



FITNESS FOR WORK IN MINING: NOT A 'one size fits all' APPROACH

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Abstract

Health promotion programs can help prevent work-related illness or injury. However, in many industries only a very small number of organizations effectively plan, implement, monitor and review risk management processes, and the emphasis has been on injury management rather than prevention. In coal mining, this is exemplified by the lack of accepted strategies to maintain and enhance the fitness levels of miners. A recent survey of a cross-section of OH&S officers working in Queensland and New South Wales mines, nevertheless, indicated that lack of fitness, stamina and skill rank highest, along with work environment factors, as contributors to injury.

There is relatively little evidence on the efficacy and cost effectiveness of existing injury prevention programs. An opportunity exists to develop a more holistic approach to the fitness of miners as a component of the health surveillance program. This begins with the selection of miners following a medical examination supplemented by relevant fitness or work related tests, enabling more targeted strength, aerobic and flexibility programs designed to match the physical demands of mining and maintain or enhance fitness at levels required for injury minimisation.

This presentation uses the workplace health literature and surveys of the mining industry to suggest strategies to implement realistic and more holistic fitness interventions for miners in line with continuing health surveillance and preservation of longer term health.

Introduction

Increasing competition has led to significant change in a majority of businesses in the industrialised world, stimulating efforts to reduce costs and increase efficiency. This has changed patterns of employment, particularly towards a greater use of contract, casual and part-time work and other non-standard employment structures. Commensurate with these organisational changes is the necessity to understand their impact on the health of the individual and the family. Maintaining the health of the workforce falls under duty of care legislation and generates significant costs in the coal mining industry. It has been suggested that the industry has emphasized safety and that within the occupational health and safety domain, the health component has been somewhat neglected. This would appear to be particularly relevant when considering preventive aspects of health, where companies have struggled to identify the most appropriate strategies to maintain and enhance the fitness levels of miners.

In this paper, we consider what it means 'to be fit for work in mining', and why it is a significant issue. Using both the workplace health literature and surveys of the mining industry, including our own, we outline strategies to implement realistic fitness interventions for miners. These adopt a more holistic approach that is in line with continuing health surveillance initiatives and the maintenance of longer term health.

Traditionally, fitness for duty has been described as "the detection of medical problems that may compromise personal, co-worker, and/or public safety" (Kales et al. 1998). This view of work ability focuses solely on the identification of pre-existing medical conditions and the resultant risk of injury. Mining and some other hazardous industries have responded to legislation and increased awareness of risks by also testing employees for drug and alcohol intoxication, and in some instances, excessive fatigue. Thus, if a worker is found not to have either medical problems or impairments related to drugs, alcohol or fatigue, he or she is considered 'fit for work' – implicitly extending the concept of fitness for work beyond the absence of illness or injury. However, a broader view of this concept should consider the interaction between a worker's capacities and the demands of the job, and how much they do, or do not, match. It should also take a long-term view of how a worker's health and fitness status may change over a career, the capacity for and limits to physical adaptation, and

cumulative effects of work demands. This more comprehensive concept of fitness for work is consistent with the goals of career-long health surveillance, and would allow interventions to preserve health and maintain work capacity to be implemented in a timely way, and tailored to the individual's needs.

A specific challenge in defining fitness for work in mining is that the actual physical fitness requirements of many work-tasks have been under-emphasised in recent years. This reflects conflicting philosophies as well as major structural change. Historically, it has always been accepted that underground mining work imposes heavy physical demands on miners, and that not all are suited to this work. Mechanisation in general, and open-cut methods specifically, have reduced many physical demands, but in an inconsistent way. Some manual tasks have disappeared completely, but mechanisation has itself created new physical demands, especially in maintenance, moving and set-up of equipment. The legal and philosophical background has also changed, with equal employment opportunity legislation leading to the presumption that most work should be open to most people, and that exceptions must be properly justified. Finally, these changes have occurred against a background in which physical activity and fitness levels have arguably declined, and levels of overweight and obesity have clearly increased (Cameron, 2003).

