International Journal of Occupational Safety and Ergonomics (*JOSE*) 2004, Vol. 10, No. 2, 169–177

Identification of Ergonomic Issues That Affect Workers in Oilrigs in Desert Environments

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The main objective of this research was to conduct an assessment of ergonomic-related problems in oilrigs in a desert environment. A checklist, physical audit and medical records were used in the investigation. The results showed significant health, environment and work-related problems that could be attributed to ergonomic deficiencies in the work system of the oilrig. Some major ergonomic issues identified were hard physical work, back pain, discomfort, hot environment, long shift, and diverse schedule. Ninety-four percent of the employees perceived the workday as very long, 79% were dissatisfied with the work schedule, while 61% of the employees perceived the summer work environment as extremely hot. Ergonomics should be considered in the work system design so as to reduce or eliminate problems in oilrigs in hot desert environments.

desert environment work shift ergonomics occupational health and safety

1. INTRODUCTION

Improving worker productivity and occupational health and safety (OHS) are major concerns of industries, especially in developing countries [1]. Ergonomics or human factors application in industries has been found to have positive effects on worker performance, health and safety and satisfaction. This has both direct and indirect effects on overall performance of an industry [2, 3, 4]. Although application of this concept has gained significant momentum in developed countries, it remains rather slow in the developing regions of the world [1].

Common features of industries in developing countries are improper workplace design, ill-structured jobs, mismatch between worker abilities and job demands, poor human-machine system design, inappropriate management programs and adverse environment. This leads to workplace hazards, poor workers' health, injuries and disabilities, and in turn reduces worker productivity and increases cost [1]. Effective application of ergonomics in work system design can achieve a balance between worker characteristics and task demands. This can enhance worker productivity and provide worker safety, physical and mental well-being, and job satisfaction [4]. Research studies have shown positive effects of applying ergonomic principles in work and workplace design, equipment and facilities design, and environment design [2, 4, 5, 6, 7, 8, 9, 10, 11, 12].

Ergonomics studies have produced data and guidelines for industrial applications. The features of ergonomic designs of equipment, workstations, and facilities are well known [2, 3, 6, 13, 14, 15]. However there is still a low level of acceptance and limited application especially in industrially developing countries. The main concern of work system design is usually the improvement of machines and tools alone. Inadequate or no consideration is given to the work system as a whole [1]. Therefore, poorly designed work

The study was funded through the SQU Research Grant ENG/99/01. The contribution of Mr. Yahya Al-Raqueshi in data collection is acknowledged.

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systems are a common occurrence in industries [1, 4, 16]. Neglect of ergonomic principles brings inefficiency and pain to the workforce. An ergonomically deficient workplace can cause physical and emotional stress, low productivity and poor quality of work [17].

Heat stress as a potential safety and health hazard has been recognized in the literature, and guidelines of exposure have been formulated [18, 19, 20]. Combined effects of heat and noise on human performance have been reported [21]. They considered a temperature of up to 30.6 ºC and a noise level of 90 dBA. An 8-hr work shift is adopted in most industries. However, many industries still use a 12-hr shift. Both types of work shifts have various advantages and disadvantages [22].

A significant proportion of workers working in the oil industry in hot climatic areas, especially in the Middle East, are exposed to desert environment conditions. There are also chemical and biological hazards. It is generally most effective to examine work conditions on a case-by-case basis when applying ergonomic principles to solve or prevent problems. No specific literature could be found on ergonomic issues of oilrigs in hot desert environments. Therefore, ergonomic assessment of this type of diversified work is of interest.

The main objective of the current research was to identify and assess ergonomic factors that affect worker productivity, occupational health and safety in oilrigs under hot climatic conditions.

