CHAPTER 2

REVIEW OF LITERATURE
2.1 Search strategies

A comprehensive literature search using electronic database Pubmed, Medline, Science direct, Cochrane database of systematic reviews, Proquest, EBSCO, SCOPUS, Academic search premier, CINAHL Biomed Central, Clinical trials.gov and web of science databases was undertaken to identify literature. Additional studies were added by manual searching of the reference lists of original investigations and review articles.

The custom range of publication dates was from 1970 till date. The search was conducted using following key words.

Key words

Musculoskeletal disorder (MSD); Work related musculoskeletal disorder (WRMSD); neck pain, upper back pain; low back pain; shoulder pain; elbow pain; hand and wrist pain; work; sick leave; Cumulative trauma; repetitive work; awkward posture; ergonomics; outcome measures; ergonomic intervention. MSD questionnaire, medical laboratory, job rotation and rest breaks.

2.2 Prevalence of WRMSD global and India

MSD are one among the major causes of pain and reduced quality of life among global population. The “Annual Survey of Occupational Injuries and Illnesses” (ASOII), BLS\(^3\) reported that in 1995, 62% of the illness were due to disorders associated with repeated trauma except low-back disorders, which were listed as injuries.
In 2005, 107.7 million adults, one in every two aged 18 and above, reported suffering from a musculoskeletal condition mainly lasting three months or longer during the past year. This is almost twice of any other medical condition reported. Neck and Low back pain are most common physical conditions requiring medical care. Workplace acquired musculoskeletal injuries, collectively known as musculoskeletal disorders (MSDs), occur each year due to cumulative and repetitive motion or accidents. The estimated incidence of MSD in low back in 2011/12 was 51000 cases. Health professionals are one among the various occupations with the highest estimated prevalence rates of back disorders. This prevalence of MSD is high among males compared to females.

MSD in the upper extremity was more common in keyboard, repetitive action and manual handling task. The Skilled construction and building trade’s occupations had highest estimated prevalence rates of ULDs.

MSDs are recorded by the “U.S. Department of Labor” and, “Bureau of Labor Statistics”. These disorders often require longer recovery time than other types of work place injuries because of severity of injury or illness. MSD as well as injuries produces significant cost due to lost work days and it was estimated around $127.4 billion in year 2004. Musculoskeletal injuries often causes physical limitations in terms of ability to perform daily activities of living.\(^5\)

One of the earliest COPCORD study on the MSD in India on 6034 villagers was carried in Village Bhigwan under the aegis of ILAR/APLAR, reported incidence of 12.8%.\(^{28}\)
Study by Sharma R (2012) done in India reported prevalence of MSDs in Delhi was 7.08%, in Dibrugarh it was 11.52% and 9.53% in Jodhpur. Prevalence of MSDs was lowest in the age group of 18-30 years across all the three study centers the and it gradually increased with advanced age groups from 40 years and above. About 9.31% participants in Delhi, 8.31% in Dibrugarh and 4.32% in Jodhpur reported absence from work due to MSDs. Some functional limitation was also observed in 84.10% participants in Delhi, 86.20% in Dibrugarh and 66.44% in Jodhpur.

2.3 Prevalence of WRMSD among health professionals

Prevalence of WRMSDs have also been reported among Nurses, Physical therapists, physicians, Surgeons, and dentists.

Self-reported musculoskeletal symptoms among dental professional are reported earlier by many authors, and a recent review found dental professionals to have a twelve month prevalence of musculoskeletal symptoms ranging from 24% to 100%.25

Symptoms of WRMSD are also not uncommon in laparoscopic surgeons. In a study done in Korea 89.1% of endoscopists reported musculoskeletal symptoms with the minimal involvement of one body site. The average number of body site involved was 3.9 ± 2.8. Right shoulder was maximal symptomatic area reported during endoscopic procedures, followed by left shoulder and left side finger. However during rest period or inactivity, the symptomatic area of the body was different than during working. Neck pain and upper back pain were relatively frequent.29
Another study on physical therapy occupation reported that physical therapy can lead to work related musculoskeletal disorders (WRMDs) in Physiotherapist because of nature of their profession. Physiotherapists also routinely involved in activities such as transferring dependent patients, lifting heavy equipment and assisting with mat activities. These tasks increases the risk for both acute as well as chronic WRMDs. Cromie et al in a survey on physiotherapist in the state of Victoria, Australia, reported that work-related pain or discomfort had been experienced by 91% of respondents, while Bork et al identified an incidence of 61% of WRMSD among physical therapy graduates from the University of Iowa, USA. Buddhadev Neeti, KotechaIlesh in a study noted the work related low back pain prevalence ranging between 22% and 74%.

