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Chapter- 17

An Ergonomic Approach to Sustainability for the Manual Material Handling Workers: A Review

Satabdi Ghosh[1] and Krishnendu Sarkar[2]*

Keywords: Unorganised sector, Musculoskeletal Disorder, Awkward postures, Human factors, Occupational Health

Abstract:
Manual Material Handling (MMH) involves workers' physical handling of objects, such as lifting, carrying, pushing, or pulling. MMH activities can significantly contribute to the development of Musculoskeletal Disorders (MSDs) among workers. MSDs encompass a range of conditions affecting muscles, tendons, nerves, and joints due to repetitive movements, awkward postures, forceful exertions, or sustained exertions over time. In the context of MMH, workers often need help with ergonomic challenges, such as lifting heavy loads without proper techniques, working in awkward positions, or performing repetitive tasks without adequate rest periods. These factors increase the risk of developing MSDs, particularly in the upper limbs, lower back, and shoulders. To mitigate the risk of MSDs related to MMH, ergonomic interventions are crucial. These may include redesigning workstations and tools to reduce physical strain, training on proper lifting techniques, implementing task rotation to vary movement patterns, and promoting regular breaks to allow recovery. Effective ergonomic measures enhance worker health and safety, increase productivity, and reduce healthcare costs associated with MSDs in occupational settings. Integrating ergonomic principles into sustainable development strategies for MMH workers contributes to organizational sustainability by lowering absenteeism, healthcare costs, and worker compensation claims.

Introduction:

The term 'Ergonomics' originates from the Greek words 'ergon' (work) and 'nomos' (laws), signifying the study of work. Ergonomics is a holistic discipline that encompasses all facets of human activity. It is a scientific field focused on understanding how humans interact with various elements within a system. This discipline considers physical, cognitive, social, organizational, and environmental factors. Ergonomics utilizes theoretical principles, methodologies, and empirical data to enhance human well-being and system performance (Eklund, 1999; Gajbhiye et al., 2023a & b; Khant et al., 2023; Ranganathan et al., 2024a & b).

Satabdi Ghosh
[1]Department of Operation Theatre and Anesthesia Technology, School of Health Sciences, The Neotia University, Sarisha, West Bengal, India
E-mail: satabdicu@gmail.com; Orcid iD: https://orcid.org/0000-0003-4570-4098
Krishnendu Sarkar
[2]Department of Physiology, Krishnagar Government College, Krishnagar, Nadia, West Bengal, India
E-mail: krishnendu4776@gmail.com; Orcid iD: https://orcid.org/0000-0002-0663-9804
***Corresponding Author:** krishnendu4776@gmail.com

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Occupational health, according to the International Labour Organization (ILO) and the World Health Organization (WHO), encompasses health issues related to the occupation of any worker. Studies and interventions should aim at preventing such health hazards in the workplace, which may ultimately affect workers' physiological and psychological capacities. Specifically, interventions should promote physical, mental, and social well-being for every worker. In essence, it encourages the adaptation of work to individuals and individuals to their jobs (WHO, 1985).

Applying Ergonomics in the workplace offers numerous benefits. Workers experience healthier and safer working conditions, enhancing their overall well-being. Employers benefit from increased productivity, which directly results from low-cost Ergonomics interventions. These interventions can include organizational restructuring to realign workstations with strategic goals, and optimizing productivity. Additionally, proper tool design, rotating work schedules, work pacing, scheduling improvements, and exercise programs collectively contribute to both productivity enhancement and the promotion of human wellness (Johnson, 1993).

India experienced an industrial revolution towards the late 19th century, leading to the development of numerous industries. However, during this period, there needed to be more awareness regarding the health and safety of workers. In India, research in occupational health has been hindered by a need for more foundational data and inadequate funding availability (Gangopadhyay, 2012). In India, the projected number of workers in the unorganized sector in 2004-05 was approximately 390 million, contributing to around 85 percent of total workers, including all age groups below and above the average working age range (Naik, 2009). Nine out of ten workers in India work in the unorganized sector (Pandya and Patel, 2010). Despite their large numbers and significant contributions to the national economy, they remain one of the poorest segments of our population. Work in the unorganized sector is marked by low wages that often fall short of meeting basic living standards, including adequate nutrition. Workers typically face long hours, hazardous conditions, and a lack of essential services such as first aid, clean drinking water, and sanitation facilities. These workers do not receive the benefits of the Minimum Wages Act or the Factories Act.

