

How hard do mineworkers work? An assessment of workplace stress associated with routine mining activities

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ABSTRACT: Mining operations are frequently associated with difficult working conditions and high levels of workplace stress. Workplace stress can be defined as the harmful physical and emotional responses that occur when the psychological and/or physiological requirements of the job do not match the capabilities or needs of the worker. Evidence in the literature suggest that unacceptable levels of workplace stress influence workers' health and safety and could result in accidents and injuries, as well as poorer worker well being.

Information on the physiological strain (the combined strain reflected by the thermoregulatory and cardiovascular systems) of mineworkers is rather limited and, where information is available, it has been based on the physiological responses of young, healthy males only. There is also no information available on the role of psychological factors in the development of workplace stress in the local mining industry.

At present mines are required to accommodate a diverse workforce comprising of males and females. The current difficulties experienced with the placement of female miners in underground occupations where physical work is performed, highlights the need for more information on the physiological strain and psychological stress associated with mining occupations. To address this lack of specific knowledge exploratory studies were undertaken and the results obtained are discussed in this paper.

1 INTRODUCTION

Reducing occupational injuries and ill health is a strategic objective of all the stakeholders in the South African mining industry. In order to achieve this objective it is necessary to provide the safest and healthiest working environment possible for all mineworkers, males as well as females.

To create an optimal work environment and reduce workplace stress it is of cardinal importance to determine what is actually happening in the miners' work environment, i.e. to ask the question: what levels of physical strain and psychological stress are mineworkers experiencing while performing their tasks?

Very little information is available on the physiological strain (the combined strain reflected by the thermoregulatory and cardiovascular systems) experienced by mineworkers and, where information is available, it has been based on the physiological responses of young, healthy males (Van Rensburg et al., 1991).

Despite some investigation of psychological stress in the mining environment (Kowalski-Trakofler, Vaught & Scharf, 2003), there is a paucity

of documented characteristics or prevalence of workplace stress in the mining industry, more specifically in the unique South African multicultural and multilingual context (Watkins & Elliot, 1997).

In order to obtain information on the physiological strain and workplace stress associated with mining two exploratory studies were conducted at a platinum mine and this paper deals with the results obtained.

2 METHODOLOGY

2.1 *Physiological strain*

The Physiological Strain Index (PSI) is a useful tool to determine the impact of environmental temperatures and physical work on individuals. The PSI is based on core body temperature and heart rate, two physiological parameters that adequately depict the combined strain reflected by the cardiovascular and thermoregulatory systems (Moran et al., 1998). Core body temperature indicates the increase in body heat storage during exercise as a result of heat built up during muscle contraction, while heart rate reflects demands placed on the circulatory system in

response to metabolic and environmental conditions (Moran et al., 1998).

CorTempTM Physiological Monitoring Systems were used to determine the heart rates and body core temperatures of miners performing routine work underground. On completion of the shift, data collected were downloaded and used to calculate PSI values. The PSI describes the physiological strain on a universal scale of 0 – 10 and categorises the level of strain as “No-to-little”, “Low”, “Moderate”, “High” or “Very high”.

Environmental thermal conditions in the underground workplaces where the mineworkers performed their normal routine duties ranged from 19 to 27°C wet-bulb (average 23,1°C), with dry-bulb temperatures ranging from 22 to 29°C and averaging 25,7°C.

2.2 Psychological stress

One of the methods of evaluating the psychological stress experienced by a worker is to evaluate the joint effects of the demands of a work situation and the range of decision-making freedom that a worker has in his/her job. The ‘Job-strain’ model developed by Karasek in the seventies argues that ‘job strain’ occurs when job demands are high and job decision latitude is low.

The Job Content Questionnaire (JCQ) administered in the present study has been widely researched and is used to define job demands and job decision latitude. (Karasek, Brisson, Kawakami, Houtman, Bongers, & Amick, 1998; Nieuwenhuijsen, Bruinvels, Frings-Dresen, 2010). The JCQ involves a self-administered assessment of psychosocial job characteristics through measurement of the dimensions of the demand-control model and the issues focused on included control, physical demand, psychological demand, social support and noise in the workplace.

2.3 Subjects

A total of 19 healthy mineworkers (eight females and 11 males) working day shift participated in the exploratory study to determine physiological strain.

Thirty-four miners volunteered to participate in the phase to assess psychological stress. This sample was made up of 21 underground miners and 13 surface workers, 21 of whom were males and 13 of whom were female.

All miners participated in the study on the basis of informed consent. The experimental protocols were approved by the CSIR Research Ethics committee, in the case the assessment of psychological stress, and by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand in the case of the physiological strain assessments.

3 RESULTS

3.1 Physiological strain

Heart rate is an indicator of strain on the cardiovascular system. For the female group the average heart rate measured during the working shift was 112 beats per minute compared to the 86 beats per minute for the male group. Heart rates ranged from 58 to 200 beats per minute and from 51 to 177 beats per minute for females and males, respectively.

Brouha (1967) suggested that the average working heart rate during an eight-hour shift in industry should not exceed 110 beats per minute as cumulative fatigue is likely to ensue beyond this heart rate level. In the current study the average working heart rate of the female mineworkers exceeded the limit and 49,4% of the group’s working heart rates were above 110 beats per minute compared to the 13,5% of their male counterparts. According to Kilbom (1995), heart rates of below 90 beats per minute are associated with “light” strain on the cardiovascular system. Heart rates that range from 90 to 110 beats per minute indicate a “moderate” strain, while those between 150 and 170 beats per minute suggest that “extremely heavy” strain is being placed on a worker.

