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Injury Prevention among Construction Workers: A Case Study on Iranian Steel Bar Bending Workers

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***Abstract*—**Nowadays the construction industry is growing specially among developing counties. Iran also has a critical role in these industries in terms of workers disorders. Work-related musculoskeletal disorders (WMSDs) assign 7% of the whole diseases in the society, which make some limitations. One of the main factors, which are ended to WMSDs, is awkward posture. Steel bar bending is considered as one of the prominent performance among construction workers. In this case study we conducted to find the major tasks of bar benders and the most important related risk factors. This study was carried out among twenty workers (18-45 years) as our volunteer samples in some construction sites with less than 6 floors in two regions of Tehran municipality. The data was gathered through in depth observation, interview and questionnaire. Also postural analysis was done by OWAS. In another part of study we used NMQ for gathering some data about psychosocial effects of work related disorders. Our findings show that 64% of workers were not aware of work risks, also about 59% of workers had troubles in their wrists, hands, and especially among workers who worked in steel bar bending. In 46% cases low back pain were prevalence. Considering with gathered data and results, awkward postures and long term tasks and its duration are known as the main risk factors in WMSDs among construction workers, so work-rest schedule and also tools design should be considered to make an ergonomic condition for the mentioned workers.

***Keywords*—**Bar benders, construction workers, musculoskeletal disorders (WMSDs), OWAS method.

I. Introduction

WMSDs contain occupational musculoskeletal injuries and illnesses and repetitive strain/stress injuries. These are multifactorial problems, include many physical, psychological, psychosocial, and organizational risk factors and not limited to the terms "injury" or "illness" [1], [2]. All of these terms refer to same basic family of disorders affecting the tissues of the musculoskeletal system tendons, muscles, ligaments, bones, nerves, and vascular structures. WMSDs are generally limited to the upper extremity and low back [2].

There has been a growing effort in recent years to explore the causes of MSDs, because musculoskeletal disorders (MSDs) is still a main cause of disability and lost work time [3] and WMSDs embrace over half of all reported occupational illnesses [4]; also it is an important cause of functional impairments and disability among construction workers [5]. In spite of huge growing construction industry among developing countries like Iran, and high rate of WMSDs among construction workers, there is no noticeable ergonomics study among bar benders who are in high risk.

II. Background

Buildings construction is in the top ten high risk major industries for the MSDs of various parts of body [6]. Different investigations concerning WMSDs for construction workers have been conducted in European countries [7]-[9]. In observation on Taiwanese construction workers [10], wire-tying of iron rods one of the bar-bending task was known one of the most stressful tasks among all kinds of construction tasks.

Generally, most musculoskeletal symptoms in workers are in the low back (44%), shoulders (33.3%) and neck (32.0%) [11]. An investigation [12] of Swedish workers indicated that iron reinforcement workers bent over up to 58% of their work time while working on floor slabs. Also, according to the survey among dam construction workers of Iran that belong to 2009, the most prevalent (55.5%) MSDs were in the low back region.

There were statistically significant positive associations between prevalence of MSDs and many independent variables, namely, age, weight, education level, service record, smoking, type of job, lengths of time of standing and sitting at work, total work duration, work pressure, undesirable postures and surface for walking [13], also the effect of physical activities in reducing musculoskeletal morbidity has confirmed in the other research [14]. Years worked were strongly significantly associated with MSDs and pain in the neck, shoulders and wrists/hands [11]. Moreover, effects of body mass index, hearing disorders, and sleep disorders were verified.

Hazards related to repetitive movements and discomfort postures could be reduced by informing the workers about these risks and encourage them to practice sporting activities like stretching exercises and reduce their hearing and sleep disorders [15], ergonomic interventional, frequent rests [16], rotation schedules [17], modification in manual material handling, workers education [16], and new engineering

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solutions [17] were seemed useful.

III. Materials and Methods

The methods of data gathering in this cross-sectional study were observations, interviews and questioners among blue-collar workers. Interview was carried out among 20 steel bar-benders (18-45 years). The target group was volunteers in a cluster sampling method. Sampled workers were construction worker that worked in some sites with less than 6 floors in two regions of Tehran municipality.

NMQ and OWAS from related data were gathered. After video capturing; all of the frames were analyzed by OWAS method. Also Ergoflow software was used for posture analyze Helpful Hints.