Organized sectors in developing countries are mostly safe. This leads to Manual Material Handling (MMH)-related acute injuries and Musculoskeletal Disorders (MSDs). MSDs affect muscles, bones, and tendons, encompassing acute and chronic conditions based on their causative factors. Acute MSDs typically result from sudden muscular damage, often due to accidents. In contrast, chronic MSDs develop over prolonged periods due to ongoing exposure to risk factors associated with the work environment.

This review examines work-related musculoskeletal disorders (MSDs) among Manual Material Handling (MMH) workers in the unorganized sector. It seeks to identify the prevalence of MSDs and their correlation with various occupational risk factors such as job autonomy, working behavior and work-related stress. Furthermore, the review aims to explore

the role of Ergonomics in promoting sustainable development among these workers by improving health outcomes.

Musculoskeletal Disorders – Definition and Risk Factors

Manual Material Handling (MMH) involves workers' physical handling of objects, such as lifting, carrying, pushing, or pulling. MMH activities can significantly contribute to the development of Musculoskeletal Disorders (MSDs) among workers. MSDs encompass a range of conditions affecting muscles, tendons, nerves and joints due to repetitive movements, awkward postures, forceful exertions, or sustained exertions over time. In the context of MMH, workers often face ergonomic challenges, such as lifting heavy loads without proper techniques, working in awkward positions, or performing repetitive tasks without adequate rest periods. These factors increase the risk of developing MSDs, particularly in the upper limbs, lower back, and shoulders. To mitigate the risk of MSDs related to MMH, ergonomic interventions are crucial. These may include redesigning workstations and tools to reduce physical strain, training on proper lifting techniques, implementing task rotation to vary movement patterns, and promoting regular breaks to allow recovery. Effective ergonomic measures enhance worker health and safety and increase productivity and reduce healthcare costs associated with MSDs in occupational settings. Integrating ergonomic principles into sustainable development strategies for MMH workers contributes to organizational sustainability by lowering absenteeism, healthcare costs, and worker compensation claims.

Manual Material Handling and Its Health Effects

The materials handling industry plays a crucial role in the global economy, yet it faces significant challenges related to occupational injuries and illnesses. Understanding the underlying risk factors and associated costs could help mitigate these issues. Manual Material Handling (MMH) is mainly linked to severe injuries, pain, disability, fatalities, and reduced productivity for workers and their families, leading to substantial economic losses for society as a whole. Extensive literature supports the notion that high physical workloads and hefty lifting, significantly increase the likelihood of these adverse outcomes (Andersson, 1997; Burdorf and Sorock, 1997; Gordon and Weinstein, 1998; Hoogendoorn et al., 1999; Marras, 2005; Myers et al., 1999; National Research Council (US) and Institute of Medicine (US), 2001). Similarly, the wide variety of musculoskeletal disorders (MSDs) affecting the upper and lower extremities is linked to various physical exposures, including manual material handling (MMH) (Putz-Anderson et al., 1997).

Injuries related to MMH have grown significantly. These injuries can occur from lowering, lifting, pulling, pushing, etc., along with environmental interactions like slipping and falling (Tayyari and Smith, 1997). Heavy MMH activity is associated with the risk of developing MSDs. A study in the aluminium industry of Iran showed that about 66% of respondents in the last week and 78% of respondents in the last year reported suffering from at least one

musculoskeletal issue. The most prevalent body parts involved were the lumbar region, knees, and upper back. These complaints had significant associations with job duration and the age of the workers (Aghilinejad et al., 2012).

MMH is a significant contributor to the expenses of compensable workplace injuries. The current MMH guidelines (Snook and Ciriello, 1991) were developed based on maximum acceptable weights and forces. The experiments were carried out over a 21-year period before the results were published, raising the question of whether these guidelines are relevant for today's workers.

