European Journal of Physical Education and Sport Science
ISSN: 2501 - 1235
ISSN-L: 2501 - 1235
Available on-line at: www.oapub.org/edu

DOI: 10.46827/ejpe.v6i9.3493 Volume 6 | Issue 9 | 2020

# MINIMIZING THE ADVERSE EFFECTS OF WORK ENVIRONMENT IN UPPER LIMB: A LITERATURE REVIEW

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**Abstract:**
**Introduction:** Occupational problems are highly prevalent and act as impediments to effective labor. As per the statistics by WHO, in the year 2003, it was seen that back injuries shared the highest proportion in occupational disorders (60%), followed by neck and upper limb. **Body:** In the upper limb, any joint, be it the shoulder, elbow, wrist or hand, can be affected. Variable structures ranging from the tendon, ligament, nerve or muscle can be involved leading to problems effectuating in the form of pain, tenderness, swelling, and functional deficits. Common problems seen are carpal tunnel syndrome, muscle sprain-strain, and osteoarthritis in joints, etc. **Management:** ULMSDS can be prevented by incorporating activity in daily life awhile also keeping a check on posture. At workplace, architectural adjustments and changes in physical and social environment can help prevention exacerbation of upper limb conditions. Regular rest intervals can also be included to avoid prolonged fixation of joints in one position. **Conclusion:** This paper

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focuses on ULMSDS in an attempt to improve the quality of life through various intervention strategies within the work organization thus enhancing work quality and output of the companies.

**Keywords:** workplace problems; upper limb; functional deficit

## 1. Introduction

The term musculoskeletal disorder, as per WHO, denotes "*…health problems of the locomotor apparatus, i.e. Of muscles, tendons, the skeleton, cartilage, ligaments and nerves*." They include all forms of ill-health ranging from light, transitory disorders to irreversible, disabling injuries. [1]

The concern regarding the relation between work and disorders of the musculoskeletal system dates back to the early 18th century.

Bernandino Ramazzini, an Italian physician, in 1713 [2], was the first one to report an association between work and musculoskeletal disorders. He recorded that pain in the upper limb was related to "*…constant sitting, the perpetual motion of the hand in the same manner, and the attention and application of the mind*." [2, 3, 4]

Work-related musculoskeletal disorders (WRMSDS), in general terms, are disorders that are caused or aggravated by work. [1] They are highly prevalent and affect the human body adversely.

Innumerable factors at the workplace are causative of WRMSDS. The major ones reported are:

- Prolonged repetitive work/monotonous work [1, 5, 6,7, 9, 10, 14, 16, 17, 18, 20, 21, 27, 28, 46, 47, 53, 54, 58, 69]
- Awkward working postures [1, 5, 6,7, 10, 12, 14, 15, 16, 17, 18, 19, 20, 21, 29, 30, 31, 32, 34, 35, 51, 52, 53, 54, 58, 69]
- Sustained/excessive force and heavy-object handling (lifting, pushing-pulling) [1, 6,7, 9, 10, 14, 21, 27, 34, 35, 58]
- Frequent and repeated manipulation of objects [1]
- Continuous work without rest breaks [1, 7, 14, 21]
- Working with hand-held power tools, like vibrators, at a stretch [1, 6,7, 8, 9, 10, 11, 20, 26, 27, 34, 35, 45, 58]
- Poor work environment (temperature, lighting) [1, 6,7, 34, 35, 36, 37, 38, 39, 40, 42, 43, 44, 45, 50, 51]
- Poor work organization (work load, job demands) [7, 50, 51, 58]
- Individual factors [5, 7, 15, 23]
- Psychosocial factors [1, 5,7, 15, 22, 23, 27, 33, 34, 35, 50, 51, 55, 58]

Refer Table 1 for common factors causing and exaggerating WRULMSDS.

Peter W. Buckle and J. Jason Devereux noted that there existed no significant relation between duration of exposure and the occurrence of upper limb disorders. [9, 15]

As a trend it has been noticed that females [20, 25, 48, 49, 71, 72] and older people [24, 69] are affected more as compared to males and the younger population.

