



# WORKPLACE ERGONOMICS AND MUSCULOSKELETAL HEALTH: PREVENTING AND MANAGING WMSDs

<sup>1</sup>Dr. Amal Chandran, <sup>2</sup>Dr. Remi Elizabeth

<sup>1</sup>PG scholar, <sup>2</sup>Associate professor,

<sup>1</sup>Department of PG studies in Swasthavritta

<sup>1</sup>Alva's Ayurveda Medical College, Moodubidire

**Abstract :** Work-related musculoskeletal disorders (WMSDs) are a leading cause of occupational injuries, absenteeism, and reduced productivity worldwide. These disorders primarily affect muscles, tendons, nerves, and joints due to repetitive movements, prolonged postures, and ergonomic hazards in various work environments. This review explores the epidemiology, risk factors, health consequences, and prevention strategies associated with WMSDs. Research highlights that poor workplace ergonomics, high physical demands, and psychosocial stressors contribute significantly to the development of these disorders. Effective interventions, including ergonomic modifications, exercise programs, and workplace training, have been shown to reduce the prevalence and severity of WMSDs. Additionally, early diagnosis and multidisciplinary management play a crucial role in minimizing long-term disability. Despite advancements in occupational health, WMSDs remain a persistent challenge, necessitating comprehensive workplace policies and continuous monitoring. This review emphasizes the need for collaborative efforts between employers, healthcare professionals, and policymakers to create safer work environments and mitigate the burden of WMSDs.

**Keywords:** Work-related musculoskeletal disorders, ergonomics, occupational health, ergonomic interventions

## I. INTRODUCTION

Work-related musculoskeletal disorders (WMSDs) are among the most common occupational health issues worldwide, affecting millions of workers across various industries<sup>1</sup>. These disorders encompass a wide range of conditions that impact the muscles, tendons, nerves, and joints due to repetitive movements, prolonged static postures, excessive force exertion, and inadequate workplace ergonomics<sup>2</sup>. WMSDs can develop gradually over time due to chronic exposure to occupational risk factors or arise from acute incidents<sup>3</sup>. Common examples include lower back pain, carpal tunnel syndrome, tendonitis, and shoulder impingement syndrome<sup>4</sup>.

The prevalence of WMSDs is particularly high in industries that require repetitive manual tasks, heavy lifting, prolonged standing or sitting, and high levels of physical exertion<sup>5</sup>. Sectors such as manufacturing, construction, healthcare, agriculture, and office-based jobs have reported significant cases of WMSDs<sup>6</sup>. Additionally, psychosocial factors such as high job demands, low job control, and workplace stress contribute to the onset and exacerbation of these disorders<sup>7</sup>.

Beyond the individual health consequences, WMSDs impose a significant economic burden on organizations and healthcare systems<sup>8</sup>. They are a leading cause of absenteeism, reduced work efficiency, early retirement, and increased compensation claims<sup>9</sup>. In response, occupational health and safety regulations emphasize the need for proactive measures to mitigate WMSD risks, including ergonomic workplace designs, training programs, and early intervention strategies<sup>10</sup>.

Despite ongoing research and intervention efforts, WMSDs remain a major challenge in occupational health, requiring multidisciplinary approaches for effective prevention and management<sup>11</sup>. This review aims to provide a comprehensive analysis of WMSDs, exploring their causes, impacts, and evidence-based strategies for prevention and control<sup>12</sup>. By synthesizing current knowledge, this paper seeks to guide employers, policymakers, and healthcare professionals in creating safer work environments and reducing the burden of WMSDs<sup>13</sup>.

**Table No. 1:** Basic details of musculoskeletal system

Musculoskeletal Structure	Description
<b>Muscles</b>	Participating in physical activity enhances muscle strength and functional capacity by inducing changes such as increased muscle volume and heightened metabolic capabilities <sup>14</sup> .
<b>Tendons</b>	Tendons consist of parallel collagen fiber bundles in a gelatinous mucopolysaccharide matrix. Tensile forces cause collagen strands to unfold and straighten, with further loads leading to stretching of these strands <sup>15</sup> .
<b>Bones</b>	Bone, a specialized connective tissue, continuously replaces itself. Its hardness provides mechanical support, while cartilage's elasticity enables joint movement <sup>16</sup> .
<b>Joints</b>	Movable (diarthrodial) joints allow bones to fit together for weight-bearing and range of motion. They are enclosed by a fibrous capsule lined with a synovial membrane that secretes synovial fluid <sup>17</sup> .
<b>Intervertebral Discs</b>	These discs, comprising one-third of the spine, contribute to spinal flexibility and load transmission. Disc degeneration or herniation is a major cause of low-back pain <sup>18</sup> .