However, despite a range of ergonomic and job re-design efforts, many of the work tasks undertaken by miners still require significant manual handling, exertion of high forces, often with non-optimal postures, and frequently in poor environments. Furthermore, the work is often of an intermittent nature. There is a real danger that in trying to comply with the goals of equal employment opportunity, and the ergonomics credo that work should always be modified to fit the human, the effects of those "irreducible" physically demanding work-tasks on miners will not be properly appreciated. Because of population-level health and fitness changes, the expectation that all members of the general workforce could perform all mining work-tasks, and that they could do so with no risk of injury, may be increasingly unrealistic.

The Physical Demands of Coal-Mining

We present results of our own studies and the broader literature to first describe some of the general issues of mining's physical demands, and then to consider some of the specific challenges in the areas of musculoskeletal and cardiovascular health.

Our own data confirms that many tasks remain physically demanding, at least in underground coal-mining. A group of miners rated the frequency, intensity, and duration of a range of work tasks involved in the development, production and extraction processes. These tasks frequently involved manual handling associated with repetitive lifting, shovelling, operating heavy machinery, and handling awkward objects such as cabling and ventilation materials. Figures 1 & 2 show the perceived job demands of various underground tasks. The data demonstrates that the frequency and intensity of the tasks performed by the workers in different positions are quite varied. This emphasises the need for a level of functional fitness consistent with the demands of the position, as might occur when selecting an elite athlete for a particular position in a team sport.

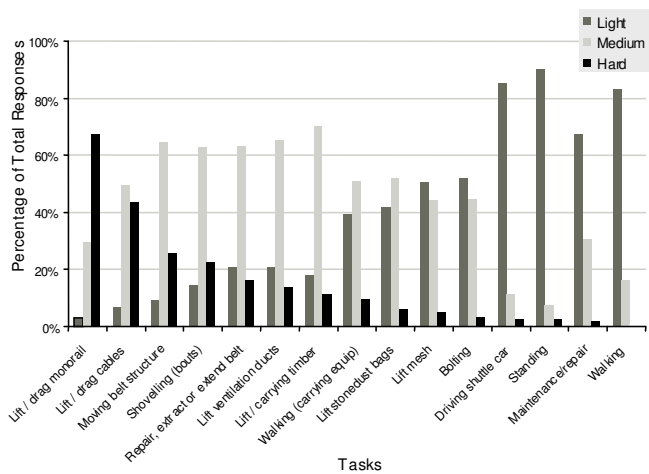


Figure 1: Miners perception of work task intensity

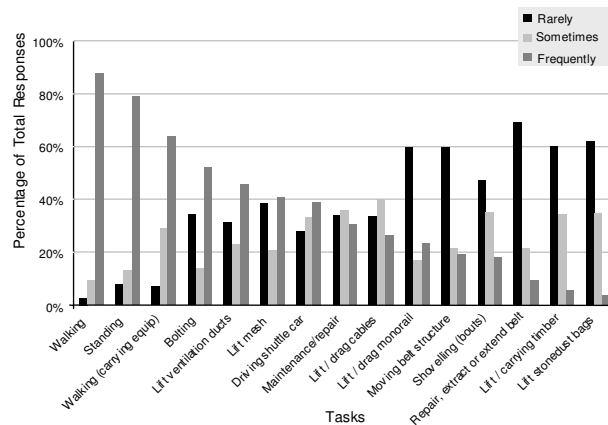


Figure 2: Frequency of work tasks performed

Figure 1 presents miners' perception of work task intensity, demonstrating that many of the tasks are rated by the majority of workers as *medium* to *hard*. In addition, the frequency of the tasks (Figure 2) was not always correlated with intensity. Therefore, some intermittent but extremely demanding tasks were performed, which could provoke an intense physiological response for a brief period of time, putting the body under extreme stress. However, the infrequent nature of these extreme tasks may not be sufficient to elicit a *training* response and thus may not cause a physiological adaptation to the task. Similar conclusions have been reached for industrial workforces generally (Makowiec-Dabrowska, 1995). Graphical data of a miner's heart rate over a shift, see Figure 3 (Abt, et al 1999), shows the intermittent nature of underground mining with peaks of very high intensity work causing a dramatic rise in heart rate. This individual record may under-represent the actual situation.