2.4 Tissue Pathomechanics and WRMSD

2.4.1 Model of the development of WMSD

Armstrong et al (1993) have developed a model of musculoskeletal disorders that emphasizes dose, exposure, capacity and response. Exposure refers to work demands such as posture, force and repetition rate that have an effect (dose) on internal body parts. Metabolic changes in the muscle, stretching of the tendon or ligaments, compression of the articular surfaces of joints are examples of what is meant by a doser. The dose may produce a response such as change in the shape of a tissue, the death of cells or accumulation of waste products in the tissues. The primary response can be accompanied by secondary responses such as pain can be a doser that causers another response i.e increased muscle contraction.
Capacity refers to the individual worker’s ability to cope with the various dose to which his musculoskeletal system is exposed. An individual’s capacity is not fixed. It may change over time as the person ages. Armstrong also pointed out that muscles can adapt to work demands faster than tendons and this may lead to reduced tendon capacity.\textsuperscript{34}

2.4.2 WRMSD mechanism
The mechanism of WRMSD is thought to be repeated micro trauma at cellular level.

2.4.2.1 Muscle pain
The endurance capacity of muscle for loads less than 15\% of maximal voluntary contraction is excellent.\textsuperscript{21} Above this threshold level, rest periods are needed to avoid any acute or chronic problems. Pain due to accumulation of waste products in the muscle is called cramp and is accompanied by muscle weakness or fatigue during which muscle loses its strength up to 50\% of its normal strength. This cramp is noticed in task requiring repetitive movements.

Normally the muscle will recover and even strengthen after rest period. However, rest period of at least 48 hours is usually an intrinsic part of strength training program. Damage to muscle tissue continuously may go beyond their repair capability, leading to decrease in strength or endurance of muscles.

In conscious person, skeletal muscle always has some degree of tightness or some degree of muscle fire recruitment this is known as muscle tone and is controlled by central nervous system. Muscle tone is essential for the maintenance of
posture. People under mental stress may, without realizing it, develop increased tension in their muscles that they cannot control. At work, the pre stressed body part may be a source of pain even though the task loading is mild.\textsuperscript{34}

2.4.2.2 Tendon pain

Tendons have tensile strength of 50-100 MPa (megapascals). It consist of bundles of collagen micro fibrils with many cross-linkages between them. At rest the fibrils have "Crimped" appearance. Under constant load, tendons exhibit 'creep' and viscous lengthening takes place.

Pain arising from inflammation of tendons (tendinitis) is known to be work related when it occurs in hand and wrist (NIOSH 1997). There is evidence that force, posture and repetition are all associated with the disorder and evidence is even stronger when workers are exposed to stressors in combination.

While performing highly repetitive movement, there is increase in blood supply to the particular muscle causing decrease in the blood supply to the adjacent tendons and ligaments. Impaired blood supply to the tendons is thought to be the cause of many occupational shoulder pain because it increases the rate of cell death within the tendon.

Also increase tension in the tendon reduces their blood supply which may explain why static positions are associated with tendon problems.
Because of frequent mechanical loading there can be inflammation of the cartilage surrounding a joint or tendinitis. Also, when the wrist are in extreme position the flexor tendons of fingers gets pressure against the bones of the wrist, which increases friction in the tendons. Rapid repetitive movement of the fingers or hand can cause the sheaths surrounding tendons to produce excess synovial fluid. This results in swelling causing pain and restriction of tendon movement in the sheath which is known as tenosynovitis. Repeated exposure can ultimately lead to formation of scar tissue and impedes movement of tendon within the sheath and thus degrades function resulting in reduced mobility, pain and weakness.\(^{34}\)

Stiffness and ‘snapping’ of fingers during voluntary flexion is thought to be caused by thickening of fibro-osseous canal through which the finger flexors pass. This is known as trigger finger (stenosing flexor tendinitis). High prevalence is found in some meat packing jobs that require static grasping of powered knives activated by trigger.

