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Safety Climate and Prediction of Ergonomic Behavior

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One of the most important ways to prevent accidents is to consider safety climate or culture. Moreover, some studies suggest that behavior contributes to 86%–96% of all injuries. This cross-sectional study took place in an Iranian petrochemical company in 2010. Vinodkumar and Bhasi's safety climate questionnaire and an ergonomic behavior sampling checklist were the data collection tools. Cronbach's α for questionnaire reliability was .928. With reference to the results of a pilot study, a sample of 1755 was determined for behavior sampling. We used principal component analysis (PCA) to derive the coefficient of paths in the path model and the Anderson–Rabin method to calculate factor scores. The results showed that safety climate was an effective predictor of ergonomic behavior ($p < .01$*). They also showed the importance of decreasing the number of workers with negative safety climate. Moreover, it is necessary to promote workers' ergonomic behaviors in the workplace.*

safety climate ergonomic behavior structural equation model safety culture

1. INTRODUCTION

Effective safety management requires paying attention to human factors as well as system components that are responsible for risky or safe situations. By considering human factors, organizations with high reliability can recognize hazards before incidence. Using leading criteria such as safety climate or safety culture is one of the most important methods to achieve this purpose. Human factors include procedures comprising (a) facilities, equipment and environment; (b) management systems and (c) people [1]. Considering these elements in the management process may lead to controling accidents and their cost. The term safety culture was first officially used in an initial report on the Chernobyl accident [2]. Wiegmann, Zhang, von Thaden, et al. formulated a global definition for safety culture: "safety culture is the enduring value and priority placed on worker and public safety by everyone in every group at any level of an organization. It refers to the extent to which individuals and groups will commit to personal responsibility for safety, act to preserve, enhance and communicate safety concerns, strive to actively learn, adapt and modify (both individual and organizational) behavior based on lessons learned from mistakes, and be rewarded in a manner consistent with these values" (p. 8) [3]. More specifically, safety culture is seen as a subfacet of organizational culture [4]. Safety culture is a subset

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of overall organizational culture and a subset of organizational factors, denoting the extent to which upper level management demonstrates positive and supportive safety values, attitudes and behaviors. It is a most stable and substantial force within organizations, shaping the way members think, behave and approach their work [5]. Zohar coined the term safety climate in an empirical investigation of safety attitudes in Israeli manufacturing, and defined it as "a summary of molar perceptions that employees share about their work environments" (Zohar, 1980, as cited in Yule [2]). As many definitions of safety culture and safety climate have common elements, safety climate may reflect the underlying culture of a work group or organization, although its focus is actually much narrower than that of safety culture [2].

Ergonomic Behavior

A definition of safety behavior [6] can be adapted for ergonomic behavior: behavior that is directly related to ergonomics, such as correct manual handling, correct posture or talking to colleagues about ergonomics.

In fact, ergonomic behavior means applying ergonomics principles. For example, lifting correct weight and keeping objects close to the body while lifting; this can prevent musculoskeletal disorders and cumulative trauma disorders. If a worker behaves correctly, that worker's behavior is ergonomic. According to McSween, in most organizations, behavior contributes to 86%–96% of all injuries [7]. These data do not suggest that workers are directly blamed for 96% of their injuries. From the perspective of behavioral psychology, behavior is a function of the environment in which it occurs. Unsafe work behavior is, accordingly, the result of (a) the physical environment, (b) the social environment and (c) workers' experience [7].

The cost of musculoskeletal disorders is estimated at ~0.08% of Iran's government budget in 2000 [8]. So, the importance of paying attention to ergonomic behavior is clear.

First, we show that our objective behaviors are known as behavior in the literature. Manual handling [1, 9] and manual lifting [1, 8, 10, 11, 12] are recognized as behaviors. Moreover, manual lifting components including load close to the body while lifting, proper load weight and reasonable lifting schedule and appropriate grip are known as ergonomic behavior, too [1, 7]. Workers' posture is one of the most important items known as behavior in the workplace [1, 8, 12, 13, 14]. In addition, elements of posture such as elbow bending and trunk twisting are also proposed as behavior [7, 15].

This study was conducted in the functional departments of a petrochemical company in the south of Iran, in 2010.

2. METHODS

This was a cross-sectional study, conducted with the ergonomic behavior sampling (EBS) technique based on safety behavior sampling (SBS), and a safety climate questionnaire (SCQ). Collected data were analyzed with the principal component analysis (PCA) to derive coefficients in the path model and the Anderson–Rabin method was used to calculate factor scores.

