to evaluate workplace ergonomics, which include human or mechanical observation method, self-report, etc. Among the mentioned ergonomic assessment methods, pen and paper based observational methods have special advantages [11,19]. No need for specialized equipment, rapid assessment of equipment and rapid evaluation in short time is an important feature of this method.

These methods include OWAS-RULA-REBA-PATH. Mechanical methods are less used in agriculture due to the problems such as worker mobility, work interruption and high costs [11]. It is not recommended to use REBA method in Manual Material Handling activities. This method does not take into account duration of activities, so it is not applicable in this study. Postur, Activity, Tools, Handling (PATH) method evaluates 3 parts of the body (trunk, legs, and hands), equipment, and their weight and manual handling. The modified OWAS codes were used for postures. In this method, activities are divided into four groups including manual handling, the activity of hands, hand grips, public and private activities. PATH method can be easily used for these groups [11]. The Researches conducted using PATH method can be divided into application of PATH in drainage jobs [11,20], quantification of ergonomic risks of blacksmiths in highway construction [11,21], ergonomic analysis of harvest workers [11,22], describing ergonomic exposures of workers constructing Kayson compartment [11,23], and ergonomic evaluation of musculoskeletal disorders in construction workers in Iran [11,24]. Many construction activities require high physical abilities, and their activities have not changed over years. Workers carry heavy objects with improper postures, they use hand and wrist frequently, and unfortunately, most of the construction works are done in the same manner. Physical work of workers is the cause of musculoskeletal injuries [11]. According to the above-mentioned reasons, it seems necessary to evaluate ergonomic risks of musculoskeletal disorders in construction workers using PATH method to improve their working conditions and provide prevention recommendations.

MATERIALS AND METHODS

In this descriptive-cross sectional analytic method, 72 workers were chosen randomly in three groups of jobs including brickwork, (preparing material and brick layering), joinery (plastering, tiling, painting) and foundation (preparing armature, swage, and concrete) in Gonabad, Iran, in 2015. According to the fact that there are various jobs in construction works, in order to make studies easier, these jobs are divided into brickwork,

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joinery, and foundation. Workers postures were evaluated using PATH method and their demographic information was obtained through interviews. This method is a pen and paper method which is used for ergonomic evaluation of non-repetitive jobs like agriculture, mining and construction. PATH method is an observational method that is used to assess the ergonomic situation in non-repetitive activities such as agriculture, mining and construction. Codes are applied to describe the situation is altered state of OWAS method. In this method, activities are divided into four groups: Handling activities, hand grip, public activities and activities of Specific tasks. The purpose of handling is the weight of used tools and objects. Weight tools and objects determined before ergonomic analysis. Extraction the tasks and activities of the job is a necessary for ergonomic analysis by PATH method. PATH method evaluates three parts of the body (trunk, legs, and hands), equipment, and their weight and manual handling. The modified OWAS codes were used for postures [11]

To record the results, a group of workers who had similar tasks were studied for 20 minutes. The following positions were analyzed to evaluate the positions of body, hands, and legs.

Body Positions:

1. Neutral: Bending forward or bending at the waist (bending sideways), less than 20 degrees or twisting less than 20 degrees.
2. Mild bending forward: Bending forward between 20 to 45 degrees.
3. Sharp bending forward: Bending forward more than 45 degrees.
4. Bending sideways or twisting: Bending forward less than 20 degrees along with bending sideways more than 20 degrees or bending forward less than 20 degrees along with twisting more than 20 degrees.
5. Bending and twisting: Bending forward and twisting more than 20 degrees.

Position of Legs

1. Neutral: Knees bend less than 35 degrees
2. One leg upward
3. Legs bend and one leg bends more than 35 degrees
4. Squatting: Knees bend more than 90 degrees
5. Walking
6. Kneeling
7. Seating on the chair

Position of Hands

1. Neutral: Both hands are located alongside the shoulder.
2. One elbow is above the shoulder.
3. Both elbows are above the shoulder.

Then, SPSS20 software was used to analyze data. General linear model, and calculation of frequency and the percentage frequency were used in this study.

RESULTS

The average age of workers was equal to 33.44± 10.21 and their average work experience was equal to 9.26±7.20. The results obtained from evaluation of body posture demonstrated that in 39% of their working time they were in neutral status, i.e. 54% in foundation construction, 4% in joinery and 51% in swaging. In overall working condition the following percentages were achieved in different positions such as neutral (39%), mild bending (43%), sharp bending (15%), bending sideways (27%) and bending and twisting (1%). The results obtained from the evaluation of frequency in body status in three phases of construction are shown in Table 1.

