

Association Between Fatigue and Occupational Physical Trauma Among Male Iranian Workers in the Copper Extraction Industry

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Abstract

Background: Fatigue may lead to occupational physical trauma among the workforce.

Objectives: This study was designed to explore the relationship between work-related physical trauma and fatigue in the copper extraction industry.

Materials and Methods: This cross-sectional study was conducted among 453 male workers employed in the copper extraction industry in Kerman, Iran. The validated Persian version of the Piper Chronic Fatigue Scale was used for the data collection. An additional self-administrated questionnaire was prepared to obtain demographic and occupational data, including age, work experience, smoking, and history of physical trauma in the workplace.

Results: The results showed that 28.5% of the participants had experienced work-related physical trauma during the past three years. Severe fatigue was most commonly reported on the subscale for life and emotions (14.79%). A higher rate of work-related fatigue was associated with physically strenuous activities and an inappropriate work place. The mean fatigue scores for subjects both with and without physical trauma experiences were 3.75 ± 0.98 and 2.86 ± 0.79 , respectively ($P = 0.005$).

Conclusions: General fatigue and its subscales had a significant relationship with workplace physical trauma among miners. Workplace physical trauma can be reduced by managing fatigue with different programs, including decreasing the workload, scheduling rest breaks at the facilities, and possibly providing welfare and entertainment opportunities for the workers.

Keywords: Fatigue, Occupational Physical Trauma, Copper Extraction Industry, Iran

1. Background

Fatigue, a condition characterized by a diminished capacity for work and a decreased efficiency in performance, is usually accompanied by a feeling of boredom and exhaustion. Fatigue may affect human performance and in turn reduce work efficiency as well as physical and mental functions. An excessive workload, noticeable changes in job tasks, and alterations in the rhythm of daily activities work shift can play an important role in the development of work-related fatigue (1, 2). An increased workload, more work pressure, and a long history of working different shifts all result in sleep deprivation and also produce physical and psychological effects; at the same time, fatigue can also cause issues with properly enforcing required work and regulations and consequently increase the opportunity for accidents to occur (3-5). Fatigue-related events, such as a poor response time, exhaustion, and distraction, should be considered motor-psychological dysfunctions that can lead to accidents.

Between 2-2.5 million American workers suffer from fatigue (6). Previous studies have found that the prevalence of fatigue varies between 2-25%, and 80% of the symptoms

of chronic fatigue syndrome are sudden in onset, with flu-like symptoms. Chronic fatigue is diagnosed when fatigue has been present for a minimum of six months (7, 8).

A number of studies have declared fatigue to be one of the most important risk factors for occupational physical trauma (9-12). Mining is considered a hard and harmful task, and miners are more vulnerable to accidents and work-related diseases than most employees due to their work environment (3). In addition, work pressure is increased due to tiredness and exhaustion. One of the major problems faced by the miners is that fatigue is the result of poor working conditions, lack of job satisfaction, work shift, and so on (4).

Few studies have investigated the personal factors that affect occupational physical trauma in Iran (13, 14); those that do exist have not given the subject sufficient attention.

2. Objectives

This study was designed to assess the relationship between fatigue and work-related accidents in the copper extraction industry as an introduction for providing proper

solutions to reduce the effects of fatigue and also for consequently controlling physical trauma in mine workers.

3. Materials and Methods

This cross-sectional study was conducted in a copper extraction industry in Kerman, Iran, in 2014. Among all mine workers, 453 individuals with at least three years work experience were selected for inclusion in this study. Statistics regarding their accident history in the workplace were gathered using an existing record system. The data collection tool consisted of a validated Persian version of the Piper chronic fatigue scale (15, 16). An additional self-administrated questionnaire was prepared to compile their demographic and occupational data. In this way, age, work experience, smoking status, and history of physical trauma in the workplace were assessed. Moreover, using this questionnaire, the opinions of workers regarding the main causes of fatigue were obtained. The validity of the latter was also checked by a panel of experts.

A pre-test method was used to assess the item clarity of the self-administrated questionnaire. In this pre-test, a questionnaire was given to 30 workers of an iron ore mine in Yazd, Iran, and they were asked to complete it and express their viewpoints about any problems. The pre-test was used to make some changes that fully resolved any issues with the items.

To determine the face validity, the questionnaires were distributed to ten experts in the field of occupational health and industrial psychology; the face validity as well as the content validity of the questionnaire was approved as a tool for measuring the fatigue of workers. In order to determine the internal validity, a pilot study was conducted on 60 employees, and the scores of both the scales and subscales were found to be higher than 0.9.

The Piper fatigue scale (PFS) scoring method was described as follows:

1. Questions 2 - 23 were used to calculate the four dimensions of tiredness and total fatigue and included 22 options on the following topics: behavior (6 items), affect (5 items), sensory (5 items), and cognition/mood (6 items) (17).

2. Five items (questions 1 and 24 - 27) were included to obtain complementary information.

3. Every subscale related to FPS was scored using a number between 0 and 10. The interpretation of the results was conducted as follows: Zero, no tiredness; 1 - 3, minor fatigue; 4 - 6, moderate exhaustion; 7 - 10, severe fatigue.