The mean core temperature for the female group over the full shift was 37,68°C compared to 37,24°C for the male group. Core body temperatures ranged from 35,8 to 39,3°C and from 35,6 to 38,3°C for females and males, respectively.

For the female group the average PSI measured during the working shift was 4,1 compared to 2,9 for the male group. PSI values ranged from 0,7 to 8,4 and from 0 to 7 for females and males, respectively. In view of the higher core body temperatures and heart rates of the female group, it is not surprising that this group had higher PSI values than the group of male mineworkers, since PSI is a composite index that uses core body temperature and heart rate to reflect the combined strain of the thermoregulatory and cardiovascular system.

A PSI value of 5 and above is the level at which low strain becomes moderate strain and a PSI score of 7 and above is the level at which moderate strain becomes high strain. In the female group 21,2% of the PSI values fell in the moderate strain category and 2,6% in the high strain category. For the male group only 4,2% of the values were in the moderate strain category and no male experienced high strain.

3.2 Psychological stress

Results obtained by means of the JCQ indicate that, firstly approximately 80% of participants obtained a score of 18 or lower for the section concerning ‘Control’. The results indicate that the ma-

majority of platinum miners in this sample felt that they had low levels of control over their work which could be a source of psychological stress.

Secondly, in the psychological demand subsection, approximately 60% of the participants scored nine or lower. The experience of psychological demand by more than half of the platinum miners indicates that they may be at risk for workplace stress and the health effects that are known to be symptoms of workplace stress discussed in the introduction.

Thirdly, in the physical demand section the distribution analysis indicates that approximately 80% of participants report high levels of physical demand in their job. The long-term experience of job content that is high can result in workplace stress and also in harmful physical and emotional responses that occur when the psychological and/or physiological requirements of the job do not match the capabilities or needs of the worker.

In terms of social support on the JCQ, approximately 90% of the results fell below 3 indicating that in general the miners do not feel that there is a sense of social support in their workplace. Again this indicates that this group may be at risk for workplace stress and the resulting health outcomes.

Finally, in the noise subsection, the results indicate that approximately 75% of the participants scored the noise in their workplace above 1.5, which implies that workplace noise is a factor in their experience of well-being in the workplace and may be another indication of risk for workplace stress in this population.

3.3 Comparison between females and males

Results of this study indicate that females are experiencing significantly more physiological strain than males when performing mining tasks. This finding is not surprising: the aerobic capacity (maximum oxygen uptake, which provides a quantitative measure of a person's ability to sustain high-intensity physical work for longer than five minutes) of females is typically 15 to 30% below the values of their male counterparts (Wasserman, 1999). Furthermore, for the same physical task, women work closer to their aerobic capacity than men and are more likely to become fatigued.

The findings confirm the observations made in the South African mining industry that suggest that female mineworkers are at a disadvantage as far as the ability to perform physical work is concerned (Hofmann et al., 2007). In order to address risks associated with limited physical and functional work capacity in relation to inherent physical job requirements, some mines have implemented the Rehabilitation and Functional Assessment (RFA) Test Battery, a risk assessment tool designed to address these risks (Hofmann et al., 2007). According to RFA test

outcomes during 2009, 43% of new female recruits were classified as unfit to perform physically demanding work that ranged from light to very heavy. The corresponding figure for new male recruits was 8%.

The mean scores of each section of the JCQ for females and males showed that, on average, the psychological stress experienced is similar. However males in the sample experienced greater social support within their job context than females. This result may be due to the larger numbers of males in the mining workforce and may be an indication that women in mining feel less able to cope emotionally with the job content. Similarly, males reported more stress from the noise in the environment than did the females, although this difference was not statistically significant.

The results seem to indicate that there is very little difference between the workplace stress experienced by females and males. However, if as we hypothesise psychosocial experiences are a major determinant of the health and well-being of the worker, then females may be more at risk for workplace stress due to the experience of lower social support and in high noise exposure work environments males may be more at risk for the stress symptoms. These results need to be confirmed in a larger sample of participants and, if they are confirmed, may provide indicators for interventions to prevent poor health and for planning of improved work environments where the risk of workplace stress is reduced.

4 CONCLUSIONS

The results reported in this paper are based on findings obtained during exploratory studies and need to be confirmed in larger study populations. It nevertheless highlights a number of issues to consider in terms of worker health and safety.

There is a need to maximise the fit between female mineworkers and the work environment. The fact that females are experiencing more physiological strain than males when performing mining tasks and the gender-related differences in terms of physical work capacity should be considered in the allocation of female miners to occupations with a high physical-work component.

Good ergonomics design of workplaces and tasks is one of the strategies for preventing excessive physiological strain. However, in view of technical and physical constraints in the mining environment, the selection of workers on the basis of physical abilities, and, appropriate lifestyle interventions, should be considered as components of a comprehensive plan for reducing excessive levels of physiological strain associated with mining tasks.

The JCQ results on average indicate moderate workplace stress. However, the factors that

contribute to workplace stress tell a more concerning story, namely that 80% of the participants felt that there were low levels of control over their work. More than half the participants experienced high psychological demand in their job content. 80% reported high levels of physical demand in the two mining workplaces where they work, on surface and underground. A significant 90% of the participants reported low levels of social support in their workplace and 75% of them felt the effect of high noise exposures.

These results indicate that the job content of platinum miners appears to be a source of risk for workplace stress and that they may be at risk for the health and psychological symptoms that are reported to follow prolonged exposure to stress. In view of these results, the comprehensive plan to maximise the fit between mineworkers and the work environment should include measuring, monitoring and prevention strategies to reduce high levels of workplace stress.

An integrated approach to the psychological and/or physiological requirements of the job that matches the capabilities and needs of the worker will help to improve the health and safety of workers in the mining industry.

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