The higher affection in females is seen due to the exposure to higher stresses. Hormonal changes common during menopause are also thought to be provocative. [20, 231]

The difference in the average dimensions of female hands when compared to those of males was also seen to play an important role though the physiology is yet not clear. [20, 25]

## 2. Prevalence

Exhaustive amounts of studies have been performed around the globe in an attempt to understand the relation between work and upper limb musculoskeletal disorders (ULMSDS) resulting in extensive yet highly variable data. Data extracted from some major studies, both from India and from around the world, has been presented below.

As per the data from Australian studies nearly 20% of the general community complains of upper limb pain (most commonly shoulder) in any 1 month period. [58, 59] In a particular study focusing on occupation-related disorders, from a total of 12 million Australians who worked during a 12 month period prior to 2009, 5-3% experienced at least one work related injury or illness. [9]

In 1999, 67% of work-related disorders in Sweden were noted to be MSDS. [34, 63] A study focusing on female workers in the electronics industry particularly showed that the occurrence of back pain was maximal (91%), followed by neck (80%), then wrist (45%), and lastly shoulder (20%). [10, 65]

In a similar attempt, data collected from surveys across the European member states in 2002 used the self-report method to prove the fact that upper limb disorders were more prevalent as compared to neck and lower limb disorders.

Participants from three states were included in the study. From amongst the three, 30% and 40% workers reported neck and upper limb disorders in Netherlands and Belgium, respectively. [15]

A survey on the working conditions within the European Union estimated that 17% of workers across the 15 member states of the European Union experience muscular pains in the arms or legs believed to be caused by work. [15, 251]

Luime et al found 19% 12 month incidence for neck MSD and 14.8% for shoulder. [48, 66] In Denmark, MSDS accounted for 39% of all occupational illnesses in as reported by Punnett L. And Gold J (2004). [34, 64]

The occupational disease register in Finland in the year of 1981 recorded as many as 1396 cases of MSDS with work stress being the causative factor. [56, 57]

In a National household survey across Great Britain in 1995, it was estimated that approximately 506,000 people had experienced work-related musculoskeletal disorders (affecting the neck or upper limbs) in the previous 12 months that were caused or made worse by work. [15, 250]

As per reports by Cordell Health, UK, 1.4 million working people suffer from a work-related illness. [60]

A corresponding study in the USA showed that MSDS were the most common problem suffered by the workers in private industries with 34% of all cases. [34, 62]

In France, 50% prevalence in cervical spine, 39.8% in shoulders, and 16.5% in elbows was seen in 1119 female employees. [48, 68] 47% neck and 37% shoulder MSDS were seen in a 12 month period in a Greek hospital nursing staff. [48, 67]

From a study performed in Italy in 2007, it was estimated that ULWRMSDS were 41.6% of all work-related pathologies. [5]

In a study carried out by WHO, in the year 2003, it was seen that back injuries shared the highest proportion in occupational disorders (60%), followed by neck and upper limb, and then knee and hip. [1]

A cross-sectional study conducted in various clinical departments in a tertiary care hospital in Chennai, India, from January to June 2013 showed that about half (50.7%) of the participants had symptoms at least in one part of their bodies for over 12 months with around 26.4% relating to work. Among all the symptoms, low back pain was the highest (45.7%), followed by neck pain (28.5%) and shoulder pain (23.5%), whereas hip/thigh pain (7.1%) and elbow pain (5%) was the least reported. Irrespective of regions, body pain during last 12 months was complained by 56% of nurses 55% of physiotherapists, 54% of dentists, 39% of lab technicians and 38% of physicians. [72]

A study regarding awareness of ergonomic guidelines in laparoscopic surgeries among the surgeons of various fields in three medical colleges at Ahmedabad, India was conducted. 66% surgeons reported arm and shoulder pain while 32% reported neck pain during or after surgery. The regional prevalence of WRMSD in this population was as follows: 49.3% participants reported low back as site of pain, 26.6% participants reported neck as site of pain, 22.6% participants reported knee as site of pain, 14.6% participants reported shoulder as site of pain, 25.3% participants reported wrist and hand as site of pain and 14.6% participants reported elbow as site of pain. [73, 74]

A survey done in Nigeria reported that the prevalence of upper extremity musculoskeletal disorders was found to be, neck (66.8%) and shoulder (60.1%), followed by hand (32.6%), upper arm (32.0%), lower arm (31.5%), wrist (28.1%), and elbow (22.5%), among computer users in a bank. [31, 61]

The above classification of WRMSDS based on region of pain is broad and gives an idea of its prevalence in each part. A more specific, condition-based classification helps to outline the prevalence of each condition. There are many conditions specific to a joint but some are more common than the others.

