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Introductory Chapter: Work-Related Musculoskeletal Disorders

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1. Introduction

According to the National Institute for Occupational Safety and Health [1], musculoskeletal disorder (MSD) is a damage that affects the musculoskeletal system of the human body, especially at bones, spinal discs, tendons, joints, ligaments, cartilage, nerves, and blood vessels. Such injuries may result due to repetitive motions, forces, and vibrations on human bodies during executing certain job activities. Previous injuries, physical condition, heredity, pregnancy, lifestyle, and poor diet are the factors that contribute to the musculoskeletal symptoms.

Work-related musculoskeletal symptoms can be observed at workplaces when there is a discrepancy between the physical capacity of the human body and the physical requirements of the task. Musculoskeletal disorders can be related to the work activities and conditions, and they could significantly contribute to the development of MSDs. However, these are not necessarily the only causes or significant risk factors.

The World Health Organization recognizes conditions that result in pain and functional impairment that affect the neck, shoulders, elbows, forearms, wrists, and hands as work related when the work activities and work conditions significantly contribute to the development of work-related disorders (**Figure 1**).

Work-related musculoskeletal disorders (WRMSDs) are described as wide range of degenerative and inflammatory conditions that affect the supporting blood vessels, peripheral nerves, joints, ligaments, tendons, and muscles. Such conditions could result in functional impairment and pain which are widely experienced at the upper extremities and the neck [2].

At the workplace, the causes of musculoskeletal disorders are diverse but poorly understood. Aptel et al. [3] stated that biomechanical factors such as repetitive motion, strenuous efforts, extreme joint postures, and/or psychosocial factors establish the key role in work-related musculoskeletal disorders. In [4], it is provided that certain psychological factors are associated with musculoskeletal discomfort and may eventually provide one way to intervene to reduce MSDs.

This chapter aims to analyze the ergonomics, administration of occupational health and safety, economic impact, prevalence, intervention, and prevention of WRMSDs.

2. Risk factors

Hales and Bernard [5] cited the causes of work-related musculoskeletal symptoms in two categories: physical and psychosocial.

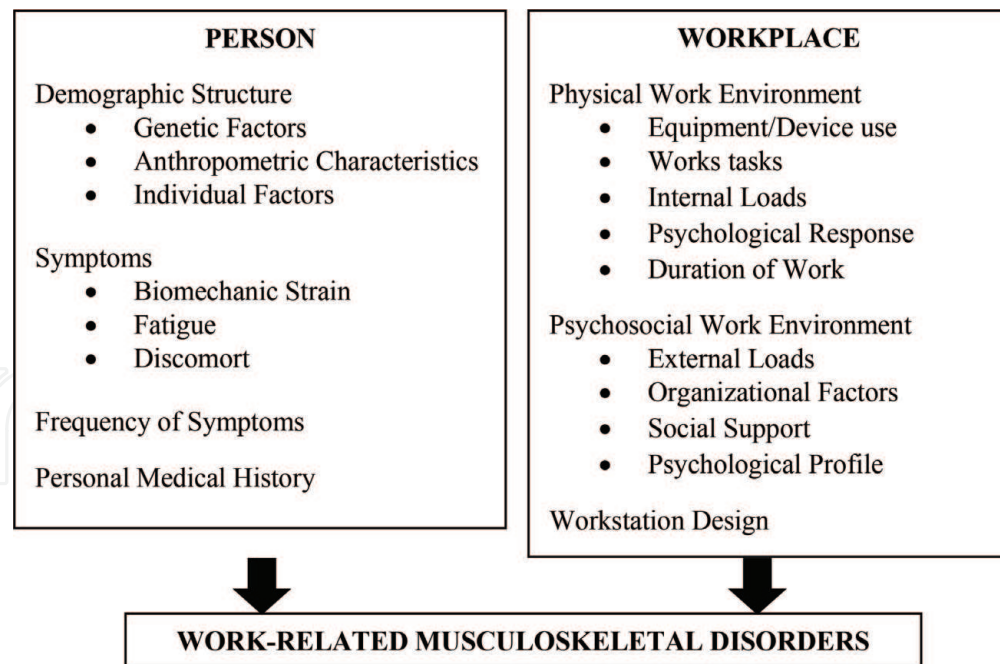


Figure 1.
Factors scheme.