## MUSCULOSKELETAL DISORDERS

Musculoskeletal disorders (MSDs) are injuries or disorders of the musculoskeletal system resulting from repeated exposure to various hazards or risk factors in the work place. The musculoskeletal system includes all muscles, bones, tendons, sheaths, ligaments, bursa, blood vessels, joints, intervertebral discs etc. The Social Security Administration

SSA) defines disorders of the musculoskeletal system as conditions that might result from hereditary, congenital, or acquired pathologic processes<sup>19</sup>. Other terms used to describe MSDs include<sup>20</sup>:

- Repetitive strain injury
- Repetitive motion injuries
- Cumulative trauma disorders
- Soft tissue disorders
- Regional musculoskeletal disorders
- Occupational overuse syndrome or strain or sprain

Many common locomotor issues are typically short-lived and resolve either on their own or with simple treatments like analgesics or physical therapies such as physiotherapy or osteopathy. However, despite their transient nature, they constitute a significant portion, around 20%-30%, of the workload for primary care physicians. Musculoskeletal diseases are pervasive globally, although the prevalence of specific conditions may vary<sup>21</sup>.

### Musculoskeletal disorder hazards

Generally classified into three categories: -

- A. Biomechanical hazards
- B. Additional hazards
- C. Individual hazards

#### A. Biomechanical hazards

This is also referred to as the primary risk factors. Biomechanical risk factors are those which place a load upon structures of the musculoskeletal system. There are three biomechanical risk factors; high force, awkward posture and repetition. Any one of those may lead to a musculoskeletal disorder by themselves; however, when two or more hazards are combined together the risk for a musculoskeletal disorder increases substantially<sup>22</sup>.

##### ▪ High force

Greater the force that is required, greater the level of stress placed on the musculoskeletal system. Some activities that can result in forces being applied include lifting, lowering, pushing, pulling, carrying, gripping and pinching. Some of the factors that need to be considered with regards to force are that posture being usual while applying the force, how often the force is applied and the weight of the object being handled and speed of the movement.

##### ▪ Awkward posture

An awkward posture is any fixed or constrained body position that overloads muscles, tendons or joints. In general, the further away a joint gets from a relaxed, or neutral position, the greater the risk for a musculoskeletal disorder. Generally, towards the end of a joints range of motion, muscles become either too short or too long and the ability to generate force is reduced. If muscles are repeatedly placed in these positions or held for prolonged periods of time they begin to fatigue and surrounding tissues become stressed, making them more susceptible to a musculoskeletal disorder.

##### ▪ Repetition

A task is repetitive when similar exertions, actions or movements are done often during a specific period of time. During repetitive tasks, the musculoskeletal system can begin to fatigue, if enough recovery time is not provided. As the musculoskeletal system begins to fatigue, it cannot tolerate as much stress. Even though the amount of force applied may not change during the tasks, a musculoskeletal disorder may occur if the musculoskeletal system is too fatigued to handle the stress.

**B. Additional hazards**

Additional hazards for musculoskeletal disorder include:

- **Vibration**

There are primarily two types of vibration, whole body and segmental. Whole body vibration is typically transmitted through feet or buttocks to the rest of the body. Segmental vibration occurs when a particular segment of the body is exposed to vibration, such as the hands when holding a power tool.

- **Temperature**

Working in either very cold or very hot environments can increase the risk for a musculoskeletal disorder.

- **Contact stress**

Contact stress occurs when a part of the body comes in contact with hard, sharp surfaces or objects. Repeated or prolonged contact could result in inflamed tendons, obstructed blood flow and muscle fatigue.

- **Work methods**

Work needs to be approximately taught, monitored and enforced for the protection of workers as a mean to reduce exposure to hazards. Factors negatively affecting work method can include poor physical and mental status, the lack of proper training in safe operating procedures or safe work practices, poor feedback given to workers etc<sup>23</sup>.