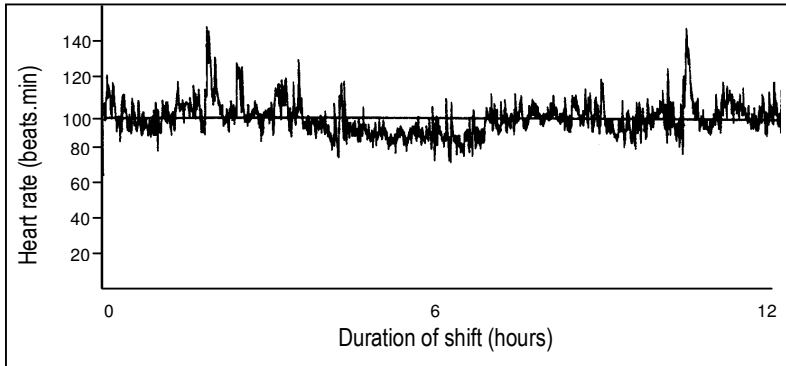


Figure 3: Heart rate during a shift of an underground miner. Figure from Abt & Tranter, 1999.

Data from Montolouit et al. (1995) show that values greater than 75% of maximum heart rate are attained for a small but significant proportion of the shift (Figure 4.). In the course of evaluating simulations of work-related tasks, our own research has shown heart rates attaining values close to maximum in several common underground tasks, with clear individual variation (Figure 5). All these observations emphasise the need for health promotion approaches that are individual rather than generic.

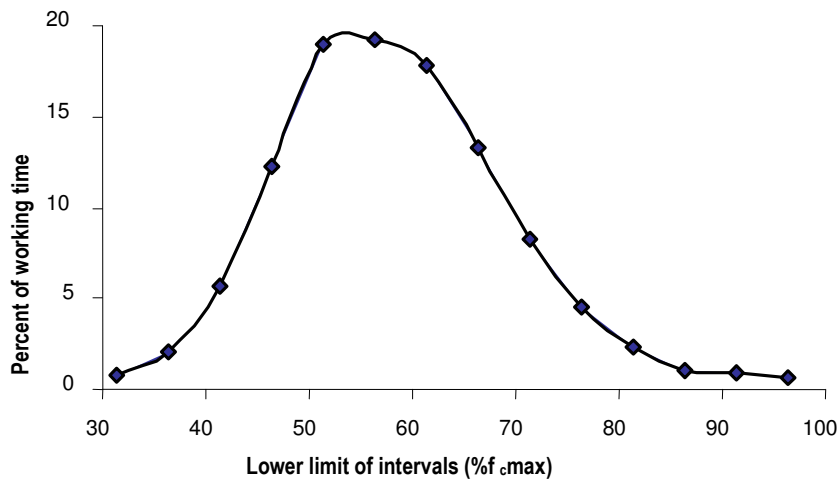


Figure 4: Heart rate as a percentage of maximum, versus percent of time over a shift