2.1 Physical factors

These include intense, repeated, or sustained exertions; awkward, non-neutral, and extreme postures; rapid work pace; repeated and/or prolonged activity; insufficient time for recovery, vibration, and cold temperatures.

2.1.1 *Inappropriate postures*

The muscles and joints involved in an activity and the amount of stress or force tolerated or generated are determined by the body posture due to the fact that as the back bends, there is more stress exerted on the spinal discs during object lifting, handling, or lowering than when the back is straight. The tasks requiring sustained or repeated twisting or bending of the shoulders, wrists, hips, and the knees also increase the stress on the joints. Therefore, prolonged or frequent work activities can be very stressful.

2.1.2 *Repetitive motions*

Frequently repeated motions (e.g., every few seconds) and prolonged periods could end up in accumulated muscle-tendon strain and fatigue. If the time allocated between the exertions is sufficient, the muscles and tendons can recover from forceful exertions and stretching effects. During inappropriate postures and forceful exertions, the impact of repetitive motions due to performing the same work activities can be increased. Risk factor such as repetitive actions can also depend of the performed specific act and the body area.

2.1.3 *Duration*

The amount of time that someone is continuously exposed to a risk factor is called duration. The job tasks that require the use of the same motions or muscles for long periods increase the probability of general and local fatigue. Generally, if

the period of the continuous work increases (for the tasks require extended muscle contraction), more rest or recovery period is required.

2.1.4 Frequency

Within a given period of time, the number of repeated exertions by a person is defined as frequency. In fact, if the exertion is repeated more often, the speed of movement of the exerted body part increases. Moreover, the recovery period decreases when more frequent exertion is completed, and this increases the probability of general and local fatigue with the duration.

2.2 Psychosocial factors

WRMSDs do not only result in the physical stressors. However, a set of multiple factors determine the formation. Psychosocial risk factors such as stressful job, social pressure at work, and job dissatisfaction are such factors which contribute to the formation of WRMSDs. When an injury occurs, psychosocial factors, such as incongruous pain and depression, are the main reasons for the development of a disability and transition from acute to chronic pain [6].

These include monotonous work, time pressure, a high workload, unorganized work-rest schedules, complexity of tasks, career concerns, lack of peer support, a poor relationship between workers and their supervisors, and poor organizational characteristics (climate, culture, and communications).

The way to structure and manage the work processes are called as organization of work and it deals with the following subjects:

- Work scheduling (work-rest schedules, work hours, and shift work).
- Job design (task complexity, required effort and skill, and the degree of control of work).
- Interpersonal facets of work (relationships with colleagues, subordinates, and supervisors).
- Concerns regarding career (job security and opportunities to grow).
- Style of management (teamwork and participatory management).
- Characteristics of the organization (culture, communication, and climate).

Many of the above components are called as “psychosocial factors,” and they are known as risk factors for psychological strain and job stress. Stress is a conceived emotional and physical reaction of the human body to events or circumstances which cause excitement, danger, confusion, irritation, or frightening. Particularly, it is a transition from someone’s normal behavior according to a cause that results in tear and wear on the body’s mental or physical resources.

There are internal or external stimuli that cause stress. The internal stimuli are those stressors that involve self-expectations, impersonal barriers, and conflicting desires. Apparently, internal stimuli depend on personal aspects. However, external stimuli include situations where expectations, time limit, lack of resources, and lack of vision and goals present.

Stressors may be physiological, psychological, social, environmental, developmental, spiritual, or cultural and represent unmet needs. Stress causes changes in the human body that are usually centered on the nervous system and endocrine system. Therefore, the human body's internal environment is constantly changing, and the body's adaptive mechanisms continually function to adjustments in heart rate, respiratory rate, blood pressure, temperature, fluid and electrolyte balances, hormone secretions, and level of consciousness.