Data extracted from the completed questionnaire were analyzed using the statistical package for the social sciences (SPSS) software, version 18. Chi-square test, Pearson's

correlation coefficients, and regression analyses were employed for different stages of the data analysis.

4. Results

According to the results, most employees were miners and had between 6 - 14 years of job experience. In addition, 178 (39.29%) employees had a positive smoking habit.

Table 1 shows the distribution of age and job experience in each fatigue group.

During a three-year interval, 28.5% of subjects experienced work-related accidents. The main causes of accidents were traumatic events (16.78%), electric shocks (13.45%), falling (11.46%), and throwing stones (10.32%). For this same time interval, 45.53% of the staff did not experience work-related injuries.

Table 2 illustrates the total amount of reported fatigue in the study. The overall fatigue score was 3.75 ± 0.98 among people with a history of work-related accidents and 2.86 ± 0.79 for those without any previous accidents ($P = 0.005$).

A moderate-to-high positive correlation was seen between the FPS subscales, with r values, ranging from 0.69 - 0.75 (Table 3). A strong correlation was observed between the total FPS and its subscales.

Using the Cronbach alpha, the reliability of the self-administrated questionnaire was 0.75.

The participants declared that 45.38% of their fatigue was related to a high number of required job-related tasks and also strenuous activities and inappropriate workplace conditions, 18.67% due to a lack of justice and job security, 16.15% as a result of family problems and insomnia, 12.38% for financial difficulties and inadequate income, and 7.42% that remained unanswered.

The relationships between the averages of the subscale scores and the total PFS with the work-related history of accidents is shown in Table 4. There was a statistically significant relationship between a work-related history of an accident and the total PFS, as well as fatigue subscales, except for the mental/cognitive subscale, which did not show a significant relationship ($P = 0.164$).

The outcome of regression testing that analyzed the relationship between demographic variables (age and work experience) and fatigue (total FPS scores) (Table 5).

Thus, the model indicated the following:

$$\text{FPS} = -2.081 + 0.158 (\text{age}) + 0.268 (\text{work experience})$$

5. Discussion

Our findings showed that among mine workers, general fatigue and its subscales were high and severe fatigue

Table 1. Distribution of Age and Job Experience in Each Fatigue Group^a

| Variable | No Fatigue | Mild Fatigue | Moderate Fatigue | Severe Fatigue | Total |
|--------------------------|------------|--------------|------------------|----------------|-----------|
| Age, y | | | | | |
| 22 - 29 | 25 (16.23) | 67 (43.50) | 39 (25.33) | 23 (14.94) | 154 (100) |
| 30 - 34 | 32 (21.62) | 21 (14.19) | 84 (56.76) | 11 (7.43) | 148 (100) |
| > 35 | 36 (23.85) | 47 (31.13) | 38 (25.16) | 30 (19.86) | 151 (100) |
| Job experience, y | | | | | |
| 3 - 6, y | 39 (26.90) | 48 (33.11) | 32 (22.06) | 26 (17.93) | 145 (100) |
| 6 - 14, y | 41 (22.06) | 64 (34.40) | 43 (23.11) | 38 (20.43) | 186 (100) |
| > 14, y | 25 (20.50) | 35 (28.69) | 34 (27.86) | 28 (22.95) | 122 (100) |

^aData are expressed as No. (%).

Table 2. The Relationship Between Total PFS and Accident History^{a,b}

| Total Fatigue | Accident History | | Total |
|------------------|------------------|-------------|-----------|
| | Yes | No | |
| No fatigue | 9 (10.58) | 76 (89.42) | 85 (100) |
| Mild fatigue | 45 (20.45) | 175 (79.55) | 220 (100) |
| Moderate fatigue | 36 (32.73) | 74 (67.27) | 110 (100) |
| Severe fatigue | 20 (52.63) | 18 (47.37) | 38 (100) |
| Total | 110 (24.29) | 343 (75.71) | 453 (100) |

^aFreedom degree = 3.

^bP Value = 0.005.

was observed in the “life and emotional” sub-dimension more than in any other.

Fatigue in the workplace is an important medical concern. In order to be evaluated, job fatigue must first be properly identified in terms of both the measurement and evaluation of physiological characteristics. The problem is that fatigue cannot be directly assessed; only its effects can be recognized or its related psychological symptoms can be evaluated by measuring its subscales (1).

The results of the present study highlighted the level of fatigue in routine activities, life and emotions, thinking processes, and physical-psychological symptoms among a cluster of mine workers. The physical labor involved with working in a mine not only increases the workload but also reduces the opportunity to rest, which is the main cause of chronic job fatigue. Ghasemkhani et al. conducted a cross-sectional study among the staff of electrical panels (18). Their results showed that the rate of fatigue was increased in workers with a high workload; this fatigue interfered with their labor on the next working day and also had an effect on their routine activities (18).

