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Analysis of Working Postures at a Construction Site Using the OWAS Method

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This study used OWAS to analyze the working postures of construction workers on building the foundations of a log cabin. Three construction workers, with an average work experience of 40 years, participated in this study. Eight elementary jobs of building the foundations of a log cabin were videotaped at a construction site and analyzed later in the laboratory. For an overall distribution of trunk postures, OWAS identified that a bent and twisted trunk posture (34%), which fell into action category 3, was the major poor posture for construction workers. This study also identified that tying beams with steel bars, assembling column templates, and cement grouting of the ground were the 3 principal jobs in which workers building the foundations exhibited poor working posture. This article suggests ways to reduce and evaluate poor posture in a dynamic construction site.

construction posture occupational injury OWAS

1. INTRODUCTION

Musculoskeletal injuries are a major occupational concern worldwide. Awkward working posture is a physical factor identified in occupational musculoskeletal injuries. The National Institute for Occupational Safety and Health reported that awkward working posture had a strong relation to the causation of musculoskeletal injuries [1]. In scientific literature, awkward posture is one that involves considerable deviation from neutral. Typical examples of awkward posture include reaching behind, twisting, working overhead, wrist bending, kneeling, stooping, forward and backward bending, and squatting [2].

Construction workers are exposed to various physical factors at work, which include awkward posture, heavy lifting, forceful exertion, vibration, and repetitive motion [3]. These physical factors were reported to result in an elevated risk for musculoskeletal and occupational injuries [4, 5, 6, 7].

Exposure to physical factors at work is the basis for evaluating the risk for occupational musculoskeletal injuries for construction workers. However, construction work is dynamic in nature, which impacts the content and frequency distribution of job tasks across individuals and over time [8], and thus makes it difficult to evaluate systematically exposure to physical factors in construction work [9]. One solution for evaluating exposure to physical factors of construction workers is to examine their working postures. To our knowledge, the observational method is the main approach toward evaluating exposure and distribution of physical factors in specific construction works [10, 11, 12].

Many postural observational methods have been advocated in the literature to evaluate exposure to musculoskeletal disorder risk factors associated with work [13, 14]. One widely used postural observational method is the Ovako working posture analysis system (OWAS). OWAS is a simple observational method for analyzing and

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controlling poor postures at a worksite. OWAS was created in the mid-1970s by Ovako Oy, a private steel company in Finland. Since that time, OWAS has been widely used in several industries for postural analysis [15, 16, 17, 18]. Conventional OWAS is based on sampling from typical working postures for the whole body, which covers the most common and easily identifiable working postures for the trunk, arms, and legs, along with an estimate of the worker's force. OWAS uses a four-digit code to describe various postures and force combinations (Table 1). The codes include four trunk postures, three arm postures, seven leg postures (three additional leg postures are included in the extended OWAS, but are not used here), and three variants of force. Taking these four (trunk, arms, legs, and force) code levels into account, OWAS has 252 (4 × 3 × 7 × 3) basic combinations of code levels. Furthermore, OWAS classifies the risk of injury based on working posture into the following four action categories (AC): (a) AC 1: postures are normal and natural with no particular harmful effect on the musculoskeletal system, no action is required; (b) AC 2: postures have some harmful effect on the musculoskeletal system, corrective actions are required in the near future; (c) AC 3: postures have a distinctly harmful effect on the musculoskeletal system, corrective actions should be done as soon as possible; (d) AC 4: postures have an extremely harmful effect on the musculoskeletal system, immediate corrective actions for improvement are required.

This study used OWAS to analyze working postures of construction workers on building the foundations of a log cabin. There were three objectives of this study. Firstly, to provide an overview of postural distribution of construction workers on building the foundations of a log cabin; secondly, to identify the most problematic working postures and jobs of construction workers on building the foundations of a log cabin; thirdly, to propose recommendations for work improvements for construction workers on building the foundations of a log cabin.

2. METHOD

2.1. Construction Site and Participants

The construction site of the log cabin studied was located in Chien-Shih, Hsin Chu County, Taiwan. Three male construction workers, with a mean age of 59.7 years (*SD* 2.5, range: 57–62), participated in this study. Their average work experience at a construction site was 40 years (*SD* 3.6, range: 36–43).

2.2. Data Collection

The procedure of building the foundations of a log cabin was analyzed and divided into 15 elementary jobs. Jobs that involved mainly machine power (an excavator) were disregarded. This study focused on jobs executed mainly by manpower. Thus, eight out of the 15 jobs were selected for postural observation (Table 2).