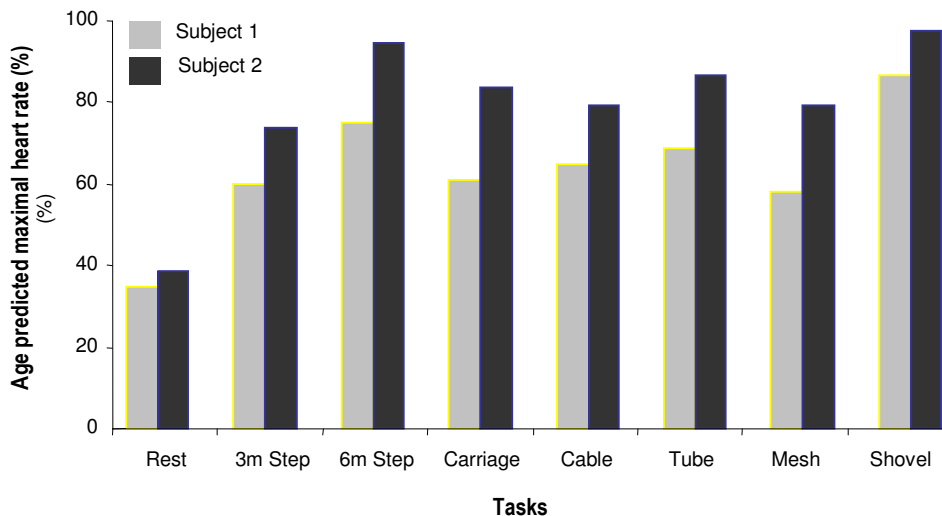


Figure 5: Percentage of maximum heart rate for various tasks – a comparison of 2 subjects.

Indeed, the assumption that people who are required to lift heavy loads in the workplace are therefore physically well conditioned is not well founded. A study by Ruzic et al. (2003) found that workers exposed to high physical loads did not necessarily have improvement in functional and motor abilities, in fact they were only found to have a stronger handgrip. The disparity between actual fitness and the perception of fitness levels suggests that miners may be unaware that they lack the necessary functional capacity to safely perform a particular work task without risk of injury. This indicates a need to properly educate miners on the need to be physically conditioned for the task and the reality that their work alone is insufficient to maintain the required level of fitness.

Within the industry, there appears to be a recognition of these issues even though they rarely surface in accident reports or other conventional health and safety statistics. In our survey of a cross-section of Occupational Health and Safety personnel in Queensland and New South Wales coal mines (open-cut and underground), a lack of fitness was identified as the number one ranking of factors contributing to work related injury, while a lack of stamina was ranked as the 5th level contributor to injury (Parker, et al. 2004). Although it is hard to evaluate the basis for this high rating it probably reflects a mix of direct observation, discussion with miners, investigations of incidents, and overview of injury and accident trends, as well as involvement in training activities where OH&S personnel can observe errors and ability. The high rating given to lack of fitness as an injury factor suggests that there is considerable opportunity for intervention strategies to reduce its impact, since it can be altered more easily than some other variables, such as the underground environment itself.

Musculoskeletal Health

The workers' roles at a mine site are extremely varied and job specific. However many positions still involve a significant amount of physical work with tasks involving strength, mobility and muscular endurance. Because work intensity is generally intermittent, this raises concern with respect to musculoskeletal injury since many may be unprepared for high intensity loading which may exceed their physical capacity (Figure. 6). Sprain and strain injuries remain the most common injuries sustained at coal mines in Queensland (Parker 2002). While some of these injuries are the direct result of trauma, others may be attributed to cumulative damage from repeated minor injury. Soft tissue structures of the joints are susceptible to microdamage which, if excessive, may lead to overuse injury. This occurs when the damage exceeds the repair capacity of the tissue and the problem may be compounded with increasing age as the potential for repair decreases.

An example of the effect of cumulative load was demonstrated in a study of 355 radiographic records of workers exposed to long periods of heavy physical exertions or whole body vibration (Brinkmann, 2000). The results for miners indicated significant decreases in the lumbar disc height. It was suggested that this may be due to loss of disc tissue and /or endplate fracture of adjoining vertebrae as a function of high loads and repetitive handling. The effectiveness of ergonomic redesign was demonstrated by the finding that miners with improved damped seat design had no changes to vertebrae in contrast with those with unsprung seats.

Some vertebral bodies and discs showed an increase in height which suggests the possibility of a 'training effect' or positive adaptation to the loads to which they were exposed. This emphasises the difficulty in defining loading thresholds for positive or negative effects and individual tolerances to load.

The difficulty in preventing this type of injury reflects the limited information available on, the relationship between the various task and overuse injury (overload) the effects of cumulative loading on tissue damage, individual tolerances to these loads, and the lack of reliable and valid measures of cumulative load. Other confounding effects such as age, work environment and work organisation increase the complexity of the problem. In addition to ergonomic interventions where these are possible, appropriate physical conditioning of the structures directly affected by the demands of the work would help to attenuate these injuries, therefore reducing unnecessary pain and suffering on behalf of the miner and lost productivity time and compensation for the mine.