The aim of this study was to establish a relationship between safety climate and ergonomic behavior. Vinodkumar and Bhasi's SCQ was the data collection tool [16]. It uses a Likert scale of 1–5, ranging from *strongly disagree* to *strongly agree*. This questionnaire was used because it was developed in process and chemical industries like the present research field and, in addition, it has good reliability and validity. After piloting the questionnaire among 42 workers and calculating Cronbach's α for six factors, it was considered valid. SCQ consists of 49 questions and six categories. These categories include management commitment and actions for safety (F1), workers' knowledge and compliance with safety (F2), workers' attitudes towards safety (F3), workers' participation and commitment to safety (F4), safety of the working environment (F5) and emergency preparedness in the organization (F6).

The questionnaires were distributed among 151 functional workers of Khuzestan Petrochemical Company (KPCo) within five shift work groups (day work or no shift work, A, B, C, and D). The work of those groups was similar but took place at different times.

2.1. Procedure for Sampling Ergonomic Behavior

2.1.1. Workstations

Departments in the organization where ergonomic behavior was to be sampled were identified. In this study, those were workstations considered as functional units of KPCo.

2.1.2. Unergonomic behavior

After defining unergonomic behaviors as any action that could have harmful consequences, a list of unergonomic acts was drawn up. The list was adjusted based on a literature review and present conditions in the factory such as the type and nature of the job, reviews of accident reports and present cultural conditions. Table 1 shows an ergonomic behavior checklist and criteria for considering a behavior ergonomic (if a behavior was outside those criteria, it was unergonomic). The criteria for lifting and carrying were adopted from the Health and Safety Executive's charts [17]. Furthermore, posture criteria were based on rapid entire body assessment (REBA) [18]. For team lifting and carrying, we calculated the maximum weight with Equation 1 [19]:

$$W'_{max} = 0.85 \times \text{number of persons} \times W_{max}, \quad (1)$$

where W'_{max} = maximum weight during team lifting and carrying; W_{max} = maximum weight during individual lifting and carrying.

2.1.3. Pilot study

Workers were observed to determine the proportion of their unergonomic behaviors. The number of required observations was based on data collected during the pilot study, required accuracy and a given level of confidence. Two terms were recorded during the pilot study:

TABLE 1. Ergonomic Behavior Checklist

Behavior	Criteria	Ergonomic	Unergonomic	Notes
Carrying				
proper load weight	<18 kg			
load close to body	quite close			
proper grip of load	holding handles, holding tightly			
carrying on dry, clean, even floor	clean and even floor			
symmetric carrying	load and hands symmetrical in front of the trunk			
distance of carrying	<4 m			
Lifting				
proper load weight	<18 kg			
moving feet	moving feet, no twisting while lifting			
load close to body	quite close			
proper grip of load	holding handles, holding tightly			
use of legs while lifting	bent knees, no bending back for lifting			
Posture				
upper arm	flexion and extension < 20° without abduction			
leg	both legs straight			
trunk	trunk straight and without twisting and/or side bending			
lower arm	60° < flexion < 100° without side motion			
wrist	flexion and extension < 15° without side motion			
neck	flexion < 20° without side bending			

1. Total number of observations (N_1);
2. Number of observations in which unergonomic behavior was observed (N_2).

Thus, the proportion of unsafe behaviors was [7, 12, 20]

$$P = \frac{N_2}{N_1}. \qquad (2)$$

The sample size of required ergonomic behavior observations (N) was derived from

$$N = \frac{\left[Z_{1-\alpha}^{2} P(1-P)\right]}{e^{2}}, \qquad (3)$$

where e = desired accuracy, Z = value obtained from standardized normal tables for a given level of confidence α, P = proportion of unsafe behaviors.

2.1.4. Calculation of required number of observations

After the pilot study, the proportion of unergonomic acts was estimated at ~47.7%, with 5% accuracy and 99% confidence level; the total number of observations was estimated to be 900. Ergonomic behavior sampling needs to be random. This is usually achieved by selecting observation periods at random from the whole workday. So, the next step consisted of random observations. This means that both the workers (134 workers in functional units) and the frequency of observations (8 h between 8:00 and 17:00, one hour was workers' rest) were random. Since workers' behavior can change from time to time, the duration of observations is critical for the accuracy of the results. This duration should be as short as possible to observe and specify behaviors. In this study, the average duration was 3 s. Unergonomic behaviors were carefully recorded in a time limit of 3 s. The observer carried out random observations with the subjects unaware they were observed. To recognize the relationship between the workers' demographic characteristics and unergonomic behaviors, specific demographic variables (age, work experience, education, shift work and marital status) were collected in interviews and a special questionnaire.