Intensive and extensive stress results in disorders in the musculoskeletal system. Emotions like anger, frustration, irritation, confusion, tension, and nervousness cause the stress. It is not only the experience and frequency of such feelings but also the repetition of the activities and motions that induce injuries or musculoskeletal disorders.

In considering human emotions and feelings and applying the results of the research to their impact on the musculoskeletal system, it is probably platitudinous to make a statement that the greater the knowledge and understanding of the human being, the better the result obtained. In order to identify and understand the effect of the emotions on the musculoskeletal system, important risk factors for musculoskeletal disorders should be recognized.

2.3 Psychological risk factors

Moreover, together with the above conditions, some other work aspects contribute to both physical and psychological stress as well. The human body in fact is limited in kinematic motions as it is a mechanism formed by biological characteristics. Beyond this, it also includes a brain which thinks, reasons, and feels. Thus, feelings such as joy, pain, anger, sadness, depression, frustration, outrage, boredom, fear, jealousy, hate, love, and (even) schizophrenia are experienced by human beings.

When exposed to stress, human beings show responses such as fear, frustration, anger, fatigue, tension, depression, anxiety, helplessness, confusion, and lack of vigor.

3. Common types of occupational MSDs

- i. Tendonitis: it is the most common hand problem, which happens when the tendons connecting the fingers to muscles in the forearms get inflamed. Tendons help attach muscle to bone to allow movement of a joint [7].
- ii. Tenosynovitis: this is another common ailment, where the synovial sheaths (sacks filled with fluid) swell which surround and protect the tendons. Carpal tunnel syndrome (CTS) is the condition which is a result of this swelling. The carpal tunnel is a small opening close to the bottom of the hand which accommodates the tendons and the median nerve that provides sensation to the hand. In the case of swelling of the synovial sheaths, the carpal tunnel cramps and puts pressure on the nerve. There are several syndromes of the CTS, but the most frequent ones are numbness, tingling, or a burning sensation in the palms, fingers, and wrists. These conditions can lead to strength and sensation loss in the hands in time [7].
- iii. Nerve compression: throughout the body, there are several nerves that transmit signals from the body parts to the brain. These often move in the spine through small tunnels available between the vertebrae. There are many conditions which cause the nerves to become compressed, pinched, or

- squeezed, which can result in weakness, numbness, severe pain, and loss of coordination. The condition in which the sciatic nerve in the spine becomes compressed is known as sciatica. The symptoms of this condition appear in the back of the leg and at the side of the foot [7].
- iv. Raynaud's syndrome/disease: this is a loss of blood circulation, which results in whitening and numbness of the fingers. It is sometimes called "white finger," "wax finger," or "dead finger" [7].
 - v. Reflex sympathetic dystrophy: this is a rare, incurable condition characterized by red, swollen hands and loss of muscle control. It is consistently painful [7].
 - vi. Ganglion cyst: this disorder arises when a swelling or lump in the wrist resulting from jelly-like substance leaks from a joint or tendon sheath [7].
 - vii. Cervical radiculopathy: this is the condition of an injury due to the extending out of those nerves that provide sensation and trigger movement from cervical vertebrae which result in weakness, numbness, or pain in the hand, wrist, arm, or shoulder [7].
 - viii. Lateral epicondylitis: this is a condition when the outer part of the elbow becomes painful and tender, usually as a result of a specific strain, overuse, or a direct bang [7].
 - ix. Rheumatoid arthritis: this is a disabling autoimmune disease which is progressive and happens in a long term. It causes pain, swelling, and inflammation in and around the joints and other body organs. Hands and feet are affected mainly, but it can be seen in any joint as well. It usually occurs at the same joints on both sides of the body [7].

4. Economic impact

Musculoskeletal disorders (MSD) are a major concern globally not just due to the pain and disability suffered by the individual worker but also due to its economic impact not just on the employer but also on the society as a whole. In 2013/2014, 8.3 million work days were lost in UK due to musculoskeletal disorders [8]. In the European Union (EU), more than 40 million workers are affected by musculoskeletal disorders that translate to one in seven people [9]. In the USA, musculoskeletal disorders accounted for 29–35% of the occupational injuries in private industries which resulted in absence from work from 1992 to 2010 [10].

