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Ergonomic Inputs for the Improvement of Safety and Health Exercises in the Mining Industry

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Introduction

Mining is a relatively unsafe industry and workers in the industry are more prone to be killed or to suffer non-fatal injuries or illnesses. In accordance with the Bureau of Labor Statistics (BLS) [1], their hurts are liable to be severer than employees in the non-public sector. Thousands of workers perish from excavating collisions each year, particularly in the process of coal and hard rock mining works [2]. A large amount of the fatalities today occur in developing countries, such as China. China's coal mines are the world's deadliest, killing an average of 13 miners a day [2]. China is also reported for the largest number of coal-mining fatalities, disclosing about 80% of the world's total, although it yielded only 35% of the world's coals. In comparison, annual coal mining deaths numbered more than 1,000 a year in the early part of the 20th century in the U.S. They reduced to an average of about 450 yearly mortalities in the 1950s and to 141 in the 1970s. The annual average in coal mining declined to 30 fatalities from 2001-2005. However, 60 to 70 mineworkers still perished each year in the U.S. coal and non-coal mining industry [2].

Coal mining is a part of the mining sectors accompanied by other mining and extractive businesses such as oil and gas. Coal mining can be further estranged into two areas: bituminous coal underground mining and anthracite mining [1]. Bituminous coal underground mining hires marginally more than half of all coal mining workforces but faces a higher portion of work-related injuries, illnesses, and fatalities [1]. The rate of fatal injuries in the U.S. coal mining industry in 2007 was 24.8 per 100,000 full-time comparable workers, almost six times the rate for all the non-public industry [1]. In 2008, the percentage of nonfatal injuries and infirmities in the coal mining industry was 4.4 cases per 100 full-time workers, which was 13% higher than for the total non-public one [1]. In the bituminous coal underground mining, the rate of nonfatal injuries and illnesses was 66% higher than that of all the private industry whilst bituminous and lignite surface mining had a rate that was 49% lower than all the private industry [1].

Despite such high prevalence ratio of injuries and illness, safety and health risks have not really been well researched in the mining business which is caused by longer shift times, higher workloads, fewer job variations and decision latitudes [3]. Hefty bodily jobs and pressures are still concerned parts but are likely to be discontinuous instead of constant. The involvement of slips, trips and falls and rising age of miners to manual handling injuries is still not evident. In some cases, the issues of equipment design for processes and safeguarding and whole-body vibration exposures when operating machines and vehicles are becoming more critical [3]. The link amongst continued sittings, inadequate cab designs and vibrations with back and neck pain is being recognized but has yet to be addressed in any systematic way by the mining industry.

On the plus side, however, certain mining companies have well-developed partaking systems to solve their problems and these require to be expanded to other fields such as ergonomics [3]. This means that mining sectors generally have an imposing track record for providing constant enhancements in safety and risk governance standards. Whilst safety and environmental controls of mining activities continue as key drivers, the proficiency and capability presented within the industry should certify that any latest and/or appearing hazard challenges are dealt with in a regularly determined manner. In this sense, there is no doubt that expectations of supportable development for the enhanced delivery of ergonomic programs and interventions seem to be further increased to the mining industry safety and health practices.

Ergonomic Evaluations

Mining workers

Mining is often categorized as being a very demanding business with challenging circumstances. Whether on the surface or underground, the process of unearthing ores can be described as dynamic works [4,5]. The recent literature suggests that the mining job is in a condition of continuous transformation. Vibrant work courses in the mining industry have introduced the preventive concept of safety and health risks, and these risks have not been always steady. Furthermore, these hazards are not continuously correctable through hierarchal models, proposing a categorized accent on engineering control, administrative management, and personal protective equipment (PPT) [5].

Occupational hazards are a part of the mining procedures and present challenges to the mining community to research and evaluate approaches to lessen the dangers. Practically, this aim is not one of eradicating hazards, but one of moderating the risk of injuries [6]. For this to happen, perils and their related risks amongst the miners should be documented by those who execute, control, and/or have a stake in the task [6].