2.4.2.3 Nerve injury

Repeated or prolonged exertion can lead to damage to nerve supplying a muscle or passing through it. This can cause sensation of tingling or numbness in the areas of body supplied by the nerve. The pressure threshold limit for the nerve viability is approximately 40-50 mmhg. Activities or conditions that increase the pressure are likely to degrade nerve function.\(^{35}\)

The relative role of interference with blood supply and direct mechanical trauma to the nerve are not well understood.
Disorder of nerve function are known as neuropathies. Chronic abnormal inputs from peripherally damaged nerve cells can sensitize nerve cells within the spinal cord resulting in the hypersensitivity to painful stimuli characteristic of RSI (repetitive strain injury). According to the theory, ‘RSI’ is really a form of peripheral neuropathy in which a damaged nerves can contribute to chronic pain by sending abnormal discharge into the nervous system.\(^{36}\)

### 2.5 WRMSD risk factor among health professionals

An adequate supply of healthy workers is essential to the effective, efficient functioning of health care systems. Out of all occupational injuries and illness reported by employer every year WRMSD account for one-third of it (NIOSH 2006, BLS).

NIOSH [1999] conducted a study on sonographers in hospital were most of them had reported neck, shoulder, and arm pain while performing ultrasound. Following risk factors were found- awkward and Static postures while using transducer, awkward positioning of both patients and equipment. Poor workplace ergonomics in terms of equipment design, furniture, lighting, continual pressure for sustained periods of time during examination, Sonographer age, height and gender (NIOSH 2006).

There is strong evidence showing that working posture with high level as well as prolonged static contraction, extremes of postures at neck and shoulder are at increased risk of neck or shoulder MSD. Around 12 high quality studies reported OR
of 3 or above, thus proving association between tension–neck syndrome with static posture or static loads.\textsuperscript{12}

The work of surgeons requires very precise movements with their hands at critical moments during surgery along with high level of mental concentration categorizing it as physical demands of mild to moderate level. Grace et al (2009) in a cross-sectional study on 135 surgeons reported 80\% annual prevalence of musculoskeletal symptoms. The neck was reported to be highest in prevalence of 82.9\% followed by the low back with 68.1\%, shoulder 57.8\% and upper back 52.6\%. The authors reported that “sustained static or awkward posture during surgery” was identified as the most common risk factor followed by “forceful exertion and repetition” leading to body discomforts. Wrist/hand pain was found significantly associated with repetitive movements and forceful exertions of upper limb. Factors like furniture and environment also contributed significantly in causing neck pain.\textsuperscript{37}

Young HyeByun et al (2008) did a prevalence study on 55 endoscopists in Korea using self-administered questionnaire. The study reported prevalence of 47.3\%, with a mean VAS value of more than 5.5. Factors like some specific posture of endoscopist during procedure had significant correlation with musculoskeletal pain.\textsuperscript{29}

Vijay K et al (2013,) in a Cross-sectional survey using a self-administered questionnaire among 536 Indian dentists population reported at least one work-related musculoskeletal symptom in all dentist with a period prevalence rate of 100\%. This prevalence was similar to findings of Lalumandier\textit{et al} 2002. Symptoms varied from pain, discomfort, fatigue. Lower back pain was very common, followed by wrist and hand, neck and shoulder. The study found a significant association
between lack of physical activity and number of body site affected. Biomechanical risk factors also showed relation with respective site of the body involved.  

Various studies have reported that dental practice includes high physical static workload (i.e. awkward back postures, prolonged arm abduction), which is significantly related to an increased reporting percentage of cervical, shoulder and low back pain.  

Hormoz et al (2004) did a preliminary online survey on 162 ophthalmologists using a questionnaire. Back and neck pain were the most frequent reported complaints (80% and 69%, respectively). Affected ophthalmologists had attempted various treatments for pain relief. The study identified younger age, being a woman, and laser exposure as specific risk factors.  

2.6 WRMSD among laboratory professionals  

Eshetu et al has reported a study on 156 laboratory professional. It was done using a self-administered questionnaire to measure the incidence of WRMSD on laboratory professionals. Nordic questionnaire was used to check musculoskeletal symptoms. Total 336 musculoskeletal symptom was identified affecting 9 areas of the body. Feet and ankle (21.7%) were highest in incidence followed by knees (20.8%) and upper back (10.7%) Few them had taken sick leave ranging (4.5%). Symptoms reported by participants working in hematology and clinical chemistry was more followed by parasitology and urine analysis. Authors also found that main contributory factor for reports of WRMSD was poor ergonomic design in workstations.
Another study by Florian et al (2012) reported one month prevalence among pathologist. It was an online survey through questionnaire done on 163 pathologist of Switzerland. Prevalence of musculoskeletal symptoms was 40% in this study. Neck was found to be highest in prevalence. Followed by shoulder (60.2%), upper back (45.5%), lower back (39.8%), hand/arm (27.6%).