**C. Individual hazards**

Certain attributes about an individual may also lead to a musculoskeletal disorder. These include age, body size, previous injuries, genetic predisposition etc<sup>24</sup>.

**Work-related Musculoskeletal Disorders**

Work-related musculoskeletal disorders are a group of painful disorders of muscles, tendons and nerves. Carpal tunnel syndrome, tendonitis, thoracic outlet syndrome and tension neck syndrome are examples. It should be noted that all the different generic names that are used describe virtually the same problem. It is as if each author had decided to give a different name to the phenomenon<sup>25</sup>.

WMSD are conditions in which:

1. The work environment and performance of work contribute significantly to the condition; and/or
2. The condition is made worse or persists longer due to work conditions

The term musculoskeletal disorders denote health problems with locomotor apparatus ie. Tendons, muscles, skeleton, cartilage, ligaments and nerve which are aggravated by work and the circumstances of its performance<sup>26</sup>.

Regardless of the generic expression used, WMSD are relatively diverse disorders that may affect different structures: tendons, muscles, joints, nerves and the vascular system. Depending on the structure affected and the type of affliction, the ailment would be referred to as tendonitis, tenosynovitis, bursitis, carpal tunnel syndrome etc. It should also be noted that most of these disorders may appear in circumstances unrelated to work, as in the case of certain illnesses or following activities outside of work<sup>27</sup>. Since the focus is on prevention at the workplace, the appearances of WMSD in situations caused primarily by work are dealt here.

**Characteristics of WMSD**

Work-related musculoskeletal disorders (WMSDs) can manifest in various ways, and their onset and progression remain poorly understood. Numerous theories, both complementary and contradictory, have been proposed to explain this phenomenon, indicating that it remains incompletely understood. However, despite the diversity of afflictions and mechanisms involved, WMSDs exhibit several common characteristics.

- **Resulting from overuse**

While the precise mechanisms of onset remain uncertain, there is a general consensus that work-related musculoskeletal disorders (WMSDs) arise from overuse, surpassing the body's capacity for recovery. These injuries occur when a structure is subjected to repetitive abuse, enduring a workload that exceeds its tolerance threshold, leading to adverse consequences.

- **Gradual development**

Work-related musculoskeletal disorders (WMSDs) typically develop gradually over time, evolving through repeated overuse and inadequate recovery periods. This process may begin subtly, without noticeable symptoms, only to manifest suddenly and progress rapidly. Alternatively, individuals may experience mild discomfort initially, which gradually worsens until it necessitates work cessation. While some WMSDs may develop within a few days, they more commonly extend over weeks, months, or even years.

The gradual onset of WMSDs can present a challenge because the lack of early warning signs means individuals are not prepared to address symptoms that emerge gradually<sup>28</sup>.

- **Multiple causes result in WMSD**

The genesis of work-related musculoskeletal disorders (WMSDs) typically originates from overuse, although this overload usually results from a combination of factors rather than a singular cause. Whether it's repetitive movements, poor posture, or excessive exertion, no single risk factor is inherently decisive. For instance, an arduous task performed in an

unfavorable posture can lead to musculoskeletal issues, even with minimal repetition. Conversely, a less strenuous activity executed in a relatively proper posture can still cause harm if repeated extensively throughout the day<sup>29</sup>.

### Early indicators of WMSD

Once a work-related musculoskeletal disorder (WMSD) becomes fully evident, it's often too late to intervene effectively. By this stage, the individual's health has already been compromised, and there may be lasting consequences. Therefore, it's crucial to take action early, before the situation becomes critical.

In many cases, when a specific body area is overused, the worker will experience signs of localized fatigue or discomfort well before serious consequences arise. Persistent discomfort that does not resolve over time and tends to worsen should be particularly concerning. This persistent discomfort may signify an early warning sign of a condition that could progress into a WMSD if not addressed promptly.

### Risk factors of WMSD

The causes of work-related musculoskeletal disorders (WMSDs) constitute a complex interplay of multiple factors that exert simultaneous influence. Therefore, isolating individual causes for separate description proves challenging. A risk factor in the workplace is a condition whose presence has been linked to the onset of a health problem. It may directly contribute to the development of a health issue, act as a trigger, or create conditions conducive to the problem's appearance.