Financial costs due to musculoskeletal disorders can be divided into direct costs and indirect costs. Direct costs are the costs mainly comprised of medical expenditures which are used to cure and/or prevent diseases. These include resources such as hospitals, doctors, equipment, etc. Indirect costs are the hidden costs which include costs due to loss of productivity, training, and hiring costs of new employees. These productivity losses occur when either the person is sick and does not show up at work or his productivity is reduced while at work due to sickness. There is also cost due to loss of unpaid work due to sickness when the person is not able to do his household tasks.

In both manufacturing and service sector, productivity loss is one of the biggest and severe problems. Organizations suffer from decreased job productivity

and employee absence which then creates significant economic burden not just for them but for the economy as a whole. Despite significant indirect costs due to musculoskeletal disorders, many economic evaluations done by countries exclude these costs which are greater than the direct costs. Even the countries which do include these costs significantly vary in their methodology from one another due to disagreement over the current methods and the certain flaws in them.

Ignoring or including only some part of these costs in economic evaluations has a twofold effect: firstly, health benefits as a result of a proposed health intervention are underestimated and, secondly, not enough resources are allocated to research in workplace safety and health as a result of under estimation of these costs. In the USA, despite occupational injuries costing society up to \$250 billion, a budget of \$0.3 billion was allocated to the National Institute of Occupational Safety and Health (NIOSH) in 2013 [11]. This compared with budget of \$5 billion for National Cancer Institute which costs society up to \$219 billion.

For businesses to remain competitive, it is important that research of safe workplace practices is promoted and the businesses are given guidance about workplace safety because without a healthy human resource, no entity can grow. This can only happen when these costs are captured in economic evaluations and given their due attention by both the employer and the society as a whole.

4.1 Costs of MSDs

Calculation of costs of MSDs is not straightforward as several factors need to be considered before total costs are computed. The following components need to be estimated to calculate the total costs of MSDs [12].

- i. Direct costs: these are the costs spent on management of musculoskeletal disorders, i.e., medical costs, administrative, compensation, and insurance costs. These costs are visible, and estimation of these is straightforward. These costs are not within the scope of this chapter and thus would not be discussed further.
- ii. Indirect costs: these are hidden costs which include costs for lost productivity both paid and unpaid, lost earnings and tax revenues, lost opportunity costs for careers, and costs of hiring and training new workers. These costs are difficult to estimate, and in the literature, most of the debate is around calculation of these costs. This will be discussed later in detail.
- iii. Intangible costs: this includes psychosocial burden such as job stress, family stress, and economic stress which leads to reduced quality of life [12]. As these costs are very difficult to express in monetary terms, they are rarely considered for cost calculations. But intangible costs give useful information about the quality of life of people with MSDs and help in measuring effectiveness of the interventions. Intangible costs are usually expressed with the help of a measure called quality adjusted life years (QALY). Even though these costs are not the focus of this study, they have been mentioned in the context of explaining methods of measuring indirect costs.

4.2 National data of costs due to MSDs

Coyte et al. [13] estimated that the total cost of musculoskeletal costs in Canada in 1994 was \$25.6 billion (Canadian) which equates to 3.4% GDP of Canada.

Indirect costs were 2.4 times of the direct costs. Lost productivity cost due to disability was \$13.9 billion dollars which is 54.3% of the total cost.

The French Government in a press release part of national Plan on Health & Safety at Work (Plain Sante Travail 2005–2009) highlighted that 75% of all the occupational diseases in 2005 were musculoskeletal disorders [14]. Thirty-one thousand diseases were compensated which lead to loss of 6.5 million work days and 650 million EUR. Indirect costs are not included in this amount.

In the UK, 8.3 million days were lost due to MSDs in 2013/2014, which equates to 15.9 days per case of MSDs [8]. It cost around £4.5 billion in lost productivity to Britain due to work-related illnesses in 2012/2013 [15]. The direct cost of MSD in Korea is estimated as \$4.5 billion, whereas cost due to loss of productivity is \$2.28 billion [16]. The total economic cost was estimated to be \$6.89 billion, which amounts to 0.7% of the GDP.