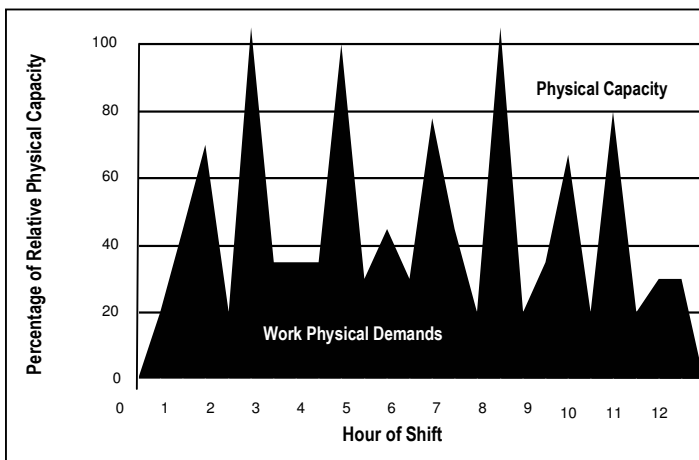


Figure 6: Hypothetical model of work physical demands over a shift and the percentage of relative capacity.

Physical strength and stamina are necessary to prevent acute and overuse musculoskeletal injury (Parker 2002). The inclusion of strength, aerobic fitness and flexibility are essential in any fitness programme for workers with physically demanding jobs, to reduce the incidence rate of, and recovery from, musculoskeletal injuries such as sprains and strains (Shepherd, 1999). However, it is not only those jobs requiring specific physical fitness that need to ensure a level of fitness. Primarily sedentary tasks such as truck or dozer driver, require appropriate fitness to counteract the adverse health effects of these largely sedentary occupations which include, however exposure to vibration. These injuries generally appear after a longer period of time. When employees in these positions have to perform physical tasks infrequently, then they are at increased risk of overloading the musculoskeletal structures involved in manual handling and force exertion. A starting point for devising tailored fitness programs is to develop a detailed knowledge of physical requirements by work category, and to pay special attention to high loading conditions even when these are not frequent. A second area of risk is when an individual in a relatively sedentary job of this type switches to a new job within the mine that may have higher physical demands. Our OH&S manger survey indicated that currently 91% of mines do not routinely medically reassess workers when they change positions.

Cardiovascular Health

While the prevalence of sprain and strain injuries might suggest that it is only in the musculoskeletal area for which fitness requirements are important, there is also some evidence that cardiovascular fitness may be a neglected feature of a coal miner's health. In addition to the data on high intermittent cardiovascular demands of coal mining tasks presented above, there is, for example, survey data on the cardiovascular health of the Australian mining workforce which indicated higher levels of hypertension and obesity than found in the general population (Bofinger & Ham, 2002). This appeared to be part of a pattern of regional differences in which the general population of coal-mining regions also had higher overall levels of hypertension and obesity than the national average. In addition, research on Russian underground coal miners indicated a direct correlation between the underground service duration and the prevalence of ischemic heart disease. Of the cases of unexpected death, 63% were related to hard strenuous work, and the performance of work in a hot environment (Cherkosov, 2000). Cardiovascular health is also negatively affected by shiftwork (Holmes, 2001), a fact that may be in part explained by poorer patterns of nutrition and greater rates of smoking in shiftworkers relative to their daytime counterparts (Knutsson, 2000).

A specific potential issue with regard to cardiovascular fitness and associated risks of cardiac infarction, concerns the cardiovascular health of the mine rescue crews, and the possibility of an incident occurring underground during a rescue. A rescue can present a situation in which significant physical loading, the possibility of awkward or lengthy manoeuvres, high stress and requirements for speed all intersect. The fitness and general health of the rescue crews must also be evaluated and maintained, in line with strategies for the miners, to ensure rescue duties can be performed without undue risk. To a lesser degree, underground self-rescue presents a similar challenge, since the ability to escape from a mine may require rapid evacuation on foot, and pose a cardiovascular challenge not seen in normal work. A compounding factor is that those whose cardiovascular fitness is low will have much greater oxygen demands than their fit counterparts for an equivalent distance of travel, which has obvious implications for the probability of successful escape while relying on self-rescuer breathing apparatus.