Figure 1 shows a typical job (tying beams with steel bars). All eight elementary jobs were videotaped at a construction site and analyzed later in the laboratory. For each job, only one construction worker was observed. The observation time

TABLE 1. Definition of Postural Codes in Ovako Working Posture Analysis System (OWAS) [19]

Posture			
Trunk	Arm	Leg	Force (kg)
1 = straight/upright	1 = both arms below shoulder height	1 = sitting	1 = <10
2 = bent forward	2 = one arm above shoulder height	2 = standing on both legs straight	2 = 10–20
3 = straight and twisted	3 = both arms above shoulder height	3 = standing on one straight leg	3 = >20
4 = bent and twisted		4 = standing on both legs bent	
		5 = standing on one bent leg	
		6 = kneeling on one or both legs	
		7 = walking	

TABLE 2. Descriptions of 15 Elementary Jobs of Building the Foundations of a Log Cabin

Job	Selected for Observation?
Ground preparation	× (excavator job)
Setting and measuring boundary	✓ (manpower job)
Excavating base	× (excavator job)
Tying columns with steel bars	✓ (manpower job)
Cement grouting on the base	× (excavator job)
Assembling column templates	✓ (manpower job)
Cement grouting on the columns	× (excavator job)
Excavating for the beams	× (excavator job)
Tying beams with steel bars	✓ (manpower job)
Assembling templates and beams	✓ (manpower job)
Cement grouting of the beams	✓ (manpower job)
Reclaiming soil	× (excavator job)
Spreading iron net[1]	× (manpower job)
Cement grouting of the ground	✓ (manpower job)
Dismantling templates	✓ (manpower job)

Notes. 1 = observation time under 10 min.

was 10–15 min, during which 60 still videotape frames were sampled at intervals of 10 s from the representative contents of the job (not interrupted by others) for later analysis. The total number of videotape frames analyzed in this study was 480 (8 jobs × 60 frames).

Figure 1. The job of tying beams with steel bars.

TABLE 3. Distribution of Postures of Force of Construction Workers Building the Foundations of a Log Cabin

Body Part/Force		Frames (%)
Trunk	straight/upright	155 (32)
	bent forward	141 (29)
	straight and twisted	22 (5)
	bent and twisted	162 (34)
Arms	both arms below shoulder height	442 (92)
	one arm above shoulder height	29 (6)
	both arms above shoulder height	9 (2)
Legs	sitting	0
	standing on both legs straight	215 (45)
	standing on one straight leg	22 (5)
	standing on both legs bent	59 (12)
	standing on one bent leg	18 (4)
	kneeling on one or both legs	79 (16)
	walking	87 (18)
Force	<10 kg	411 (86)
	10–20 kg	69 (14)
	> 20 kg	0

3. RESULTS

Table 3 shows the overall percentage distribution of postures for trunk, arms, legs, and force for construction workers performing the eight jobs. The most frequent postures for the trunk, arms, and legs were bent and twisted (34%), both arms below shoulder height (92%), and standing on both legs straight (45%). Most force was under 10 kg (86%). OWAS identified that bent and twisted trunk posture (34%), which fell into AC 3, was the major poor posture. This might be the potential source of postural risk for musculoskeletal injuries.

Of all 480 videotape frames sampled, OWAS identified 34% postures falling into AC 1, 41% into AC 2, 8% into AC 3, and 17% into AC 4, indicating ~25% postures required corrective actions soon or immediately. The most common AC 4 working posture was OWAS code 4161 (bent and twisted trunk, both arms below shoulder height, kneeling on one or both legs, force under 10 kg), which accounted for 45.7% of all AC 4 postures; followed by code 4141 (bent and twisted trunk, both arms below shoulder height, standing on both legs bent, force under 10 kg), and 4142 (bent and twisted trunk, both arms below shoulder height, standing on both legs bent, force of 10–20 kg). Code 4141 and 4142 accounted for 32.2% and 22.0% of all AC 4 postures, respectively.

Table 4 lists the percentages of postures falling into AC 1, 2, 3, and 4 for the eight elementary jobs. Table 4 shows great differences across the jobs. OWAS also gave the opportunity to compare the elementary jobs according to the number of postures which needed to be corrected soon (AC 3) or immediately (AC 4). Figure 2 presents the percentages of poor postures for the eight elementary jobs. Poor working postures were observed most frequently, ~41.67% of all observations, in the job of tying beams with steel bars, followed by assembling column templates (38.33%), and cement grouting of the ground (30%), respectively.

4. DISCUSSION

Construction workers are exposed to various physical factors at work. This study used OWAS to analyze working postures of typical construction workers building the foundations of a log cabin to evaluate the risk for occupational musculoskeletal injuries for construction workers. This study observed experienced construction workers in the field. The observations covered the whole procedure of building the foundations of a log cabin, which assured the content validity of this study. This study identified that tying beams with steel bars, assembling column templates, and cement grouting of the ground were the three principal jobs with poor working posture exhibited by construction workers when building the foundations of a log cabin. For these jobs, this study further found that all poor postures into OWAS AC 4 involved bent and twisted trunk posture. The result indicated that bent and twisted trunk was the most critical posture that should be eliminated or reduced for construction workers. Field observations showed that some poor working postures can be substantially reduced or eliminated with the help of an excavator and job redesign. For example, workers should consider using an excavator rather than manpower to carry steel bars to the worksite for the job of tying beams with steel bars, and using an excavator for the job of dismantling templates. To redesign the job, workers should consider carrying the templates to the worksite separately and then assembling the column templates rather than assemble column templates together and then carry them to the worksite. This would reduce the load of assembling column templates. In addition, workers should also be reminded to be aware of their postures and step orientation to avoid twisting their trunk, to take adequate rest time during work, and to reduce the time spent in each poor posture.