2. METHODOLOGY

The study was conducted on an oilrig operating in the desert of Oman. This oilrig was selected since it was representative of the oilrigs on land in the desert area. The rig operated in two shifts of 12 hrs each per day. A total of 66 employees formed three groups. A team leader headed each group. The task analysis using job descriptions and site visits [2] revealed that a wide variety of tasks were performed in the oilrig, such as drilling operations, rigging operations, lifting, pushing, pulling or maneuvering pipes, casings and other materials, welding, and mechanical maintenance. Work hazards included noise, heat, sunlight, pressurized water, compressed air, manual handling, and repetitive movements.

Two types of instruments were developed for data collection in the rig: checklists distributed to workers and team leaders, and physical measurement of environmental attributes. The questions included in the checklists were related to ergonomic problems, such as worker health issues, work, environment and worker satisfaction. The categories of questions in employee checklist were demography, work, health issues, environment, and satisfaction. The questions on demography and work included age and work experience, job type, schedule, job demands, and training. Work symptoms or health issues included questions about back pain, shoulder and neck pain, muscle pain, fatigue, eyestrain, etc. The environmental questions included heat, noise, dust, light, and humidity. Worker satisfaction questions were posed in the manner “How satisfied are you with (a certain attribute)?”. These attributes were related to task, schedule, environment and training. The questions were selected based on the nature of the oilrig work system. The questionnaires were different for team leaders and workers. The team leader questionnaire included types of complaints they received from the employees in terms of work, health and environment. It did not include satisfaction questions [1, 23, 24]. The questionnaires were in both English and Arabic for ease of understanding by local and expatriate workers. Fifty questionnaires were distributed to the workers and 32 completed questionnaires were returned (on a voluntary basis). The response rate was 66%. Two of the three team-leaders returned completed questionnaires.

Company statistics on occupational health injuries and cumulative trauma disorders were collected for three previous years (1997–1999) as the study was conducted in 2000. The company

collected data on injuries and illnesses that were treated in the company clinic where employees were one or more days off work. The standards of these injuries and illnesses were based on the World Health Organization's international classification of diseases [25]. These were infectious and parasitic diseases, mental and behavioral disorders (stress), diseases of the eye, diseases of the ear (noise-induced hearing loss), diseases of the circulatory system, diseases of the respiratory system, diseases of the skin, diseases of the musculoskeletal system, repetitive strain illness, injury, poisoning (exposure to chemicals), certain consequences of external causes (heat stress), and external causes of morbidity.

Measurements of noise, temperature and humidity were made every 2 hrs for 2 days in the rig during the summer. These 2 days were representative of the summer environment in the selected rig. A sound meter (digital sound level meter) was used to measure the noise in decibels (dBA), while handheld meters were used for the measurement of temperature and relative humidity. Direct observations of these measures were taken and averaged following the steps recommended by Bridger [26]. Noise was measured at ear height. Wind velocity was considered from the Annual Climatic Summary [27]. Other meteorological parameters and gases or chemicals measurements were beyond the scope of this research.

3. RESULTS

3.1 Demographic Data

The mean age of the 32 employees who participated in the study was 31 years (range: 20–40). They had a mean experience of 6 years on the job. Their education ranged from primary education to trade diploma. Sixty-six percent of the employees were Omani (local) and the rest were expatriate workers. All the employees were male. Table 1 shows the work schedule of the employees. The schedule was very diverse with a high potential of stress and health-related syndromes.

TABLE 1. Work Schedule in the Oilrig

Schedule	Number of Employees
12-hr workshift	32
14 days' work/7 days off	19
14 days' work/14 days off	3
35 days' work/35 days off	4
70 days' work/35 days off	4
80 days' work/40 days off	2

3.2 Workers' Response Data

A frequency analysis was conducted on the response data of the workers. Figure 1 shows the major problems with work in the oilrig. About 61% of the workers perceived the work environment as very hot while 30% perceived it as hot. Therefore, most workers considered the workplace as hot to very hot during the summer months. The temperature remained high even at midnight during this period. Therefore, workers were exposed to a hot environment in both work shifts. This view was confirmed from the later discussion on physical measurements. In the desert environment, worker exposure to the sun could be as long as 12 hrs with peak temperature of 40–46 ºC in the summer months. About 76% of the workers considered the humidity as low and the workplace as dry.