Amongst the common injuries from the mining workers, musculoskeletal disorders (MSDs) have been recognized as a major concern and a costly issue for the mining industry. The literature stated that strain and sprain injuries accounted for 24.0% and 25.2% of all the reported injuries for the underground coal mining, respectively, and 19.4% and 20.4% of all injuries for the underground metal/non-metal mining, respectively [7,8]. The U.S. BLS also stated that mining is one of the most dangerous jobs in terms of exposure to ergonomic hazards [6,9,10].

An analysis of results from the National Occupational Health Survey of Mining (NOHSM) found that the significance of musculoskeletal overload potential exposures from coal mining works was greater than that for metal/nonmetal mining [11]. Other studies also analyzed the NOHSM ergonomic hazard data for 24 products associated with the metal/nonmetal mining industry [6,12]. They concluded that budding experiences to ergonomic risks were most liable to the following body areas: neck and/or back; forearms, arms, and shoulders; and fingers and hands. On the whole, they considered that the potential exposure to ergonomic dangers for metal/nonmetal miners was high compared to that for non-mining professions.

In addition to these common MSD exposures, another concern is that the workforce is ageing in many mining sectors. The cumulative nature of MSDs advocates that older workers seem to be more at risks because they have possibly many years of exposures to bodily challenging works [6]. Furthermore, older workers frequently need a longer period of time to recuperate from injuries. However, older workers commonly have a good comprehending of the work process and can likely make noticeable propositions to improve the process, i.e., make it safer and more efficient. Decreasing the MSD risk elements to improve the life quality of miners seems to have encouraging effects on the productive capacity of mining plans, and cut medical costs linked to mine operations [6]. Therefore, intervention programs should be focused on (1) identifying work tasks that can considerably benefit from added ergonomic evaluation, (2) examining and categorizing physical risk features that can lead to MSDs for the recognized work tasks, and (3) developing innovative concepts for problem-solving to reduce risk factors for the mining sites.

Risk factors

Compared to most other work environments, mining places offer extra risk convolutions owing to the active nature of works. The working situation alters day-to-day and new dangers are presented as a part of the mining developments [6]. Job processes frequently change to adopt variations in the work situation. Thus, hazard exposure factors are not constant and change depending on work types and conditions, and workers performing the task [6,13].

Mining operations are also related to difficult working surroundings and underground mining is specifically deliberated to be one of the most physically challenging professions. The actual works in deep-level mines involve a range of contests to ergonomic interventions. This is caused by the characteristics of ore bodies, narrow gold-bearing reefs, geological constraints, and the depth at which the mining takes place [14].

The mining works also occur in very obstructive regions with low ceiling heights, high thermal heat loads and involve a large component of physical works even though the induction of engineering measures and mining equipment expecting to make jobs easier [14]. However, mining tools used in the narrow reefs is designed without considerations of essential ergonomic philosophies. Some examples for the typical ergonomic hazards allied with mining equipment involve limited visual issues from the driving position, confined cabin space, hard vehicle accessibility for the operator and disclosure to whole-body vibration, noise, and dust [14].

A recent study reported that major ergonomic confronts in the mining industry included rough, heavy, inadequately maintained equipment, fatigue, prolonged work hours, recurring tasks, unchallenging and over demanding tasks, shift work, human errors, and accessibility for protection [15]. Thus, it becomes clear that ergonomic intervention programs should be based on multidisciplinary knowledge foundations including physiology, bioengineering, mining, industrial and mechanical engineering, sociology, psychology, and industrial hygiene [15]. This means that ergonomists need to effectively collaborate with other research groups within any mining program and with vocational partners to address overlapping issues. For example, an essential prevention strategy for work-related musculoskeletal disorders (WMSDs) advocated by the mining ergonomics group should comprise the following fundamental issues [15]:

- Developing feasible solutions with the mines,
- Collaborating with mining stakeholders,
- Advancing ergonomics research and analyzing tool development, and
- Investigating emergent issues such as an ageing and skilled workers and new inexperienced young workforces.