More than 70% of Indians are engaged directly in MMH activities. Therefore, even a slight improvement in working conditions would benefit millions of Indian people (Sen and Nag, 1975). The informal sector is particularly plagued by low back pain, MSDs, and severe injuries related to MMH. The informal sector accounts for about 30% of the Latin American working population and about 70% in some developing countries (Koplan, 1996).

A study of MSD symptom prevalence in the informal or unorganized sectors of West Bengal (Gangopadhyay et al., 2003) assessed 25 male workers from 5 contrasting occupations and found high point prevalence estimates that varied by occupation. Pain, numbness, swelling, and stiffness were significant issues faced by meat cutters, tailors, typists, visual display terminal operators, and weavers. Gangopadhyay et al. (2006), studying informal workers in sand core manufacturing, introduced a combination of work organization and engineering changes that reduced exposure to low back pain and increased productivity by up to 30%.

A random sample of 190 railway porters out of 500 porters at a railway station in Lucknow, Uttar Pradesh, India, was studied and compared with a group of 68 controls with similar socio-economic status (watchmen, 'peons') (Gupta and Ram, 1987). Data on back pain and other socio-economic risk factors were collected through a questionnaire. The prevalence of low back pain in the porters varied by age, from 59% in porters under 25 years old to 76.3% in porters aged 36–45 years, compared to 6.2% and 11.1% in the control group. Age, duration of work, and load carried out were statistically significant risk factors. Shockingly, the average load manually carried per porter per day ranged from 5 to 9 quintals (0.5 to 0.9 metric tons), with an average of 5 to 6 quintals per day. The study recommends ergonomic training, small trolleys, and push carts to replace manual lifting.

While numerous in vitro and in vivo studies are conducted under controlled laboratory conditions using various imaging techniques, few provide insights into the intersegmental lumbar spine behavior during everyday activities. Mörl et al. (2005) measured the intersegmental lumbar spine motions to recognize inter-subject differences during load lifting. Individual differences exist in intersegmental lumbar spine motion both at the participant level and across all lumbar levels. The lumbar spine's motion was also affected by the lifting technique. Lifting with bent knees significantly reduced the lumbar motion ranges in many subjects. They concluded that special instructions are advisable for reducing lumbar spinal

motion. This understanding is vital for reducing spinal loading and preventing spinal disorders in MMH activities.

While most manual lifting in industries is performed on a smooth surface, manual lifting in outdoor environments involves surfaces that could be smoother or even. Studying the lifting biomechanics in these stressed conditions might provide insight into the probable mechanisms of the causes of lifting-related injuries (Jiang et al., 2005).

Findings suggest that lowering may pose a more significant hazard to the lower back than lifting. Research on back pain patients indicated that their overall lifting technique remained similar to that of control subjects; however, the activation patterns of paraspinal muscles differed. Findings suggest that to identify injuries in the lumbar region, extensive biomechanical analysis using EMG may be required (Larivière et al., 2002).

Role of Ergonomics in promoting sustainability

A sustainable workforce is essential as it safeguards employees' long-term health and well-being, enhancing productivity and reducing absenteeism linked to work-related health issues. Through a commitment to occupational health and safety, sustainable workforce strategies also bolster job satisfaction and retention, fostering a stable and motivated workforce crucial for sustained organizational success. Ergonomics can play a significant role in promoting sustainability among MMH workers in the unorganized sectors. Initially, it enables the assessment of MMH activities to identify health issues and their underlying causes. Subsequently, ergonomics facilitates the design of targeted interventions to mitigate these problems. By optimizing work processes, equipment design, and workplace environments to better suit physiological capabilities and minimize strain, ergonomics enhances worker health and safety and contributes to improved productivity and overall sustainability within these sectors.

There are three distinct approaches for assessing manual material handling (MMH) capabilities and establishing recommended workload limits (Sanders and McCormick, 1987):

1. Biomechanical Approach: This perspective considers the body as a system of links and joints. It uses physics principles to analyze the mechanical stresses on the body and the muscle forces required to counteract them.

2. Physiological Approach: This approach focuses on energy consumption and the stresses experienced by the cardiovascular system during manual material handling tasks.

3. Psychophysical Approach: This method evaluates how individuals perceive and respond to different workload conditions, incorporating subjective assessments of comfort and fatigue.