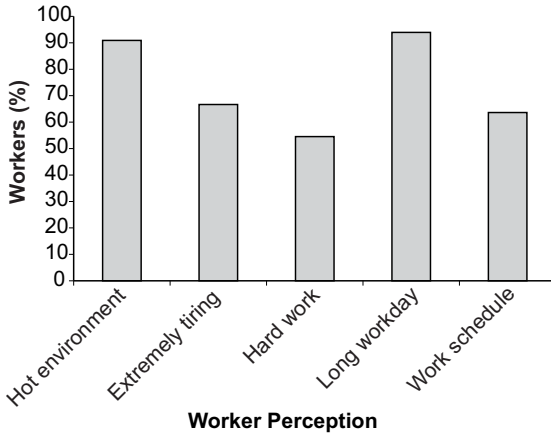

Figure 1. Worker perception about work attributes (*n* = 32).

Sixty-four percent of workers were very dissatisfied and 15% dissatisfied with the day-to-day work schedule. During the work shift workers took 2–3 breaks of about 10–15 min, depending on work pressure, in an air-conditioned room where tea, coffee and cool water were available at all times. A consistent noise level of over 80 dBA was measured on the rig floor with 95+ dBA around the power station. This necessitated compulsory use of earplugs. A majority of the workers (76%) used earplugs or earmuffs when necessary while others (24%) did not. Some of the reasons cited for the latter were discomfort and thinking that noise would not affect them. Noise-induced hearing loss was a major OHS problem in the company (22% in 1999). As there was no shortage of earplugs or earmuffs, the reasons they were not worn still need to be ascertained. It should be noted the workers worked on a 12-hr shift, so they were exposed to the noise for 12 hrs. Only about 46% of the workers perceived the noise level to be very high, others considered it affected them a little. This was probably due to their adaptation to the noisy environment.

Figure 2 shows some major health and work-related attributes (symptoms). With regard to workload, about 55% workers considered the tasks as being above their capability and about 67% felt extremely tired at the end of the workday. This was due to accumulation of work stress, aches and pains of the body limbs and long working hours. Workers complained about fatigue due to work activities (18%), back pain (36%), arm, shoulder and neck pain (24%), discomfort (33%), and muscle pain (15%). These results were confirmed with the reports of the Team Leaders. Fatigue due to muscular strain (muscle pain) was prominent for those who had significant manual handling activities. The subjective feeling of discomfort was a combination of high workload with adverse environmental conditions.

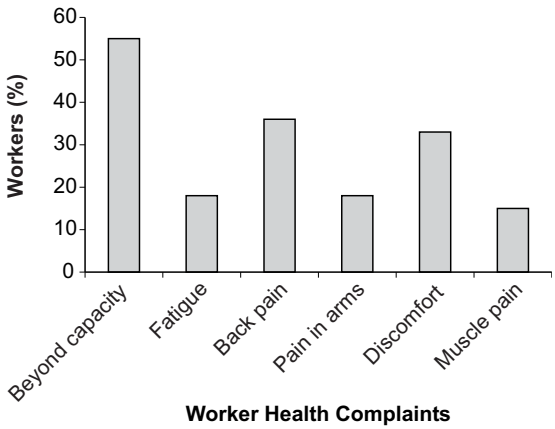

Figure 2. Major worker response to health-related attributes (*n* = 32).