In shoulder, shoulder tendonitis [26, 45, 98] and rotator cuff syndrome [24, 26, 84, 87, 88] are fairly common.

In elbow, epicondylitis [24, 84, 87, 88, 97] ,both medial [26] and lateral [26, 45] are commonly seen to persist.

Forearm tendonitis [45] is seen as fairly common while in wrist and hand carpel tunnel syndrome [7, 24, 26, 45, 47, 75, 76, 84, 88, 87, 94, 97, 139, 140, 141, 142, 143, 144, 145, 146, 147,151, 153, 154, 158, 162, 163, 164, 166, 172] is the highest in proportion.

Some common work-related disorders with their causes and symptoms are enlisted in the Table 1.

To nullify the negative effects of work on the body, the concept of ergonomics was introduced.

Ergonomics is derived from the Greek words, *ergo*-work and *nomos*-law, to denote the 'science of work'. [51]

Ergonomics, in terms of WHO, works "*…to create an appropriate balance between the requirements of the work and the capacity of the working person, by either adapting the work to the person by design of the respective work, or by developing the capacity of the humans to the work by training and vocational adjustment*." [1]

Its overall aim is to reduce stress and eliminate injuries. [6]

This paper is a review and focuses on the common WRULMSDS, their incidence and ergonomic management. The management involves the modification of work furniture and the overall environment to avoid unnecessary stress on musculoskeletal structures thus preventing upper limb disorders.

## 3. Methodology

The measurement of occupation based musculoskeletal disorders (MSDS) is an important aspect of management of MSDS. A variety of scales for both risk assessment and symptom assessment are available.

Rapid Upper Limb Assessment (RULA) [10, 12, 31, 46, 51, 71, 210, 241, 252] and Rapid Entire Body Assessment (REBA) [46, 51] are the tools most commonly used. They evaluate work stress by analysing the working posture. While RULA is confined to upper limb assessment, REBA accounts for the whole body.

Severity and Functional Scale (SFS) [24] , Assessment of Repetitive Tasks of Upper Limb (ART) [7] , and Manual Handling Assessment (MAC) [7] charts are some other tools used for risk assessment.

Ovaka Working Posture Analysing System (OWAS), a similar tool, measures movements of body segments about various joints for estimation of risk based on joint position and force. [5, 253]

NIOSH Lifting Index with the same motive helps evaluate risks related to manual handling of load during lifting tasks. [5, 206]

The Modified Nordic Questionnaire [10, 73] and Nordic Musculoskeletal Questionnaire (NMQ) [14, 34, 53,72] are used to assess musculoskeletal symptoms like pain. Numerical Rating Scale (NRS) [73, 246] is also used for the same.

Work-related Upper Extremity and Low Back Musculoskeletal Disorders [31] is another questionnaire with 52 items that collects information on personal characteristics, working condition, and musculoskeletal pain.

General symptom examination can also be done through interview method. [8, 9, 26]

Assessment for psychosocial factors, an important causative factor of MSDS, is done using the Subjective Workload Index (SWI). [14]

Siegrist questionnaire is a measure comprising of 3 scales, 2 for extrinsic components (effort and reward) and 1 for intrinsic components (over commitment). [48]

Standardized clinical assessments for measuring posture, muscle stiffness, AROM, nerve entrapment, and muscle strength for neck MSDS are also commonly used. Some assessment scales are:

- Neck Disability Index (NDI), for measuring pain intensity [246]
- Cranio-vertebral angle, for assessing working posture [31]

Advancements have been made in the field of assessing working posture accurately.