Ergonomic Involvements

Ergonomic concepts and principles have been a core tool for the safety and health research of mining industry and its profiles have been significantly grown over the last decade. However, the recent studies report that there are still many rooms to improve in the work environments, devices, and machineries that involve the safety and health of mining workers. It is also observed that there is lack of ergonomics developments and methods in small-scale mining places.

A significant number of the mining workers are still labouring in extreme postures and working conditions in the developing countries in particular. For this reason, implementation of ergonomic involvements is urgently suggested to reduce injuries and fatalities amongst the mining worker. Such as, WMSDs due to awkward postures, repeated lifting, powerful movements, and bodily works at fast speeds are a regular illness that can be characterized by ergonomic observations [16-22]. The reported increasing injury cases can be main problems for the workers at a high risk of developing WMSDs that are related to exposure causes in the mining environment. Hence, promotion of a thorough ergonomics strategy is required to the mining industry. This development strategy should consider introducing and implementing ergonomic ideas and values for the enhancement of occupational safety and health practices in compliance with related mine safety and health act(s), workers' confidence and welfare as well as output, efficiency, and effectiveness through the mining sectors [23].

The strategy to instigate ergonomics in the mining industry also should comprise role players such as the state, employers, employees, and manufactures/suppliers of mining tools, on the foundation of participatory ergonomics [23]. Detailed contributions for the role players need to review of prevailing regulation (s) addressing ergonomics and the designing of ergonomic operation plans, the formation of recognized ergonomics programs on mining works, the active involvements and contributions in the ergonomic programs, and the use of ergonomic design strategies and requirements fit for the local miners and mining circumstances by manufacturers/suppliers of mining tools [23]. Successful application of the plan should be depended on the effective presentation of ergonomic values. Thus, it would be a key value to promote the overall level of recognition amongst all the role players. This can be accomplished through conventional evidence and exposure programs to initiate ergonomics. Learning and exercising in ergonomics will be required to accelerate

dynamic involvements of all the employees in ergonomic programs for the mine sectors [23].

Ergonomic strategies also need to be viewed as an asset with lasting values. They should be beneficial to improve health, safety, comfort, and human well-being, which are truly the main goals of applying ergonomics in the local mining industry [23]. With recommendations for the successful application of ergonomic approaches, future research efforts are also proposed to further improve the operation of ergonomics in the mining industry.

Conclusion

All miners are often exposed to many injuries and fatalities so every risk potentials from the mine sites, equipment, and products should be identified, and their most noticeable features need to be highlighted through rated lists by the occurrence. Hence, specified cause incidence rates and levels need to find general trends in mining injuries and categorize them by natures, accident types and classes [24,25]. For example, most commonly incapacitated miners by age groups, activities, and job titles can be valuable markers not only of hazards and the questions that contribute to them but also potential answers.

There are a number of ways to deal with risk factors and prevent injuries and fatalities in the mining industry. These include combinations of engineering changes, innovated ergonomic design improvements, enhanced work practices, and expanded usages of PPT [6]. Risk factor awareness along with proactive safety culture practices, skills, and motivations to "problem-solving" may also offer stimulating solutions for the miners. There is often more than one method to resolve a problem, and those who normally do the job have the best knowledge of the problems. This is one of the main motivations for communicating with workers at each of the sites. For instance, open discussions of MSD risks with workers can be reduced for specific tasks in the mining fields.

Therefore, ergonomic approaches such as coaching, job and mine design, job risk analysis, PPT, and a range of associated measurements seem to be absolutely valuable tools to provide cogent solutions for the mining industry and mining workers. In addition, ergonomic controls that facilitate safer operations of mining machines and equipment can be assessed using pre- and post-intervention designs. To achieve more systematic and anticipatory results, future works are also required to develop comprehensive ergonomic programs for the longer-term control measures including mining machineries along with targeted injury prevention designs.

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