The work schedule in the oilrig is different compared to most other industries. The two 12-hr work shifts were scheduled between 6 a.m. and 6 p.m., and between 6 p.m. and 6 a.m. Local workers' work plan was 14 days of work followed by 7 days of leave, while expatriates worked for 35, 70 or 80 days followed by a leave of 35 or 40 days. The work periods were continuous without breaks for weekends. The workers' opinions about the shift schedule indicated about 94% of the workers considered the working hours as very long and about 79% were dissatisfied with the schedule. Safety and worker training indicated some deficiency. While all the workers (100%) received safety training, 52% of them considered it poor or not enough. Only 39% of the workers considered the safety procedure as sufficient for a rig operation. A majority of the workers (88%) indicated receiving training in manual materials handling. Workers in the rig were required to do heavy manual work, such as handling or maneuvering pipes and casings. In response to the question "How satisfied are you with the training?", 45% of the workers were either little or not satisfied at all and 45% were unsure about it. None of the workers had received any ergonomics training.

3.3 Team Leaders' Response Data

A Team Leader headed workers in each shift. The responses of two of the three Team Leaders of this rig indicated serious ergonomic problems as evidenced from worker complaints. Workers complained about backaches and pains, upper body aches and pains, hand and wrist pain and discomfort,

headache, fatigue, stress and dissatisfaction (Table 2). According to Ayoub [17] these complaints indicated ergonomic deficiencies. Other problems reported were heat and humidity, noise and a dusty environment. They also reported on problems in motivating the workers for better performance. A work target was set for each day. About 80% of the target was met each day on the average.

TABLE 2. Team Leaders' (TL) Response Data

Problems/Complaints	TL1	TL2
Complaints:		
Back pain	Y	Y
Upper body/neck pain	Y	Y
Hand/wrist pain	Y	Y
Headache	Y	Y
Fatigue	Y	Y
Stress	Y	N
Dissatisfaction	Y	Y
Problems:		
Heat	Y	Y
Noise	Y	Y
Light	N	N
Dust	Y	Y
Motivating workers	Y	Y
Facilities or resources	N	N
Management	N	N
Training workers	N	N
Employee performance (target achieved) on average	70%	90%

Notes. Y—yes, N—no; data on the number of times each complaint was made were not available.

3.4 Physical Measurement of Environment

Figure 3 shows representative data on the temperature for the summer months. It shows that the peak temperature could be as high as 46 ºC with a mean temperature of 33 ºC. The temperature in the desert in December and January could be considered as moderate with a maximum of 32 ºC. Temperature was measured every hour in the shade using an ordinary thermometer (Max–Min thermometers) at a height of 1.25 m [27].

To examine how the temperature varied during the day and night in the oilrig during mid-summer, measurement of temperature and humidity was conducted every 2 hrs for 2 days in July. Figure 4 shows that the peak temperature of 46 ºC was approached at about 2 p.m. The air temperature remained above 30 ºC for about 14 hrs. However, humidity at this hour was 30%. The maximum humidity of 68% was recorded at 2 a.m., while the minimum of 20% was recorded at 10 a.m. On average humidity at the rig was below the desired level (Figure 5). Humidity of at least 50% was recommended [6].