3. RESULTS

Out of the 151 administered questionnaires, 134 valid ones were returned (response rate: 88.74%). However, the number of observed behaviors was estimated at 900; to achieve more accuracy, 2631 observations were performed.

3.1. Demographic Factors

The questionnaires provided the following information on demographic characteristics. All workers were male, their mean (*SD*) age was 31.0 (5.3) years, 63.6% of them were married. Their mean (*SD*) work experience was 6.6 (4.4) years. On average, every worker had attended five safety training courses but the range was 1–20 courses. Table 2 lists other information.

TABLE 2. Frequencies of Individual Factors by Job Unit, Education and Shift Work

Variable	Frequency (%)
Job unit	
operation	73.1
maintenance	11.2
technical services	9.7
storage	6.0
Education	
secondary or lower	38.8
junior college	20.9
bachelor degree	36.6
master degree or higher	3.7
Shift work	
A	15.7
B	16.4
C	20.1
D	17.9
day work/no shift work	29.9

Notes. A, B, C, D = shift work groups; their work was similar but took place at different times.

3.2. Reliabilities of the SCQ

After data gathering, the questionnaire's reliability was assessed again, Cronbach's α = .928. Cronbach's α for each SCQ factor was measured.

F1: α = .925
F2: α = .813
F3: α = .741

F4: α = .728
F5: α = .821
F6: α = .663

By comparing these six factors with α = .700, we can see that reliability of all of them was optimum [21].

3.3. Safety Climate Score

The results indicated that mean (*SD*) safety climate score was 154.6 (19.7) out of 245. The relationship between safety climate score and age was significant ($p < .05$); Pearson correlation coefficient. For example, coefficient .172 means safety climate improves with an increase in the workers' age. However, the results did not show any other significant relationships between safety climate score and other demographic characteristics ($p > .05$).

3.4. Reliability of Ergonomic Target Behaviors Checklist (ETBC)

The reliability of ETBC was assessed by comparing six different responses of individuals who completed ETBC in similar situations; 87% of the responses were similar. So, its reliability was desirable [12].

3.5. Ergonomic Behavior

The results indicated that 43.6% of workers' behaviors were unergonomic (out of the total of 1147). The most frequent unergonomic behaviors were incorrect posture while load lifting (87% of observed unergonomic behaviors). On the other hand, carrying load with correct weight accounted for only ~0.04% behaviors; the best result for all behaviors. The results did not show any significant relationships between ergonomic behavior and demographic characteristics ($p > .05$).

3.6. Predicting Ergonomic Behavior With Safety Climate

According to the literature, the potential for predicting safety climate with safe behavior was theoretically consistent. This research confirms it for ergonomic behavior. Unergonomic behavior is predicted with safety climate through PCA and the structural equation model. Figure 1 shows that ergonomic behavior was predicted significantly