A novel wired system to assess muscular effort (using EMG) and posture (using inertial units) of upper limbs has been devised. It overcomes the main problem of traditional methods which is the lack of objective assessment. [5]

Measurement and evaluation of physical load at the workplace through designated steps also seems to provide vital and detailed information. [55]

**4. Posture**

The erect bipedal stance is achieved when COM lies within the BOS and LOG passes through the joint axis. To maintain a static posture while sitting, standing and lying, the forces exerted externally and internally on body should be in equilibrium. Both structural and functional units of joints of axial and appendicular skeleton work together to maintain the correct alignment. Hence our body structures such as joint capsule, surrounding muscles and ligaments, inter vertebral discs are at minimal tension while performing a task in static posture further reducing the risk of injuries. [155]

Any slight deviation from static posture leads to increase amount of stress on these structures. If faulty postures are habitual and assumed continually on a daily basis, the body will not recognize these faulty postures as abnormal, and over time, structural adaptations such as ligamentous and muscle shortening or lengthening will occur. Especially muscles, ligaments, and tendons are more vulnerable to the effects of repetitive tensile forces, whereas nerve, bones and cartilage are susceptible to injury from the application of excessive compressive forces. This can aggravate due to improper seat interface pressure, increased contact forces or shifting of LOG from joint axis. Maintaining faulty posture (like maintaining extended wrist while working on computer or household activities, forward head postures [31,73, 138], awkward twisting-bending [6,10,12,27, 48,129,187,188,210,217,218,288-291], heavy weightlifting [6,9,10,26,27, 48 ,51,102,108,110,111,183,185,204,205,206,210] , using tools while doing sitting-standing task, etc.) For long duration require high level of muscle activity that are large enough to cause work related disorders. [155]

**5. Occupation**

According to WHO, "*An 'occupational disease' is any disease contracted primarily as a result of an exposure to risk factors arising from work activity*." Estimates carried out for work-related disorders show that these are primarily caused due to maintenance of sustained awkward postures for a prolonged period of time while performing a task. Some occupations which are suspected for work limb disorders from our review are computer users [24,31,116,117,118,135,136] , meat/poultry industry workers [47,156,162,167,171,229,232, 233] , automobile manufacturing workers [26,119,120] , workers in the electricity industry [8] , aluminum manufacturing workers [9, 105, 106, 107, 108, 121,122] , cashiers [47,172,174,175,176] , agricultural workers

[46,49,196,197,198 ,200] , nurses [48,66,67,111,180,181,190,194] , dentists [47,161,169] , nursing assistants [48,180,181, 183] , hospital cleaning staff [48,180,181] , print circuit assembly workers [51,208] , industrial workers [51,209] , professional care-workers [48] , auxiliary staff [48,111] , workers with prolonged sitting hours [47, 173] , workers in the painting departments [9] , construction workers [123] , goldsmiths [10, 129,12,241, 288-291] , people at the post of Secretaries [31] , individuals working in cold environments [34] , physicians [48] , hospital workers [2] , workers in the mining industry [13, 242, 243] ,etc.

Some common occupations where ULMSDS are seen are enlisted in the Table 1.

## 6. Management

The evidence provided through research about how the involvement of ergonomic changes have proven to be a boon for the working industry has shown a marked decrease in work absence due to musculoskeletal diseases (MSD). This also implodes the value of ergonomics in today's advancing generation.

It's always better to manage the problem ergonomically before taking it into a rehabilitation program to yield better results. [23, 165, 221, 256, 257, 258, 259, 268, 269, 270] A multi-directional and integrated approach for various biomechanical and psychosocial aspects can be used to manage work-related upper limb disorders (WRULD). [261, 262, 263, 264, 265] The basic course of routine is based on self-management of MSDS by maintaining an active lifestyle and engaging in various workplace activities according to the subject's pain levels and their engagement in the activity. [266, 267] The workers must be encouraged to report any pain or injury that is causing them and the workplace work loss and that might lead to a disability. [223] WRULDS are already one of the major challenges our corporate industry is facing as it has been attributed to the loss of up to 40% to their economic growth. [246] There has been constant questioning about how to improve the workplace and tailor it to the employees' needs at a modest cost to accommodate both their physical and psychosocial requirements.