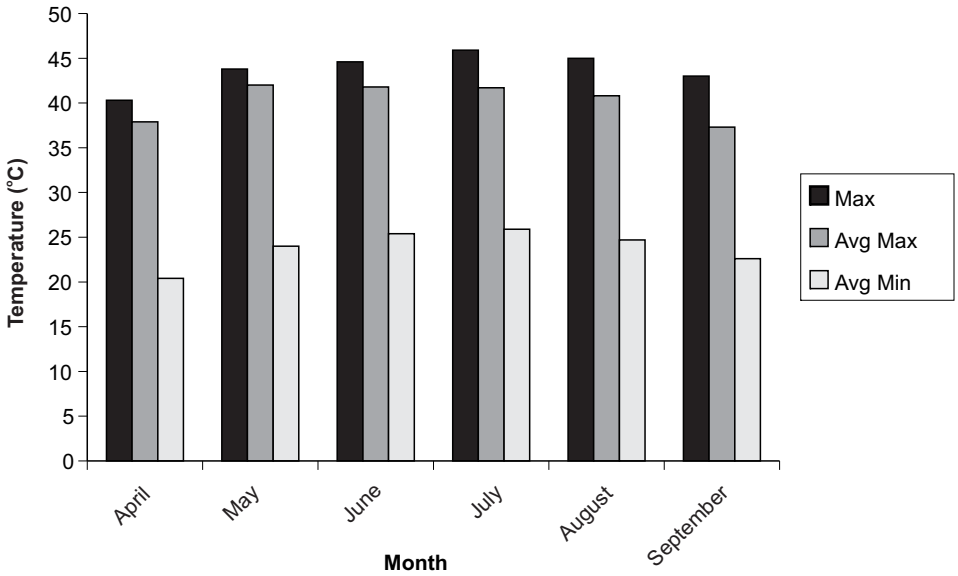

Figure 3. Air temperature during summer months in the rig [27]. *Notes.* Avg—average.

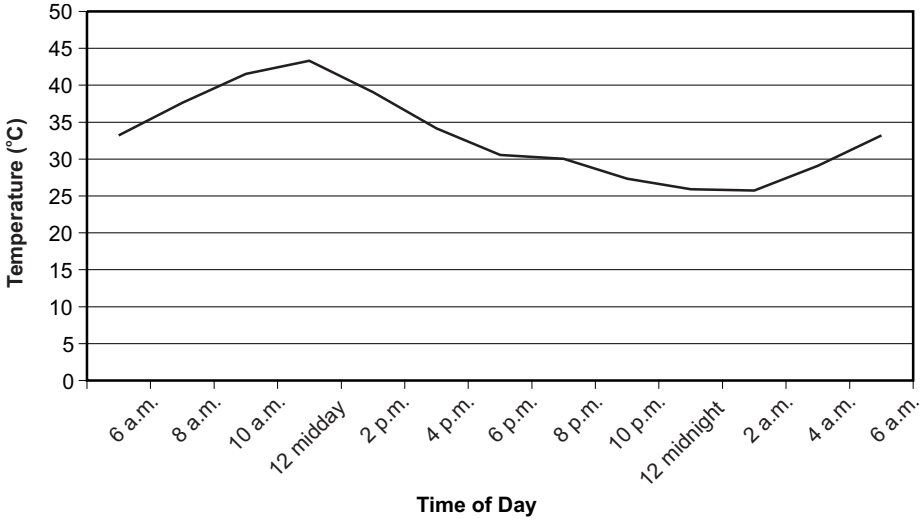

Figure 4. Temperature variation in the rig in July.

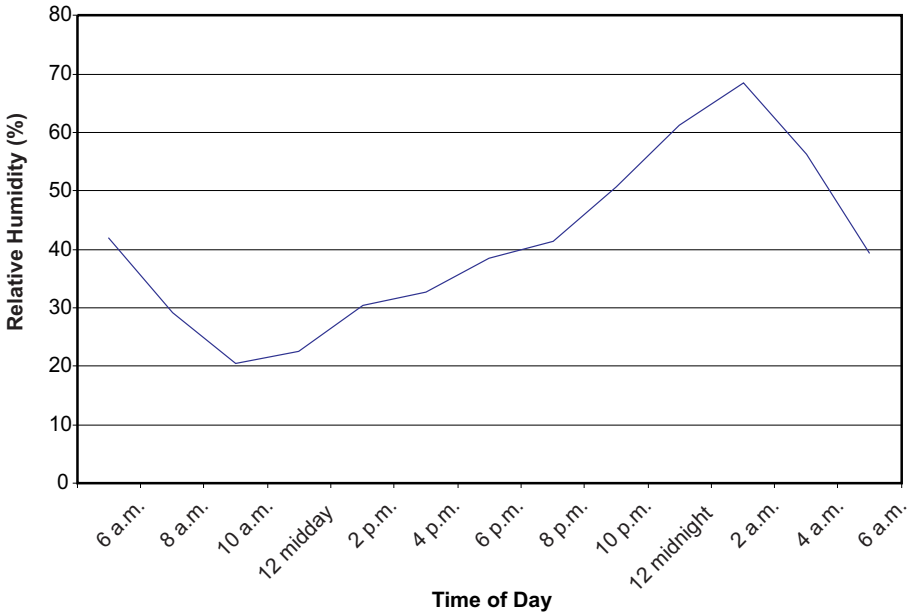

Figure 5. Relative humidity in the rig in July.