In the USA, the economic cost of MSDs is estimated between \$45 and 54 billion [17]. These include costs such as compensation costs, lost productivity, and lost wages. In the USA, work-related musculoskeletal disorders (WRMSD) account for 34% lost workdays; direct costs for worker compensations are estimated to be \$20 billion, whereas indirect costs can be five times more than the direct costs [18].

Data which is available in a German national report on safety and health estimated that 95 million days are lost due to MSD which costs €23.9 [14]. Wenig et al. [19] calculated the total costs for back pain for Germany. The study indicated a cost of around 49 billion EUR. Average back pain costs were around 1300 EUR per patient per year. 46% of the total comprised of direct costs and 54% comprised of indirect costs.

Deloitte Access Economics calculated the indirect costs for people with arthritis and other musculoskeletal conditions to be \$11.2 billion in Australia in 2012 [20]. This amount is 55% of the total health cost. Out of this amount, productivity costs accounted for \$7.4 billion, which included costs associated with reduced employment (\$6 billion), lost superannuation, absenteeism, and presenteeism.

In a French study commissioned by the national working conditions agency (ANACT) to estimate cost of MSDs in three companies with more than 500 employees, it was found that indirect costs were 10–30 times higher than direct costs [14]. Total cost was between €6800 and €11,200 per employee.

5. Intervention and prevention

The European Agency for Safety and Health at Work (2008) suggested that it is possible to draw the following conclusions about the different types of interventions based on the randomized and non-randomized comparative studies in the workplace, trials without a comparison group, and laboratory studies:

- Organizational and administrative interventions. Only a few studies were conducted on these type of interventions. In physically demanding works, the evidence is limited to show that the disorders at the neck and shoulder regions can be reduced when there is a reduction in daily work hours (from 7 to 6 hours). Also, it has been shown that without productivity loss, it is possible to introduce extra breaks within repetitive work. However, the methods to be applied prevent the occurrence of MSDs effectively are not clear and yet requires to be studied.
- Technical, engineering, or ergonomic interventions. The workload on the back without any productivity loss can be reduced by applying certain technical measures. Very few evidence is available to illustrate that these measures can

reduce absenteeism due to illness and low back disorders. However, there is strong evidence to show that the load on the shoulders, arms, and hands can be reduced by ergonomic hand tools. Moreover, literature is limited to illustrate the reduction of MSDs due to manual computer tasks or vibration.

- Protective equipment. It is not clear whether the use of back belts helps or hurts the back pain. It could not be achieved scientifically that the use of back belt can prevent back pain during manual material handling. Also, there is no evidence on prevention of upper limb disorders by using other protective equipment.
- Behavioral modification. It is widely discussed in the literature that training on work methods is not adequate if it is used as the sole measure to prevent the back pain. Reduction in the relapses of shoulder-neck pain and back pain by physical training is another issue which yet requires to be studied extensively. Therefore, the training should involve dynamic exercises, which are to be repeated three times a week at least, in order to be effective.

6. Discussion and conclusion

Occupational injuries pose costly health problems (direct cost) and lost productivity (indirect cost) problems in workplaces where people are engaged in intensive, repetitive action and long hours of work. Direct costs occupy only 25% of the total induced cost of WRMSDs. Thus, ergonomic interventions in the workplace should be organized to focus on the reduction of the lost productivity, as it occupies the majority of the costs.

Alone or in a combination, the risk factors that contribute to the formation of WRMSDs can be physical, psychological, or psychosocial. Psychosocial and physical occupational risk factors should be analyzed in detail to understand the effect on the organization. Primarily, the working conditions should be analyzed for awkward postures and repetitive jobs.

WRMSDs may cause pain, slow responses, increased probabilities of accidents, reduced quality of life, and working ability. Therefore, both the individuals and the organizations should accept the fact that they are under a constant risk, and they should get ergonomic training in which they should apply at every step of their lives to be protected from WRMSDs.

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