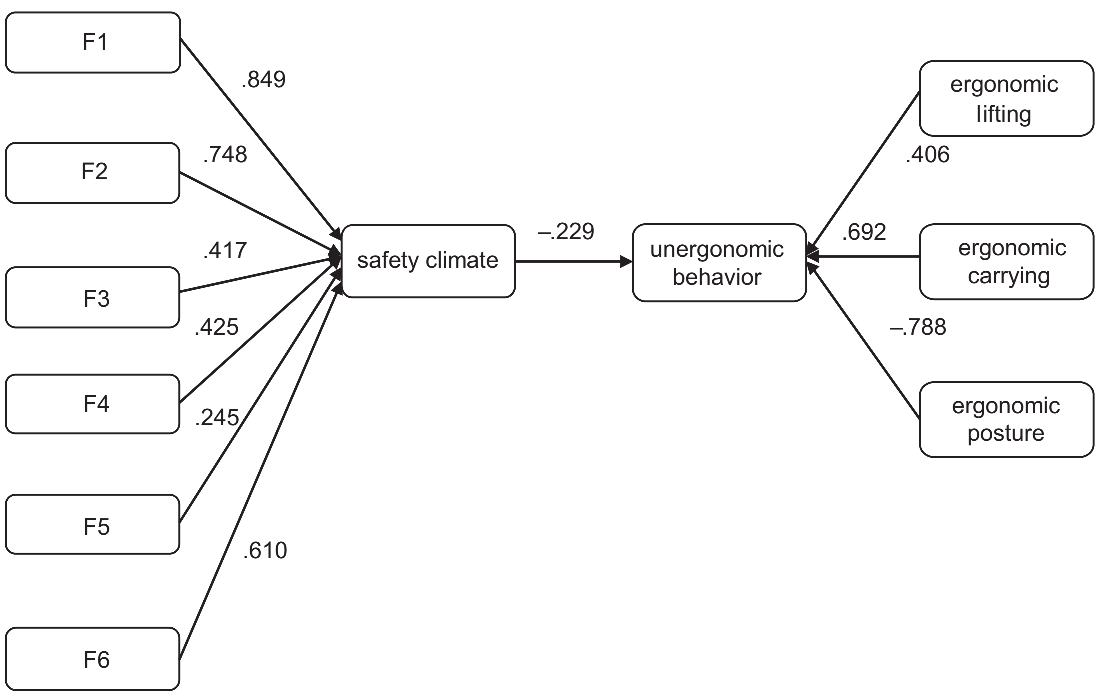

Figure 1. Path model with its coefficients of ergonomic behavior. *Notes.* F1 = management commitment and actions for safety, F2 = workers' knowledge and compliance with safety, F3 = workers' attitudes towards safety, F4 = workers' participation and commitment to safety, F5 = safety of the working environment, F6 = emergency preparedness in the organization.

with safety climate (β = –0.229; $p < .01$); this negative relationship showed that an increase in safety climate led to a decrease in unergonomic behavior. In addition, there was a negative relationship between ergonomic behavior and posture behavior (β = –0.788; $p < .01$). The results of this model showed that when workers had an unergonomic posture, there was a decrease in their unergonomic behaviors in general. This resulted from our method of gathering data. We observed only two posture behaviors: carrying and lifting. As other posture behaviors were hidden in carrying and lifting, they had to be independent. If we observed all posture sub-behaviors, the three main behaviors would be dependent.

4. CONCLUSION

The catastrophic consequences of accidents in the petrochemical industry indicate the importance of paying attention to safety principles and developing a positive attitude in workers regarding safety. This would result in promoting safety climate and improving safety culture in KPCo. The study has suggested that managers need to demonstrate outstanding safety climate to pursue excellent ergonomic behavior to ensure safety performance. For instance, leaders may show commitment and actions for safety, emergency preparedness in the organization, and plan to improving workers' knowledge about safety. This can also increase workers' commitment toward safety, their ability to deal with emergencies and perceive risk at the workplace. So, it is necessary to pay more attention to those factors. Therefore, improvement in a company's safety climate requires senior management and mangers to demonstrate their strongest commitment and action on a regular basis. This can be achieved in many ways. For example, management can and should become more visibly involved in periodic safety committees and safety training; safety resources can be properly allocated; management should declare safety policy; safety and instruction/research can be balanced; management should involve personnel in decisions affecting safety.

This study has a practical application: safety climate is a predictor of unergonomic behaviors. The company can decrease the number of unergonomic behaviors by improving safety climate. This can act as a preventive principle. This approach will result in fewer injuries and reduced accident cost in KPCo. To achieve this goal, we should focus on the following behaviors: incorrect posture while load lifting (using the back rather than legs while lifting), distance of carrying, load not close to the body while lifting, upper arm and back posture because they contribute to the greatest percentage of unergonomic behaviors.

In other words, we cannot neglect physical or social conditions and also the effect of management behavior on workers' behaviors. Moreover, some components proved efficient in improving safety in process industries [7]:

- behavioral observation and feedback;
- formal review of observation data;
- improvement goals;
- reinforcement for improvement and goal attainment.

These elements show it is important to consider workers' behaviors to promote comfort, and safety and productivity in an organization. Thus, behavior observation and feedback should be scheduled systematically in KPCo. Finally, using the ABC (activators–behaviors–consequences) model [22] could help improve ergonomic behaviors. Behaviors can be improved directly with activators such as ergonomics meetings, goal setting, rules and regulations. On the other hand, consequences such as approval, reprimand, peer approval, penalty, feedback and injury can improve behaviors by motivation.

With respect to these results and previous studies which indicated the influence of safety climate on workers' behavior in the workplace [23, 24, 25], we can conclude that workers' behavior would improve by promoting safety climate; work-related accidents and injuries would decrease, which the present study has shown. However, changing culture is a long process.

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