Noise on the rig floor was measured at various points, at ear height of the crew. It was observed that the level was above 80 dBA on the rig throughout the day. High noise of 95 dBA was observed around the center of the rig where the power station was located. Table 3 shows a 24-hr

TABLE 3. Sound Levels at Different Times of the Day in the Rig (dBA)

Areas in the Rig	12 midday	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	12 midnight
Rig floor	82.6	82.3	82.8	81.9	82.1	83.0	83.1
Near power station	90.2	89.5	96.2	91.5	93.6	95.8	90.1
Around rest area	77.3	78.3	80.5	81.2	79.2	77.0	79.3
Areas in the Rig	**2 a.m.**	**4 a.m.**	**6 a.m.**	**8 a.m.**	**10 a.m.**	***M***	***SD***
Rig floor	82.7	82.9	82.0	83.1	82.8	82.6	0.4
Near power station	94.3	92.0	93.5	93.5	95.6	93	2.3
Around rest area	78.6	79.6	81.0	80.2	76.9	79.1	1.5

noise measurement, done every 2 hrs, confirming noise above these levels. They are the averages of 24 samples, each at five different points (rig floor, rig carrier, power station, tanks area, engineering shop).

3.5 Analysis of Company Statistics

Existing OHS statistics were collected and analyzed. Figure 6 shows the total number and trend in musculoskeletal disorders and occupational health illnesses in 1997–1999. The rate was approximately 4% per annum. The objective of this analysis was to identify the types of injuries and health illnesses reported and treated in the main company clinic. The two major types of health problems identified were musculoskeletal disorders and occupational health illnesses. The dominant musculoskeletal problems were mostly back and shoulder pains and the dominant occupational health illnesses were noise-induced hearing loss and stress (i.e., mental or behavioral disorders).

Musculoskeletal disorders contributed to 37% in 1997, 45% in 1998, and 34% in 1999 of the total number of injuries and illnesses, while noise-induced hearing loss contributed to 39% in 1997, 18% in 1998, and 22% in 1999. Another significant problem reported was stress, which contributed to 13, 14 and 21% in 1997, 1998 and 1999, respectively. These OHS problems cost the company significantly, including 0.76% lost time in 1998 of the total workdays. It was beyond the scope of this study to identify exactly how many cases of health problems were reported to this clinic from this particular rig.

4. DISCUSSION

This study—conducted in an oilrig in a desert environment in the Sultanate of Oman—was representative of oilrigs in the Gulf countries. Therefore, the results of this study have immense significance as it identifies ergonomics and OHS issues in the oil industry in desert environments, especially oilrigs. Management in the oil industry could implement ergonomics principles and guidelines to reduce or eliminate OHS problems and improve employee performance and satisfaction in oilrigs.

The results of the study showed that working conditions, the work schedule and work-related symptoms were extremely diverse and severe. Work in the desert environment with 12-hr shifts and a continuous schedule for 14, 35, 70 or 80 days (in some cases) can be expected to have a significant effect on employees' health and safety. The majority of the employees were not satisfied with their work schedules, including breaks. This is obviously an inadequate and inappropriate arrangement considering the work condition and environment [6]. The workers perceived the environment as extremely hot during the summer months. The work activities