Another study showed that fatigue may lead to phys-

ical complications, mental illness, insomnia, weakness, memory loss, muscle pain, increased malaise, amnesia, and ataxia (19). In addition, in a study conducted in Taiwan, many employees stated that fatigue significantly reduced their rate of activity both inside and outside of the workplace (20).

We found that employees reported the main cause of work-related fatigue to be high amounts of strenuous work in inappropriate workplace conditions and also a lack of job security, which is inconsistent with the findings of a Chinese study where the most important reasons cited for fatigue by the laborers were a high workload, changes in the required tasks, and fears of job loss (21).

Moreover, the results of Wang’s study showed that the type of occupation and the requirement for hard physical work had an impact on fatigue; a statistically significant correlation existed between the type of occupation and fatigue (20). However, Park’s and Brake’s respective studies demonstrated that the main factors that cause fatigue are long-term activities, hard work, and scorching environments that can lead to increased heart rates (22, 23). Working in a mine requires more attention because of difficult labor, poor weather conditions, a lack of leisure and recreational facilities, and little to no access to the open air outdoors. A combination of all these factors may produce severe fatigue.

We found that the mean score of the subscales and also the total PFS had a significant relationship with an employee’s work-related accident history that was compatible with the results of Yang’s study conducted in China (21).

An increase in reaction time due to fatigue is a well-known cause of accidents. Fatigue is a predisposing factor for distraction and increased reaction times, so it follows that accidents should be more common in fatigued workers. When information is delivered to the neurological system at a faster rate than its endurance threshold, increased

Table 3. Pearson's Correlation Coefficients of the Subscales of the Piper Fatigue Questionnaire

| Variable | No Fatigue | Mild Fatigue | Moderate Fatigue | Severe Fatigue |
|--------------------------------------|------------|--------------|------------------|----------------|
| Behavioral/intensity subscale | | | | |
| Emotional/affective subscale | 0.75 | | | |
| Sensory subscale | 0.58 | 0.52 | | |
| Mental/cognitive Subscale | 0.62 | 0.67 | 0.69 | |
| Total Fatigue Scale | 0.82 | 0.78 | 0.73 | 0.94 |

Table 4. The Relationship Between FPS and its Subscales with the Work-Related Accident History of Mine Workers

| Variable | Work-Related Accident History | | | | | | P Value |
|--------------------------|-------------------------------|-------------|--------|--------------|--------|-------------|---------|
| | Yes | | No | | Total | | |
| | Number | SD ± Mean | Number | SD ± Mean | Number | SD ± Mean | |
| The Behavioral/intensity | 110 | 3.89 ± 1.23 | 343 | 2.86 ± 0.86 | 453 | 3.02 ± 0.98 | 0.004 |
| Emotional/affective | 110 | 4.05 ± 1.31 | 343 | 3.07 ± 1.2 | 453 | 3.22 ± 1.11 | 0.006 |
| Sensory | 110 | 3.51 ± 0.92 | 343 | 2.68 ± 0.88 | 453 | 2.81 ± 0.74 | 0.012 |
| Mental/cognitive | 110 | 3.54 ± 0.89 | 343 | 2.84 ± 0.84 | 453 | 2.95 ± 0.97 | 0.164 |
| Total PFS | 110 | 3.75 ± 0.79 | 343 | 2.86 ± 0.779 | 453 | 3 ± 0.97 | 0.005 |

Table 5. Regression Relationship Between Demographic Variables (Age and Work Experience) and Fatigue (Total Fatigue Subscale Scores)^{a,b}

| Parameter | B | Std. Error | P Value |
|-----------------|--------|------------|---------|
| Age | 0.158 | 0.464 | 0.002 |
| Work Experience | 0.268 | 0.496 | 0.000 |
| Constant | -2.081 | | 0.325 |

^a R² = 0.458, Adjusted R² = 0.387.

^b Dependent Variable: Total Fatigue Subscale Scores.

hesitation due to a delay in the carrying of information occurs, which is a result of prolonged working hours (13, 24).

According to a stepwise regression model, the fatigue was only considerably associated with age and work experience, but it was not related to the type of occupation or habit of smoking.

Our study had a number of strengths, including a large statistical population. Few studies have been carried out in mines, which makes our study important; we conducted this survey using a standardized questionnaire. In addition there were some weaknesses, including the subjective nature of replies and the fact that some confounding variables were not considered.

5.1. Conclusions

In general, fatigue plays an important role in the development of occupational accidents.

The findings of this study showed that the results of the total fatigue scale and its subscales among subjects were higher than normal. To reduce the fatigue of workers, their workload should be reduced and they should be also given an increased amount of rest between tasks.

Employers should also provide welfare and entertainment facilities, a good nutrition plan, and adequate sleep for employees who perform hard manual labor, such as those who work in mines. In attention, screening for pre-existing medical and psychological problems in pre-employment assessments can be a useful strategy to lower fatigue during employment.

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Footnote

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statistical analysis; administrative, technical, and material support, Mohammad Ghasemi; study supervision, Mohammad Ghasemi; revision, Gholamhossein Pourtaghi.

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