Many workplaces have already started the race to beat these work-related musculoskeletal disorders. By educating the employer, and employee. This has resulted in better efficacy and lowered down the cases of MSDS. [24, 167, 223, 270, 277, 278, 279] Policymakers and the media should understand and play a pivotal role in educating the population about the importance of ergonomics. [284] It's still unclear whether all the workplaces have been benefited from these ergonomical changes or not. [223, 281, 282, 283]

Many researchers have separated the subjects in the test group with just ergonomic changes and intervention groups with the improvisation of routine with a combination of ergonomic changes and isometric exercises. The results were found to be in favor of the intervention group but at a low rate. [271]

Incorporation of various modified devices during the ongoing process of testing and observation eased the musculoskeletal symptoms of pain which was the most prominent and common. [109, 195, 260, 272, 289]

Various modifications at the workspace level were used to combat and aid the negligence level that was leading to work-related musculoskeletal disorders. [10, 24, 70, 103, 261, 262, 263, 267, 290]

Teaching the workers how to maintain posture and avoid any biomechanical compensation during work has been a major help to prevent overuse injuries and ease any further deterioration of the existing situation. [129, 223, 245, 271, 280, 285,288, 289, 290, 291]

Biomechanical exposure of workload to the subjects and how to combat the compensatory notions helped in the better prognosis of the existing condition.

A collaborative approach with active symptom surveillance, assessment and education provided with faster recovery than no-load rest phase. [278]

Interventions due to ergonomic changes in equipment with proper devices for replacement of undue vibrations, anti-fatigue mats [73] and workstation modifications resulted in lesser break time and better results. [201, 271]

Many workplaces from primary level to tertiary level have been involved in building up workstations compatible with the worker's ergonomic fitness and requirements .[1, 26, 114, 165, 201, 265, 285, 281] From basic computer table and mouse, to chairs and other well-equipped spaces, scale back the musculoskeletal load and reduce biomechanical compensations. The subjects are educated and promoted to follow an active lifestyle with:

1. Rest intervals in between work [1, 165, 245, 265]
2. Neck, shoulder, upper back seated exercises to stretch the shortened muscles and relax the lengthened muscles [41, 44, 46, 221, 265, 271, 281]
3. Use of alternate machinery to help with excessive vibratory movements [1, 41, 46, 245, 271, 280]
4. Maintaining proper posture for avoiding any injury (static) to muscles [1, 46, 114, 165, 265, 280]
5. Reducing psychosocial burden [1, 41]
6. Reducing the workload [1, 41, 109, 114, 265, 280]
7. Maintaining speed, intensity and frequency of the work being done [1, 245, 265]
8. Occupational health check up to avoid any disability along with workplace analysis [221, 165]
9. Lifestyle changes [46]
10. Avoiding extremes of temperature [165]
11. Miscellaneous therapy use – physiotherapy/acupuncture/occupational therapy [265]

Ergonomic risk factors and hazards have been recently undertaken well and researched upon diverse workplaces to improve and promote strong safety culture, employee morale and retention.

This has been done with evaluation and implementation of ergonomic changes at the individual level with recommendations to overcome discomfort and further musculoskeletal disorder risk [298]

The following are some suggestions to decelerate the risk rate:

1. Working in neutral position with proper alignment of neck and wrist; maintenance of the natural body curves to avoid straining pains. [72, 294, 296, 299]
2. Reducing excessive forces and motions by minimizing the workload with the aid of power tools [299]
3. Maintaining a proper height for the workspace table , chair, machinery ,etc. [299]
4. Minimizing pressure points, static load and fatigue which result in overuse injuries [6, 299, 295]
5. Avoiding overstressing of muscles which results in vasoconstriction around the area and thus triggers pain receptors (muscle overload also results in fibrosis of the nearby tissue for better force distribution and spasm formation). [ 292, 293, 299, 295]
6. Stretching on the chair, 20-20 rule for relaxation of straining eyes, taking intervals to relax and avoid typing with wrists at different angles. [182, 299]
7. There are a variety of ergonomic products available in the market, including keyboards, wrist rests, mouse pads, chairs, adjustable desks. [182, 299]
8. For computer users, light clicking on keyboard and mouse keys instead of pounding, screen at straight eye level, and avoiding too much brightness and glare. [299]
9. S-shaped back to support the spine, armrests to support elbow and wrist placing, and chairs with footrests help correct static posture alignment (although long-sitting hours have proven to be a cause of various fatal health risks; modern ergonomic promotes the idea of an uncomfortable chair to promote activity among the workers). [155,299]
10. Workers should be evaluated anthropometrically and educated about the correct posture for the job activity tailored to their comfort for better work experience. [182, 299]