A. OWAS

OWAS (Ovako Working Posture Assessment System) was developed in Finland in a steel industry company, Ovako Oy, in 1973 to describe the workload in the overhauling of iron smelting ovens [18]. It classifies the most common work postures contain, 4 postures for back, 3 postures for arms, 7 (or in some cases 6) postures for legs, and 3 categories for the weight of the load handled. Whole body posture is defined by these categories with a four digit-cod. These 252 postures have been classified to four action categories indicating needs for ergonomics changes. The observation is made as "snapshots" and sampling has commonly been with constant time intervals [19].

B. NMQ

Nordic Questionnaire is a standardized questionnaire for the analysis of musculoskeletal symptoms in an ergonomic or occupational health context. The NMQ was developed from a project funded by the Nordic Council of Ministers and included questions like age, job duration, weight of carried loads, daily working hours and musculoskeletal complaints in each of the following body regions: neck, shoulder, elbow, wrist/hand, upper back, lumbar, one or both hips/thighs, one or both knees and one or both ankle/ feet [20]. The questions are forced choice variants and may be either self-administered or used in interviews. They concentrate on symptoms most often encountered in an occupational setting also the reliability of the questionnaires has been verified [21].

IV. Results

Workers were working as bar benders from 1 to 10 years. 70% worked 56 hours per week. Due to NMQ-questionnaire all of the workers were right-handed and none of them had past histories of disease before starting their job.

None of the workers had previous working postures training; also 50% of the workers were smokers who smoked 10-20 times a day. Only 36% of workers were aware of risks of their work. All the participants had troubles during last 12 month, which had been increased due to work.

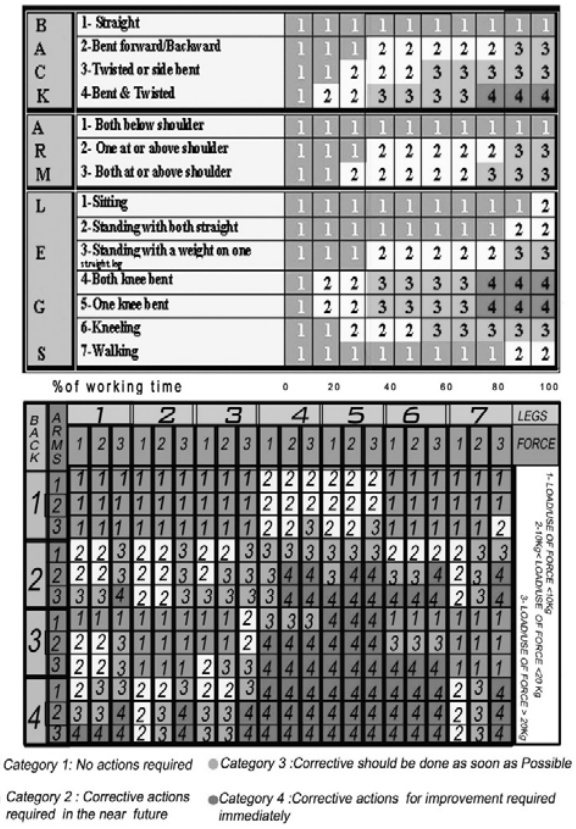

Fig. 1 OWAS Action Categories for Work Posture Combination

More than half of the workers had trouble in their wrist and hand due to inappropriate bar-bending tools that made them to use more force in order to use the tool. 40% had pain in feet ankle due to long-term task and awkward posture during work. Most of the workers complained from trouble in hand and elbow, 80% had pain in left hand fingers, and 46% had pain in palm of both right and left hand and elbow as they used unsuitable tools; besides, many of them were injured in these parts of body in contact with objects, tools and rebar which caused scratch and wounds.

Among our samples, 60% had pain in low back, which mostly occurred because of awkward posture; in spite of this condition only 20% had pain in their neck.

40% felt pain and trouble through the whole day and 40% had trouble after noon when work force increased. Pain and body troubles influenced all participants' daily activities and it was increased during work hours. They all have seen doctor for injuries including broken bone, rupture of tendons, severe low back pain, elbow and wriest pain, knee injury, hand wound and headache.

All participants stated that body pain has prevented them from doing their normal work during last 12 month.

Due to interview all participants mentioned that rebar has caused injuries in various parts of their body in different cases, also, contact with rebar was one of the main reasons of the scratch and troubles on the hands and wrist. In some cases striking with rebar caused injury in feet, braking leg and even

falling.