A Strategy for Building Fitness for Work in Mining

In this section we outline an approach to fitness for work in mining in a broader context than has generally been taken. We will present the case for a much more sustained and comprehensive strategy.

Health promotion activities in the Australian coal industry are not insignificant (our OH&S survey indicated an average annual expenditure per worker of just over \$3,600 on health promotion), but they could be characterised as eclectic in terms of focus, of widely varying duration and content (our review of the health promotion literature strongly suggests that costs exceed benefits unless programs are sustained for a minimum of 3-5 years). They are delivered by personnel whose qualifications may not always be appropriate, and they are inadequately monitored (mines in our survey rely heavily on the blunt measure of injury statistics for evaluation, and fewer than half indicated that any form of independent assessment was undertaken). This is not unlike the situation in industry generally. The vast majority of research in the area of health promotion has investigated narrow health promotion programs and the direct, short-term outcome measurement of such programs (eg: anti-smoking campaigns, dietary interventions). Despite the contention that absenteeism and performance losses are associated with workplace injury and disease and reduced productivity, there is little quality data available. Likewise, the evidence for performance based cost benefits of health interventions is limited.

A major issue with all interventions is the relatively low participation rates and/or high attrition rates. These factors all contribute to the lack of quality information on the medium and *long-term effects of interventions for both the employee and the employer*. Furthermore, blue-collar workers comprise almost 75% of such cases, with body stressing being the primary agent for injury. There is a clear preponderance of intervention aimed at white-collar workers in the area of disease, and a lack of intervention in blue-collar workers in the area of injury prevention.

The keys to developing a suitable health promotion programme for labour intensive occupations are a) *to evaluate the tasks to be performed as a basis for the design of appropriate intervention programs*; and b) *to assess workers' capacities to carry out these tasks*. In this case, an in-depth analysis of the physical requirements and stresses of the work needs to be undertaken so that suitable intervention programs can be developed which are capable of both enhancing the health of the worker and preventing injury.

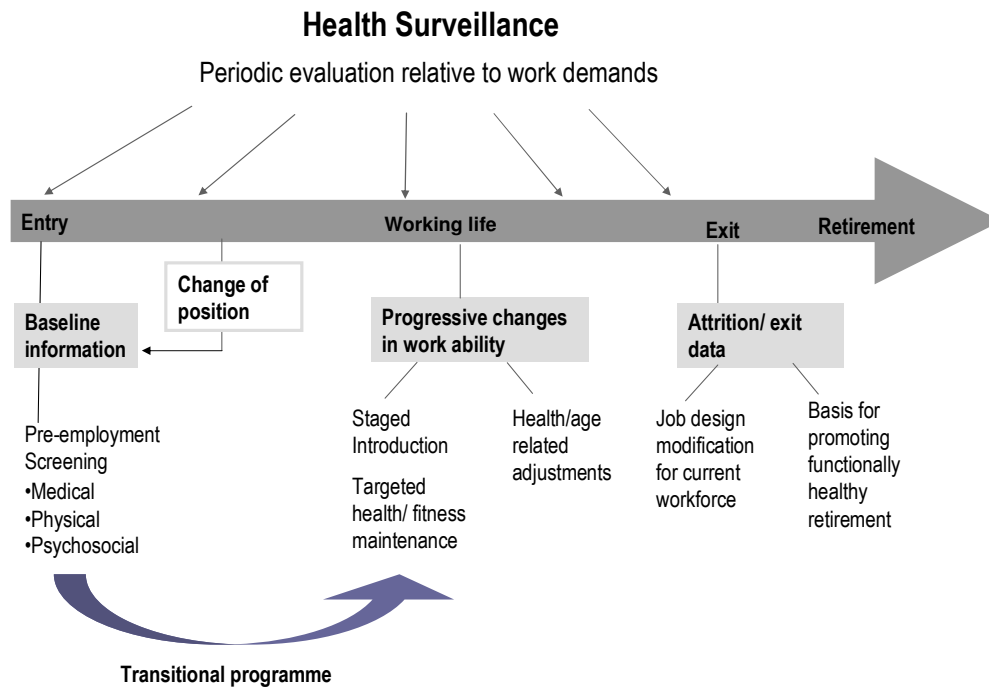


Figure 7. A Longitudinal Health Surveillance approach to worker health.