The economic resistance, functionalism and aesthetically pleasing furniture is still an imploding change that we are trying to bring to improve workers' health and safety. [182, 297]

## 7. Conclusion

Workplace stress, both physical and mental, presents as one of the prevailing factors for upper limb musculoskeletal disorders. Although these disorders have been assessed with different measurement methods, there is no specific method to assess the same. Early prevention of various ULMSDS has proven to reduce the incidence of work-related injuries thus reducing the compensation costs. Future studies assessing workplace disorders for better understanding and planning, and for designing an effective rehabilitation program would be of extreme importance.

**Table 1:** Common upper limb problem with their causes and symptoms

| Joint | Conditions | Causes | Symptoms |
|---|---|---|---|
| **Neck** | Neck pain [11, 12, 31, 44, 48, 53, 72, 73, 111, 137, 187, 190, 223] | Uncomfortable or awkward working postures (prolonged) [6, 7, 9, 10, 12, 28, 31, 32, 45, 47, 48, 51, 52, 71, 73, 102, 108, 113, 114, 115, 132, 158, 161, 162, 167, 169, 174, 175, 176, 184, 185, 210, 212, 213, 229, 230, 234, 235, 241, 246, 247] | Aches and pains [7, 9, 12, 15, 31, 44, 45, 47, 56, 69, 71, 72, 105, 106, 107, 246, 247] |
| | Forward head postures [31, 73, 138] | Regular interaction with computer interface, using a standard keyword and a mouse [24, 47, 48, 51, 53, 152, 170, 178, 179, 219, 220] | Weakening and wasting of upper limb [12, 240] |
| | Myofascial pain neck and upper back [11, 45, 53] | Heavy physical work [10, 27, 35, 48, 51, 69, 111, 184, 189, 191, 192, 194, 201, 210, 245] | Neck stiffness [26] |
| | Tension neck syndrome [44] | Improper body postures [7, 10, 46, 47, 51, 52, 53, 54, 129, 145, 210, 211, 288, 289, 290, 291] | Cramp [7, 9, 31, 100] |
| | Radiating neck complaints [26] | Carrying out a task for long time without suitable rest breaks [7, 47, 48, 51, 73, 158, 204, 205, 210, 211, 216] | Fatigue [2, 6, 7, 13, 47, 56, 71, 168, 242, 243] |
| **Axilla** | Rotator cuff syndrome [24, 26, 84, 87, 88] | Poorly designed workstations [7, 10, 31, 32, 69, 129, 130, 131, 132, 288, 289, 290, 291] | Chronic pain [56, 72] |
| | Rotator cuff tendonitis [45] | Arm postures [7, 48, 187] | Stiffness [7, 9, 31, 45, 56, 100] |
| **Shoulder** | Supra-spinatous tendinitis [20, 44] | Poor working organisation [7, 6, 13, 34, 47, 51, 69, 168, 201, 242, 243] | Shoulder pain [12, 31, 44, 53, 69, 72, 223] |
| | Cumulative trauma disorders (CTDS) [7, 9, 47, 69, 99, 100, 101, 104] | Prolonged repetitive work [6, 7, 10, 31, 46, 47, 48, 51, 53, 54, 69, 130, 131, 156, 158, 161, 162, 167, 169, 174, 175, 176, 178, 179, 184, 210, 211, 218 ,229, 234, 235] | Reduced movement in their joints [7] |
| | Repetitive strain injury [7, 9, 15, 99, 229, 236, 238, 289] | High force [6, 7, 10, 12, 24, 34, 35, 45, 46, 47, 48, 51, 53, 54, 69, 95, 130, 131, 158, 178, 179, 229, 230, 241, 244] Sustained force[7] | Muscle pain [9, 105, 106, 107, 246, 248] |
| | Frozen shoulder [7, 15, 31, 44] | Vibration [2, 6, 7, 8, 9, 10,13, 27, 34, 35, 47, 48, 51, 53, 69, 158, 178, 179, 210, 211, 242, 243] | Threshold or vibratory stimulation[24, 78, 79, 81] |
| | Shoulder tendonitis [26, 45, 98] | Mechanical compressions [6, 24, 47, 69, 95, 158, 161, 162, 167, 169, 174, 175,176] And pressures [34, 35] | Joint stress and strain [31, 45] |
| | Repetitive motion disorders [9, 99] | Heavy lifting [6, 9, 10, 26, 27, 48, 51, 102, 108, 110, 111, 183, 185, 204, 205, 206, 210] | Repetitive strain [6, 10, 28, 45, 210] |
| | Regional musculoskeletal disorders [9, 99] | Psychosocial factors [7, 10, 27, 31, 32, 35, 48, 51, 69, 132, 178, 179, 189, 210] | Spasm [31, 246, 248] |
| | Shoulder bursitis [45] | Psychological stress [2, 4, 7, 10, 11, 27, 34, 35, 47, 48, 51, 53, 56, 69, 191, 192, 194, 201, 210, 245] | Reduced muscle strength [15, 24, 85, 86] |
| **Elbow** | Epicondylitis [15, 20, 24, 44, 84, 87, 88, 97] | Working with hands above shoulder level [7, 48, 53, 186, 224, 225, 226, 227, 228] | Burning [7, 47] , burning sensation [9, 100] |
| | Lateral epicondylitis (tennis elbow) [15, 20, 26, 45] | Manual handling of material [48, 53, 69, 186, 210, 213, 224, 225, 226, 227, 228, 246, 247] | Muscle strain [10, 28, 31] |