It's crucial to recognize that the severity of the health problem hinges on the severity of the risk factors present. Simply identifying the presence of a risk factor isn't sufficient for evaluating risk; it's a matter of degree. Generally, the severity of a risk factor is influenced by three main factors: intensity, frequency, and duration<sup>30</sup>.

#### Intensity:

The significance of intensity in a risk factor is often self-evident: the greater the intensity (such as increased effort or extreme posture), the higher the associated risk.

#### Frequency:

Frequency pertains to how often the risk factor occurs within a specific time frame. Generally, the risk tends to escalate with increased frequency.

#### Duration:

Duration refers to the length of time spent in a particular posture during a work cycle or the duration of exertion within that cycle. It can also encompass the number of hours exposed to a specific risk during a work shift. On a broader scale, duration may encompass the number of years a worker has been exposed to a risk throughout their professional life. In all three scenarios, a fundamental principle usually emerges: the risk is directly proportional to the duration of exposure.

### Prevention of Work-Related Musculoskeletal Disorders (WMSDs)

Preventing work-related musculoskeletal disorders (WMSDs) requires a multifaceted approach that integrates ergonomic interventions, workplace policies, employee education, and health promotion strategies<sup>31</sup>. Effective prevention not only reduces the incidence of WMSDs but also enhances worker productivity, job satisfaction, and overall well-being<sup>32</sup>.

#### 1. Ergonomic Workplace Design

One of the most effective strategies for preventing WMSDs is implementing ergonomic workplace modifications. Adjusting workstations, tools, and equipment to match the physical capabilities of employees reduces strain on the musculoskeletal system<sup>33</sup>. Proper desk height, adjustable chairs, and anti-fatigue mats are essential for minimizing stress on the spine, joints, and muscles<sup>16</sup>. Employers should also ensure that repetitive tasks are designed with adequate movement variation to prevent overuse injuries<sup>34</sup>.

#### 2. Proper Posture and Body Mechanics

Maintaining correct posture while working is crucial in preventing musculoskeletal strain. Employees should be trained to sit with their backs supported, feet flat on the ground, and shoulders relaxed<sup>35</sup>. For manual laborers, lifting techniques such as bending the knees and keeping loads close to the body can prevent lower back injuries<sup>36</sup>. Employers should provide guidelines on body mechanics and regularly assess posture-related risks<sup>37</sup>.

#### 3. Task Rotation and Work Breaks

Repetitive movements and prolonged static postures significantly contribute to WMSDs. Task rotation, which involves alternating job roles, helps reduce muscle fatigue by engaging different muscle groups<sup>38</sup>. Additionally, micro-breaks and stretching exercises throughout the workday can alleviate muscle tension and improve circulation<sup>39</sup>. Implementing a structured break schedule ensures that employees do not remain in the same position for extended periods<sup>40</sup>.

#### 4. Use of Assistive Devices and Tools

Ergonomic assistive devices, such as lifting aids, wrist supports, and exoskeletons, can reduce physical strain in high-risk occupations<sup>41</sup>. In offices, ergonomic keyboards, adjustable monitors, and wrist rests can help prevent conditions like carpal tunnel syndrome<sup>42</sup>. In industrial settings, using mechanical hoists and automated handling systems can minimize the risk of musculoskeletal injuries<sup>43</sup>.

## 5. Employee Training and Awareness Programs

Educating employees on WMSD prevention is vital for long-term workplace safety. Regular training sessions on ergonomics, proper posture, and workplace safety protocols can empower workers to take proactive measures against musculoskeletal strain<sup>44</sup>. Employers should integrate WMSD awareness programs into their occupational health policies and encourage open discussions about early symptoms<sup>45</sup>.

## 6. Workplace Wellness Programs

Workplace wellness programs that promote physical activity, stretching routines, and stress management can help reduce the risk of WMSDs<sup>46</sup>. Exercises focusing on core strength, flexibility, and joint mobility improve musculoskeletal resilience<sup>30</sup>. Encouraging employees to engage in physical fitness activities outside of work can further enhance overall musculoskeletal health<sup>47</sup>.

## 7. Early Detection and Intervention

Early identification of WMSD symptoms is crucial for preventing chronic conditions. Employers should establish routine health screenings, ergonomic assessments, and musculoskeletal check-ups<sup>48</sup>. Prompt medical evaluation and intervention can prevent minor discomfort from escalating into severe musculoskeletal disorders<sup>49</sup>.