Table 1. The Frequency of Observation of Body Status in Three Phases of Evaluation in Construction

Jobs	Neutral	Mild bending	Sharp bending	Bending sideways	Bending and twisting	Total
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Swaging	1462(51.86)	1205(42.74)	131(4.64)	0	21(0.74)	2819(100)
Joinery	35(4.97)	341(48.50)	281(39.97)	11(1.56)	35(4.97)	703(100)
Foundation	61(11.23)	194(35.72)	288(53.03)	0	0	543(100)
Total	1558(39.29)	1740(43.88)	600(15.13)	11(0.27)	56(1.41)	3965(100)

According to above table, among the total observations of body postures in swaging, joinery and foundation tasks, the following results were achieved: 51.86, 4.97, and 11.23, respectively for the percentage frequency of observation in neutral position. The results of the body position in any of activities of foundation work are demonstrated in Table 2.

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Table 2. The Frequency of Observations of Body Status in Different Activities of Foundation

Job	Neutral	Mild bending	Sharp bending	Bending sideways	Bending and twisting	Sum
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Armature	0	48 (50.00)	48 (50.00)	0	0	96 (100)
Swaging	25 (7.00)	142(43.00)	160 (48.00)	0	0	327 (100)
Concreting	12(63.00)	7(26.00)	0	0	0	19 (100)
Total	37(8.37)	197(44.57)	208 (47.05)	0	0	442 (100)

According Table 2, among the total observations of body posture in the percentages of observation in three phases of the preparation of armature, swage, and concrete 0%, 7% and 63% were in neutral position, respectively. The results of evaluation of body status in each activity of the preparation of swage are presented in Fig.1.

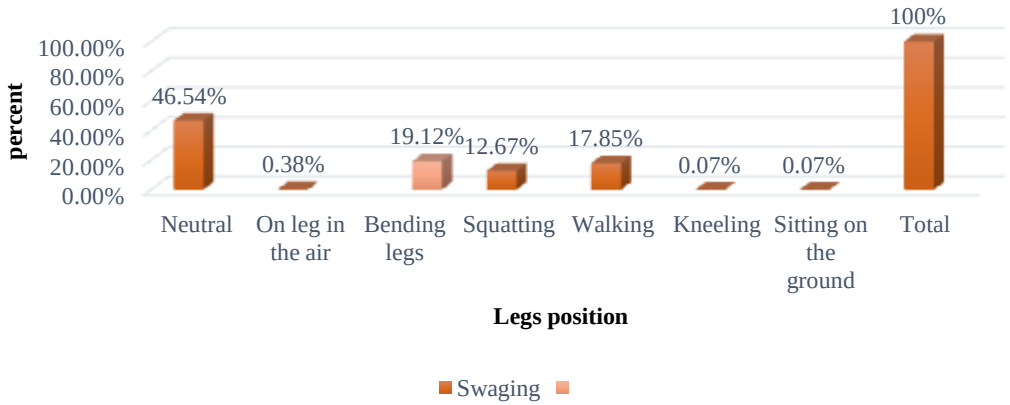

Fig.1. Legs positions; the frequency of observations and legs status in swaging

According Fig.1, among the total observations of the legs' position in swaging, legs posture was in neutral or bending position in the frequency of observation of 46.54 and 19.12, respectively. The results of the hands position in any activates of joinery are demonstrated in Table 3. The results of the carried weight in each activity of foundation have been shown in Fig.2.

Table 3. The Frequency of Observation of Hand Positions in any Activities of Joinery

Job(±SD)	Two hands below the shoulder (±SD)	One hand above the shoulder (±SD)	Both hands above the shoulder (±SD)	Total
Plastering	11 (1.60)	539(78.45)	137 (19.94)	687 (100)
Tiling	12 (30.00)	0	28 (70.00)	40 (100)
Painting	0	3010 (82.64)	632 (17.35)	3642 (100)
Total	23 (0.52)	3549 (81.23)	797 (18.24)	4369 (100)