Thus a comprehensive approach to fitness for work in mining will have as a hallmark integration with ongoing health surveillance. In Figure 7 we outline a working-life approach to this strategy. Task evaluation should be ongoing, and assessment of employees should occur at entry, periodically throughout working life, at critical junctures such as change of job or return to work following injury, and at exit from the industry. As previously stated, assessments on change of job are currently uncommon in mining. Assessments should reflect work demands, which requires the use of well validated, objective tests as similar as practicable to actual mining work. They should also contain more general tests of function including strength, flexibility and aerobic fitness that are logically related to work, but are also of value in benchmarking rehabilitation and health promotion more broadly.

One of the most critical aspects of the fitness screening process is ensuring that the medical examiner or health assessor understands the context and critical job requirements that may be required of the individual (See, 2003). Currently the mining industry depends heavily on the Coal Board Medical examination to determine the ability of the miner to perform the duties of the job. This test looks at previous injury and its effect on work ability but does not take into account factors such as strength, flexibility or cardiovascular fitness. Clearly this standardised test for all employees does not take into account the physical preparedness of miners to perform their duties without undue physical strain or risk of injury. Moreover, our OH&S survey showed that 55% of medical assessors were not familiar with underground mining, and 45% were not familiar with open-cut operations. This clearly limits the usefulness of medical assessments.

Development of baseline physical fitness data on employees will provide important information to assist with the development of health enhancement strategies throughout an employee's

working life, in order to improve health and prevent injury. Most importantly, early warning signs (where capacity measures are declining to levels where tasks become high risk or not possible) can prompt quite targeted interventions.

This does not suggest that all injuries can be prevented, and does not obviate the need for ergonomic and design interventions. Nevertheless, an opportunity exists to develop a more holistic approach to the fitness of miners as a component of the health surveillance program across working life. This begins on appointment with the selection of miners following a medical examination or as occurs in some mines, supplementation of the medical by fitness or work related tests. The latter would allow the implementation of more targeted strength, aerobic and flexibility programs designed to match the physical demands of mining and either maintain these initial levels or enhance fitness where deficiencies exist. Maintaining individual fitness profile data also provides a more secure basis for rehabilitation following injury, since the individual's capacity prior to injury is known, and goal-setting can be more specific.

It is not only at the individual level that this information has value. At a more collective level profiling physical capacity over time would allow for better prediction and workforce planning. The effectiveness of educational programs, or other interventions can also be more effectively determined by examining changes in relevant fitness values.

Of course, the development of such an approach requires a substantial commitment. Reviews of successful health promotion programs point to the paramount importance of sustained support from management as well as worker involvement in the design and execution of programs. An additional factor with respect to fitness for work in mining concerns confidentiality of information. New protocols for accessing information may be required, so that privacy concerns are addressed. For example, it is conceivable that miners may request additional testing if they have concerns about their own capacity, with a view to using exercise to maintain or enhance that capacity. In such a case, it might be reasonable to limit access to the fitness data. Despite these challenges, there are good reasons not to disregard the fact that many coal-mining tasks remain extremely physical, and that paying proper attention to what it means to be "fit for work in mining" may entail some fundamental reappraisal of policy and practice.

Conclusion

There are many issues that can potentially impact on the risk associated with physically strenuous occupations within the mining industry. These need to be explored further to determine a strategy for physical preparation strategies specific to the requirements of the position. An overview of the findings from the injury prevention survey conducted by Parker et al. (unpublished paper) indicated that a "one size fits all" approach is prevalent, with few opportunities to enhance employees' physical function or cater for workers with reduced capability due to injury or age.

Preemployment and ongoing tests alone do not address all injury problems; but in combination with medicals, physical conditioning programmes, job redesign, work scheduling, fatigue management and equipment changes, they can add a critical element to the challenge of injury prevention.

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