Some studies evaluated exposure to poor posture for a specific occupation by observing the typical whole work contents [15, 20, 21]; however, this study divided construction work into elementary jobs, and observed the workers' posture job by job on the basis of an equal time unit. This approach has some advantages over observing the whole construction work. Firstly, this approach makes it possible to identify the elementary jobs that involve a high risk of exposure to poor postures. Secondly, this approach can recognize postures with a distinctly or extremely harmful effect on the musculoskeletal system for

TABLE 4. Postures in Action Categories 1, 2, 3, and 4, for the 8 Elementary Jobs in This Study

	Action Category (%)			
Job	**1**	**2**	**3**	**4**
Setting and measuring boundary	40.0	31.7	20.0	8.3
Tying columns with steel bars	40.0	51.7	3.3	5.0
Assembling column templates	26.7	35.0	10.0	28.3
Tying beams with steel bars	26.7	31.7	8.3	33.3
Assembling templates and beams	20.0	51.7	10.0	18.3
Cement grouting of the beams	45.0	50.0	0.0	5.0
Cement grouting of the ground	41.7	28.3	0.0	30.0
Dismantling templates	30.0	51.7	11.7	6.7

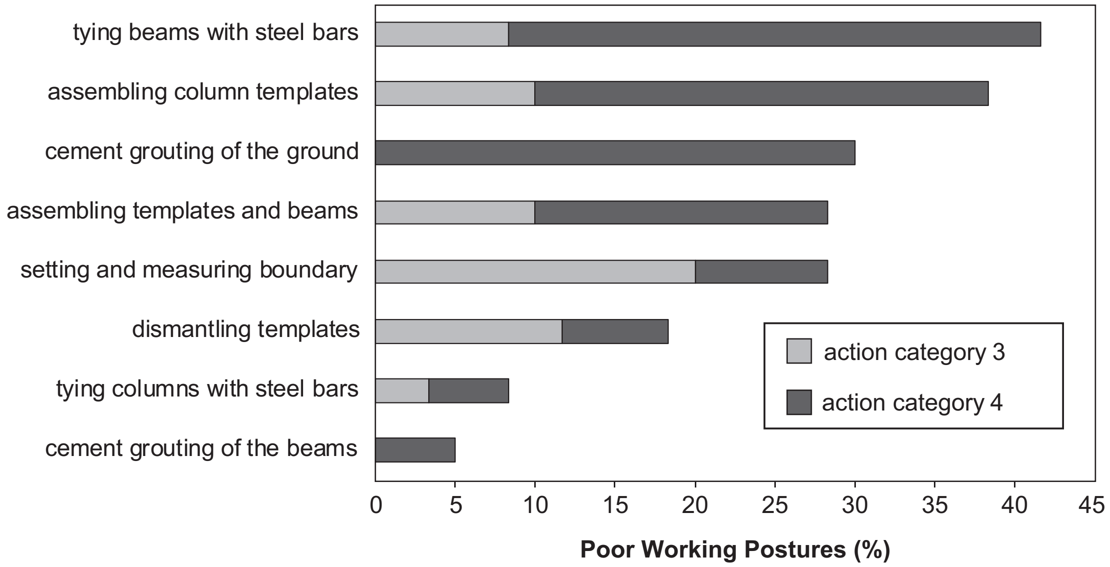

Figure 2. Poor working postures (action categories 3 and 4) for the 8 elementary jobs in this study (%).

the identified elementary jobs. Thirdly, the percentage of poor posture associated with each elementary job can serve as an index of the risk of exposure to poor posture for the job. These indices can then be used to evaluate the risk of exposure to poor posture in other construction situations, where the work content can be expressed as a time-weighted combination of elementary jobs. In other words, the risk of exposure to poor posture for other construction work can be quickly evaluated by calculating the time-weighted index of the risk of exposure to poor posture (i.e., percentages of poor posture) identified from the elementary jobs of this study. This simplifies the evaluation of poor posture in a dynamic construction situation, where the distribution of postures depends on the content of construction work.

5. CONCLUSIONS

Construction work is dynamic, which impacts the content and frequency distribution of construction jobs. Many involve poor postures that may carry a risk of injury. This study identified that tying beams with steel bars, assembling column templates, and cement grouting of the ground were the three principle jobs with poor working posture exhibited by construction workers when building the foundations of a log cabin. In addition, a bent and twisted trunk posture, 34% of all postures, is a major risk to construction workers. This study recommended workers should be reminded to be aware of their posture and step orientation to avoid twisting the trunk, to take adequate rest time during work, and to reduce the time spent in each poor posture. Further study is necessary to confirm the musculoskeletal risk to construction workers and to develop better methods to reduce it.

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