| | | | |
|---|---|---|---|
| | Medial epicondylitis [15, 20, 26] | Static work postures [2, 4, 7, 10, 27, 34, 35, 48, 69, 178, 179, 184, 244] | Muscle stress [31] |
| **Forearm** | Forearm tendonitis [45, 56] | High repletion [2, 6, 7, 24, 45, 48, 51, 69, 95, 229, 230] | Chronic muscle pain [2, 246, 248] |
| | Tendon sheath absence [47, 177] | Repetitive upper limb movements [9, 10, 24, 27, 28, 77, 229, 234, 235 ] | Weakness [7, 9, 24, 100] |
| **Wrist & Hand** | Carpel tunnel syndrome (Tardy Median palsy/ Median neuritis/Partial thenar atrophy/Nerve entrapment syndrome ) [2, 4, 6, 7, 15, 20, 24, 26, 45, 47, 69, 75, 76, 84, 88, 87, 94, 97, 139, 140, 141, 142, 143, 144, 145, 146, 147, 151, 153, 154, 158, 162, 163, 164, 166, 172, 238, 239] | Awkward sitting postures [2, 6, 13, 31, 33, 46, 53, 242, 243]<br>+/-75% of the working time [53, 224, 225, 226, 227, 228]<br>Awkward movement [7, 9]<br>Strenuous body postures [46] | Pressure on the median nerve [45, 141] |
| | Tendonitis or Tenosynovitis [7, 15, 20, 23, 44, 45, 56, 69, 238] | Pushing and pulling [6, 9, 10, 27, 69, 102, 108, 110, 111] | Hand pain [26, 31, 44, 47, 72] |
| | Osteoarthritis [6, 7, 24, 92, 93] | Segmental vibration [24, 26, 51]<br>With +/-60 min/day [53, 224, 225, 226, 227, 228] | Allodynic response to supra-threshold vibration [24, 79] |
| | Myelin nerve inactivity [47, 159, 160] | High frequency of technical actions [69, 229, 230] | Tingling (Paraesthesia) [7, 9, 24, 31, 44, 45, 47, 100, 148, 149, 151] |
| | De Quervain's disease (thumb tendonitis) [20, 26, 45] | Individual factors [31, 32, 132] | Numbness [7, 24, 31, 44, 45, 47] |
| | Fibromyalgia [53, 56, 221] | Awkward wrist postures[24, 47, 95, 158] | Joint pain [9, 10, 45] |
| | Focal neuropathy [24, 75, 76] | Improper workload [10, 34, 129, 288, 289, 290, 291] | Limitation with movement [15] |
| | Hand-arm vibration syndrome (HAVS) [7, 8] | Working with cold hands [47, 159, 162, 167] | Muscle damage in hand and fingers [24, 94] |
| | RTI(repetitive stress injury) [24, 45] | Cold work environment [7, 34, 35, 69, 229, 230] | Chronic nerve compression [47, 157, 164] |
| | Myelin sheath absence [47, 150] | Repetitive flexion of wrist [45, 210] | Changed axonal flare reaction[24, 89] |
| | Extensor tendonitis [26] | Frequent lifting [48, 184] | Soreness following a joint [7, 56] |
| | Ulnar nerve entrapment [44] | Static muscle load [7, 10, 12, 130, 131, 246, 249] | Reduced nerve conduction [47, 154, 159, 160, 163, 166] |
| | Peritendinitis [44] | Tension in muscles and tendon [2, 4] | Feeling extremely tried [31] |
| | | Perpetual motion of the hand [2, 4] | Constricted blood flow to the nerve [47, 177] |
| | | Thenar atrophy [47, 146] | Muscular atrophy [47, 151] |
| | | Violent and irregular motions [47, 145] | Loss grip strength and fatigability [7, 9, 45, 100] |
| | | Dynamic working posture [48, 51, 69, 184] | Loss ROM of surrounding joints [15, 45] |
| | | Ergonomic stressors [26] | Abnormal nerve tenderness [24, 83] |
| | | Working with hand-held power tools [7] | Nagging feeling [31] |
| | | Exceed 25-33 actions per minute [229, 237] | Occluded and impaired |