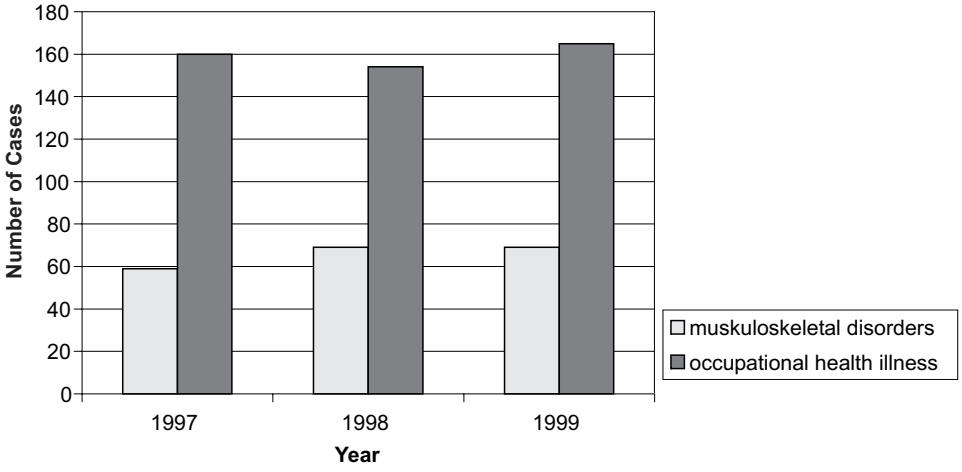

Figure 6. Musculoskeletal disorders and occupational health illnesses in the company in 1997–1999. *Notes*. *n* = 160 (1997), *n* = 154 (1998), *n* = 165 (1999).

involved hard physical labor coupled with high heat of as much as 45 ºC, and high noise of above 95 dBA. These conditions must have contributed to the health and safety problems that were evident from the results. OHS problems result in reduced performance and dissatisfaction. Employee perceptions on work attributes, health problems and dissatisfaction are serious indications of ergonomic deficiencies in oilrigs.

Studies in the literature dealing with work in hot climatic conditions mostly concentrated on human performance and a much lower range of temperatures and a usual work schedule. This study is unique as no literature could be found on ergonomics of work in oilrigs in desert environments. It considered a representative sample of oilrigs. A detailed study on ergonomic conditions of oilrigs taking more samples in desert environments and the subsequent consequences on workers' health, safety, performance and satisfaction should be conducted. The problems identified can cause trauma, noise-induced hearing loss, heat stress, musculoskeletal disorders including back, shoulder and knee problems, repetitive strain injuries, stress, fatigue and muscle strain. Strategies should be formulated to improve adverse conditions so as to reduce OHS problems and to improve performance and satisfaction in the oil industry in the desert environment.

5. CONCLUDING REMARKS

Based on the results obtained from this particular oilrig, several conclusions can be drawn. The employees perceived work in the oilrig in the desert environment as work in extreme environmental conditions and with a diverse schedule. Some major ergonomic issues identified were adverse environment, long shifts, a diverse schedule, and hard physical work. Fifty-four percent of the workers considered the work beyond their capacity. Workers' problems with back pain, discomfort, fatigue, muscle pain and pain in arms were significant. They indicate ergonomic deficiencies in the oilrig. Company statistics on musculoskeletal disorders, noise-induced hearing loss, repetitive strain injuries, and mental and behavioral disorders (stress) confirm these ergonomic problems.

The majority of the workers were dissatisfied with several aspects of their work in the oilrig. About 94% of the employees perceived the work schedule as very dissatisfactory, while 61% perceived the work environment as extremely hot (31% considered it hot). Workers were extremely tired at the end of the workday and they considered work to exceed their capacity. These were work-related syndromes that resulted from long work shifts and the schedule and adverse working conditions that existed in the oilrig.

Further research is required on the manner in which these ergonomic problems cause health and injury problems. The mechanism of an interaction of an adverse environment and a diverse schedule, and their effects on OHS should be investigated. Intervention strategies should be formulated and implemented to reduce or eliminate these problems. These changes should improve worker performance and satisfaction.

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