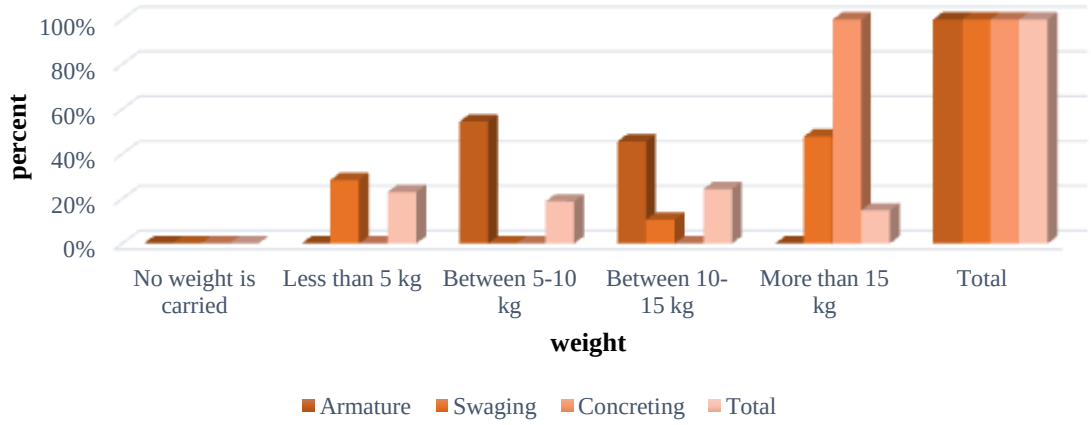

Fig.2. Weight of Equipment and Objects (kg)

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The frequency of observations of carried weights in different activities of foundation .

As can be seen, the percentages were as follows: In armature binding: No weight is being carried (0%), between 5-10 kg (54%), between 10-15 kg (45%); in swaging: less than 5 kg (28%), between 10-15 kg (47%); and in any other situations it was 0%. In concreting, carrying weights, more than 15 kg was 100%.

According to the results of Fig.2, among the total observations of carried weights in the preparation of armature, swaging and concreting in foundation, the percentage of no weight carried is 0. In the preparation of armature, 54.44% of observations, which is related to the carried weight, were 5-10 kg. While in the preparation of swage, 47.78% of observations were related to more than 15 kg of weight. In the preparation of concrete, all of the observations were related to weights with more than 15 kg. Generally, in foundation, 24.32% of observations were related to 10-15 kg.

DISCUSSION

On average, 39% of workers spend their working time in neutral position, they are different with each other in these 3 groups of jobs, and these results are not consistent with Hokm Abadi's results [9]. In foundation work compared with other occupations, sharp bending allocates more percentages to itself in a way that the preparation of armature and concrete allocate lowest and highest percentage to itself in neutral position, respectively, i.e. it is consistent with Hokm Abadi's results [11]. Preparation of armature and concreting had lowest and highest amounts of sharp bending which are different from Hokm Abadi's results but they are consistent with Haj Agha Zadeh's results [24]. One of the activities of armature is winding rebar and it is done by body bending position. This job is considered as a repetitive activity in a way that it can play an important role in musculoskeletal disorders in wrist area and it is consistent with another study [24].

By studying the position of hands in all studied jobs, the following results had the lowest percentage in neutral position such as armature in foundation, plastering in joinery, and preparing materials in swaging. Therefore, there should be ergonomic investigations in these jobs. The results of this section are consistent with another study [24].

The evaluation of the position of legs showed that 46% of workers had neutral position of legs and 19% of them were in bending position. In this situation, ergonomic practices should be conducted to prevent musculoskeletal disorders. In studied activities, neutral position of hands was less observed and the results showed that in painting, plastering and tiling in which hands is higher than shoulder, hands are in a very improper position; therefore, it can lead to musculoskeletal disorders. In these situations, we can increase the height by ergonomic interventions to reduce damages or use equipment with lighter weights. This part is consistent with another study [24].

The results showed that most carried weights are in range of 10-15 kg. Workers that have the duties of concreting and swaging carry objects that weight more than 15 kg. In these cases, it is suggested that swaging workers use plastic or wood molds instead of metals. In accordance with Hokm Abadi et al. study [11] and due to the increase in transportation of cements, it is suggested that workers carry materials several times instead of carrying them all at once or along with other workers, in these cases, it is also recommended to train workers how to carry materials properly.

CONCLUSION

Construction is a very broad activity with all types of jobs and different tasks with serious musculoskeletal risks. Many people are working in these activities. Due to the increase of construction in the country, it is necessary to conduct more studies on these topics in order to prevent musculoskeletal disorders. One of the limitations of this study is that other jobs such as plumbing, insulation, etc. are not studied. According to the results of this study, the improper status of body, hand and carried weight can cause lots of damages to musculoskeletal disorders. Ergonomic practices in swaging, concreting, painting, and plastering seem necessary to prevent musculoskeletal disorders. Training on how to carry loads properly to reduce disorders also seems effective.

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