| | | | |
|---|---|---|---|
| | | | Blood flow [2, 4] |
| | | Contact pressure [7, 45] | Pinching [9, 45] |
| | | Working under time pressure [7, 24] | Reduced nerve mobility [24, 80, 82] |
| **Spine** | Instability in lumbar spine [10, 125] | Low back pain [6, 10, 12, 31, 48, 51, 69, 72, 111, 124, 125, 126, 128, 133, 134, 206] | Swelling [7, 9, 45, 47, 100, 153] |
| | | Heavy loads [6, 9, 48, 69, 102, 108, 110, 111, 183] | Muscle load [2, 4] |
| | | Compressive forces on internal vertebral disc [10, 29, 30] | |
| | | Compression of SC [12, 240] | Loss of normal sensations [9, 100] |
| | | Frequent bending and twisting [6, 10, 12, 27, 48, 129, 187, 188, 210, 217, 218, 288, 289, 290, 291] | Inability to work and function at home [45] |
| | | Relatively fixed body position [7, 24, 73, 77, 51] | |
| | | Trunk flexion [48, 186] | Intra muscular pressure [2] |
| | | Prolonged trunk flexed posture [71, 246, 249] | |
| | | Crawling, climbing, reaching [6] | Cramp [7, 9, 31, 100] |
| | | Forward bent posture [10, 29] | Tenderness [7] |
| **Lower Limb** | Knee pain [72] | Standing and walking for long duration [210, 213, 215] | Redness [7, 12] |
| | Ankle pain [123] | Pedalling while standing-sitting position [46] | Pain [123] |
| **Other(s)** | Hearing loss [8] | Noise [8, 45, 51, 69] | |
| | Occupational asthma [8] | Smoking [48] | Blurred vision [12] |
| | Occupational dermatitis [8] | Respiratory hazards [8] | Eye burning sensation [12] |
| | Extrinsic allergic alveolitis [8] | Illumination [6, 7, 51] | Visual /eye problem [51, 208] |
| | | Duration of exposure [7, 69] | |
| | | Insufficient time for recovery [229, 230, 234, 235] | Difficulty in dressing [45] |
| | | Poor working environment [7, 210, 218] | Poor sleep [45, 56, 146] |
| | | Temperature [6, 34, 35, 45] | Hot or cold sensation [9, 100] |
| | | Gloves [45, 69] | Thermo graphic changes [24, 91] |
| | | Insecurity [47, 168] | Sympathetic reflexes [24, 96] |
| | | Lack of job satisfaction [47, 53, 168] | Chronic headache [12, 56] |
| | | Cultural factors [48, 178, 179] | Irritable bowel syndrome [56] |
| | | Lack of autonomy [24, 90] | |
| | | Individual differences and vulnerability [7] | |
| | | Lack of social support [24, 90] | |
| | | Work stress [51, 245] | Mental fatigue [51, 202, 203] |

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