## Discussion

Work-related musculoskeletal disorders (WMSDs) continue to be a significant occupational health concern globally, affecting workers across various industries. The role of workplace ergonomics in both preventing and managing WMSDs has been widely recognized, with research supporting its effectiveness in reducing the physical strain associated with repetitive tasks, awkward postures, and prolonged static positions<sup>50</sup>. Ergonomic interventions, when implemented properly, have the potential to enhance worker comfort, productivity, and overall well-being<sup>51</sup>.

- *The Importance of Ergonomics in WMSD Prevention*

Ergonomics plays a crucial role in minimizing workplace risk factors for WMSDs by adapting the work environment to the physical needs of employees. This includes optimizing workstation layout, adjusting desk and chair heights, and ensuring proper tool design to reduce strain<sup>52</sup>. Studies have shown that poor ergonomics contributes to chronic musculoskeletal discomfort, particularly in office-based jobs where employees spend prolonged hours in static postures<sup>53</sup>. Similarly, in manufacturing and construction, where heavy lifting and repetitive motions are common, improper body mechanics significantly increase the risk of back injuries, shoulder disorders, and repetitive strain injuries<sup>54</sup>.

Implementing ergonomic solutions, such as adjustable seating, sit-stand workstations, and anti-fatigue mats, has been linked to a reduction in musculoskeletal symptoms<sup>55</sup>. Moreover, ergonomic training programs that educate employees on proper lifting techniques, posture correction, and workstation adjustments have proven to be effective in lowering the incidence of WMSDs<sup>56</sup>.

- *Management Strategies for WMSDs in the Workplace*

Despite preventive measures, WMSDs still occur, necessitating effective management strategies. Early intervention is critical in preventing acute musculoskeletal discomfort from developing into chronic conditions<sup>57</sup>. Workplace programs that incorporate physiotherapy, strength training, and flexibility exercises have been shown to aid in WMSD recovery and minimize work-related disability<sup>58</sup>.

Employers should encourage a proactive approach by conducting routine ergonomic assessments and musculoskeletal health screenings to identify risk factors early<sup>59</sup>. Additionally, allowing employees to report discomfort without fear of stigma can lead to timely interventions and reduced absenteeism<sup>60</sup>.

Workplace policies should also include gradual return-to-work programs for employees recovering from WMSDs. These programs allow injured workers to gradually resume tasks with modified duties until they fully regain their functional capacity<sup>61</sup>. Research suggests that such initiatives contribute to faster recovery and lower rates of reinjury<sup>62</sup>.

- *The Role of Technology in WMSD Prevention and Management*

Advancements in technology have introduced wearable ergonomic devices, AI-driven posture monitoring systems, and automated lifting aids that assist workers in maintaining correct body mechanics<sup>63</sup>. These tools provide real-time feedback on

posture and movement, helping employees adopt safer work practices<sup>27</sup>. Additionally, virtual reality (VR)-based ergonomic training programs have emerged as an innovative way to educate workers on proper lifting and workstation setup<sup>64</sup>.

- *Challenges in Implementing Ergonomic Practices*

While ergonomic interventions have been proven effective, several challenges hinder their widespread adoption. Cost constraints, particularly in small and medium-sized enterprises (SMEs), often limit access to ergonomic furniture, assistive devices, and comprehensive training programs<sup>65</sup>. Additionally, lack of awareness and resistance to change among employees and employers can impact the successful implementation of ergonomic solutions<sup>30</sup>. Overcoming these challenges requires policy-driven workplace reforms, emphasizing the long-term benefits of ergonomics in reducing absenteeism, improving productivity, and lowering healthcare costs<sup>66</sup>.

## Conclusion

Workplace ergonomics plays a vital role in preventing and managing work-related musculoskeletal disorders (WMSDs). By implementing ergonomic interventions, proper workstation design, employee training, and assistive technologies, organizations can significantly reduce musculoskeletal strain and enhance worker well-being. Early detection and proactive management strategies help prevent acute discomfort from developing into chronic conditions, reducing absenteeism and improving productivity. While challenges such as cost and resistance to change exist, investing in ergonomic solutions ultimately leads to long-term benefits for both employees and employers. A sustained commitment to ergonomic principles is essential for fostering a healthier, safer, and more efficient work environment.

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