One of the most difficult tasks that caused many troubles for bar-benders was bar bending of chainage, which included long term awkward posture. Bar-benders had to site in an awkward posture under chainage for 4-6 hours a day in a space with lower height than 1m.

Another possible problem that workers faced was eye contact with swarf, while using grinder for cutting rebar.

We conducted to evaluate all of the observed postures among the workers. These are some high-risk postures like "tying steel wire" (code: 2361, AC= 4) and "shaping the rebar" (code: 3152, AC=4), also some other postures are shown in Fig. 2.

Table I is showing all of the registered OWAS codes among the workers. Work duration and exposure comulation time is shown in Tables II, III, IV.

V. Discussion and Conclusion

According to the results there are some high-risks postures in bar-bending work; this shows the importance of considering workers health and occupational condition to prevent WMSDs and related risks.

Considering the prolonged exposure and cumulative duration time, some ergonomic redesign and modification should be done. For instance ergonomic mat and suitable tools and also rotation among workers are suggested.

Other noticeable problems of workers are psychological factors. Psychological factors are considered important aspect of occupational health; which can affect the efficiency and satisfaction of workers.

Designing an appropriate workstation, without being limited to size of the work place, would be an acceptable solution for decreasing the awkward postures of the workers. Besides, it would be a reasonable technique to improve the psychological condition of the workers.

In addition back school training should be considered in order to prevent trouble and injury. Moreover constant posture coding and assessment is suggested to evaluate and analyze the tasks and reduction of WMSDs.

TABLE I
OWAS Codes for 13 Actions

Action	Total time	Percent of time
Picking up rebar	5	1.41
Fixing rebar	15	4.23
First step of Shaping rebar	6	1.70
Second step of Shaping rebar	10	2.82
Second picking up	7	1.98
Putting rebar aside	3	0.85
Cutting rebar with grinder	36	10.15
Cutting	14	3.95
Placing rebar	61	17.11
First step of tying wire steel	63	17.75
Bending rebar	12	3.39
rearranging rebar	48	13.53
Second step of tying wire steel	75	21.13

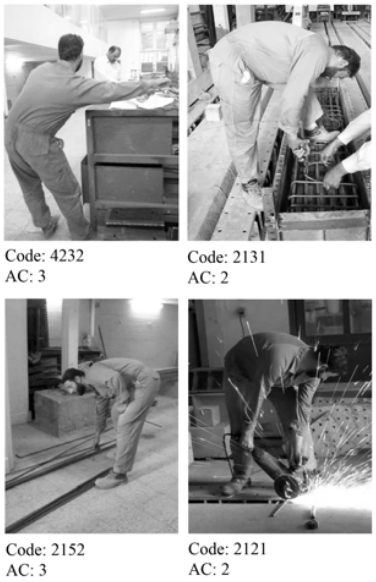

Fig. 2 Some of the postures are shown with Code and AC

TABLE II
OWAS Codes, Percentage of Time & AC for Arm Postures

Back		
Action	Time%	AC
1132	1.41	1
1321	3.39	1
2152	1.98	3
2131	0.85	2
2161	10.15	2
2131	3.95	2
2161	17.11	2
2361	17.75	4
2161	13.53	2
2221	21.13	2
3172	1.70	1
3152	2.82	4
4232	4.23	3

TABLE III
OWAS Codes, Percentage of Time & AC for Arm Postures

Arm		
Action	Time%	AC
1**1**32	1.41	1
3**1**72	1.70	1
3**1**52	2.82	4
2**1**52	1.98	3
2**1**31	0.85	2
2**1**61	10.15	2
2**1**31	3.95	2
2**1**61	17.11	2
2**1**61	13.53	2
4**2**32	4.23	3
2**2**21	21.13	2
2**3**61	17.75	4
1**3**21	3.39	1

TABLE IV
OWAS CODES, PERCENTAGE OF TIME & AC FOR BACK POSTURES

Leg		
Action	Time%	AC
22**2**1	21.13	2
13**2**1	3.39	1
11**3**2	1.41	1
21**3**1	0.85	2
21**3**1	3.95	2
42**3**2	4.23	3
31**5**2	2.82	4
21**5**2	1.98	3
21**6**1	17.11	2
21**6**1	10.15	2
21**6**1	13.53	2
23**6**1	17.75	4
31**7**2	1.70	1

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