Wang et al. (1998) used the NIOSH lifting guide and studied low back pain and related risk factors. Their findings indicated that the lifting index is a reliable tool for evaluating the potential risk of low-back injury in MMH activities.

Over the past fifty years, various methods have been developed for assessing the risk factors of MSDs. Many of these techniques use only observational methods and are, therefore, easy to

use and apply in different working conditions. These methods assess work postures and indicate overall postural risk severity. Using the findings from these techniques, policymakers or ergonomists can change work conditions, such as machine redesign or workplace layout redesign, to improve overall working conditions. Ovako Working Posture Analysis System (OWAS) (Karhu et al., 1977), Rapid Upper Limb Assessment (RULA) (McAtamney and Corlett, 1993), Quick Exposure Checklist (QEC) (Li and Buckle, 1998), and Rapid Entire Body Assessment (REBA) (Hignett and McAtamney, 2000) are a few of these observational techniques used in the field and industry setup.

Ergonomic Interventions to improve the health of MMH workers

Ergonomic interventions can be applied at different levels. At the activity level, interventions include engineering controls such as redesigned lifts. Interventions can also involve introducing safe lifting practices and using personal protective equipment at the work organization level. There is evidence in the literature that introducing appropriate interventions leads to a reduction in MSDs. Most of the workforce in any developing economy works in the informal sector, and studies on the introduction and efficacy of interventions in these countries are limited (Ketola et al., 2002; Putz-Anderson, 1988; Westlander et al., 1995).

Manual lifting techniques, including the size and shape of the load, have been extensively studied by researchers, and an association between lower back pain and MMH activity has been established. Worldwide, millions of people are affected by low back pain, which impacts their financial as well as mental health. Additionally, some tests use lifting in various settings to assess fitness for return-to-work conditions. Further studies should aim to understand the level of association between the risk factors and the prevalence of low back pain (Cole and Grimshaw, 2003).

Holmström and Ahlborg (2005) studied the effects of warming-up exercises in the morning on the stretchability of muscles, flexibility of joints, muscle strength, and endurance in construction workers. Results indicated a positive effect of morning exercise, with a significant increase in thoracic and lower back mobility and improved flexibility in the hamstring and thigh muscles. In contrast, the subjects in the control group showed a prominent reduction in the endurance of the back muscles. These results suggest that moderate warm-up exercises in the morning can improve joint and muscle flexibility and endurance.

The inclusion of rest allowances reduces the risk of injuries due to MMH. Taking timely rests during MMH activity relaxes muscles, reducing the risk of injury. Studies aimed at determining whether rest allowances could be established using psychophysical methods, as well as examining the effects of gender and handling frequency on work-rest schedules, found that total working time decreased. At the same time, total resting time also declined as handling frequency increased. High-frequency tasks necessitated more frequent rest allowances, and for the same manual handling tasks, women required more frequent and more extended rest periods than men (Genaidy and al-Rayes, 1993).

Movement assist devices are crucial for manual material handling (MMH) jobs, as they significantly reduce the musculoskeletal strain involved in completing tasks. However, studies have shown that these devices primarily minimize the gravitational forces of the task, while their added inertia can increase the dynamic manual requirements. As a result, subjects often exert high push and pull forces when using these devices. Additionally, experimental manipulations have only moderately affected the force levels observed during these tasks (Woldstad and Chaffin, 1994).

Conclusion

The unorganized sector is a dominant workplace in India and other developing countries, characterized by significant occupational health hazards such as Musculoskeletal Disorders (MSDs). Manual Material Handling (MMH) is a primary task within these sectors and is closely linked to developing MSDs. Research suggests that proper intervention helps to reduce many occupational hazards. Some intervention techniques include engineering controls, safer work practices, work organization modifications, training, and personal protective measures. In the organized setup, especially in developed countries, these interventions have been implemented and have proven helpful in preventing occupational health issues in most cases. However, it is hard to implement these interventions in developing countries since most of the workforce works in the informal sector. In conclusion, adopting an ergonomic approach helps improve workers' physical and mental health. These changes bring about sustainability within the organization by improving productivity and efficiency.

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