Marianne et al (1994) reported twelve months prevalence of MSD in upper extremity through a cross-sectional study on 128 female laboratory technicians who were mainly involved in pipetting. Risk factors associated with pipetting was studied. The prevalence was 58% in shoulder 44% in hand and 44% in the neck. Authors highlighted that pipetting requires static work of neck and shoulder muscles away from neutral position requiring forward bending of neck and arm elevation for long without support. Marianne et al noted that, pipetting for more than 300 hour per year increases the risk of hand and shoulder problems. During the study participants also reported that perceived fatigue increases as time spent on pipetting increases.

Another study by Evan George (2010) on cytotechnologist reported 55-60% prevalence of neck pain followed by upper back, hand & wrist and lower back. The study involved mainly microscope users. The prevalence was similar to study by kalavar and hunting in 1996 and Alireza et al in 2010. However, prevalence were lower than reported by Evan George. Literature reported that, microscope users had to bend the neck and upper back to view through the eyepiece. These awkward postures are also maintained while viewing computer screen, cutting frozen sections, writing etc. which in long term leads to development of forward rounded posture due extensor muscle dysfunction causing muscle fatigue, pain and stiffness.
Shreya Maulik et al (2012) reported study on musculoskeletal problems among medical laboratory technician of clinical pathology, hematology, histology, biochemistry, serology and clinical microbiology. Authors evaluated risk of MSD on postural analysis and rated most of the activities carried out in the laboratory as high risk. The main contributory factor identified was awkward and constrained postures leading to MSDs. Lower back was the most prevalent in symptoms followed by upper back and neck which is unlike the findings of previous studies reporting neck problems as most prevalent.47

2.7 Medical Laboratory and work characteristics

Collecting blood samples- This procedure requires taking blood samples from patients (usually in hospital) for testing in laboratories. It requires the lab professional to bend forward, elevate the shoulder based on the height of table were patients arm has to be placed, reach forward based on the width of table to reach the vein from were blood has to be drawn.

Pipetting- Pipetting work demands elbow use in mid prone position. Significant amount of force may have to be applied through thumb as it has to work in isolation from the hand. While depressing the plunger it may strain the thumb. Tip ejection is carried out either by the thumb, or by a power grip involving the fingers. The height and position of sample holders, solution containers determine the need for twisting, bending or stretching of elbow and hands.
Microscope use—Microscope work demands precision and the ability to concentrate for long periods of time. Looking through microscope requires keeping the head in the static position for long periods. Professionals often have to maintain same work postures for long. This work often requires forward flexion and movements of the upper extremities while adjusting knobs every time.

Microtome and cryostat—

Microtome requires the use of forceps or brush instead of fingers to pick up sections or wax fragments from blade or block face. There is a hand wheel which requires to be rotated while cutting a section. Microtomes can be manual, semi-automated or fully automated. Automated instruments reduce repetitive movements. Computer are used in medical laboratories work to keep track of patient data, sometimes it is used to generate results that are sent back to the patient’s physician.

2.8 Risk Factors for WRMSD among laboratory professionals

Main risk factors for work related musculoskeletal disorder can categorized under one or combination of these

- Force
- Repetition
- Posture
- Duration of task

Force—loading of muscle or force applied while pipetting has been quantified by various researcher. Fredriksson (1995) evaluated the forces required to operate a pipette and compared them with the thumb strength. Authors found that the peak
push force at thumb in operating the pipette is 18.4% and 14.5% of the push force capacity for female and male subjects, respectively.48 Further Biomechanical analysis by Asundi et al. (2005) evaluated the thumb push force and activities in four extrinsic muscles for different pipetting tasks.49

In the pipetting task, about 70% of the pushing power was generated from the CMC joint and the CMC motions were generated mainly by the EPB and APL. Also, the muscle forces in APB and FPB are quite large relative to all other muscles.50

The other task which requires force is computer task which is one of the components of laboratory task. For example keyboard use during entry of patient information.

Repetition-Tissue micro trauma occurs due to repetitive tasks leading to inflammation, followed by fibrosis and other structural changes in the tissue.51

During manual pipetting for extracting and dispensing fluids the muscles/tendons and articular joints of the thumb, hand and wrist are exposed to highly repetitive motion and loading. Armstrong et al in 1987 reported that there is 29 times greater risk of tendinitis in workers performing highly repetitive forceful tasks. A survey by David and Buckle (1997) reported that 90% of pipette users, who continuously use pipettes for more than an hour on a daily basis, had more of hand and elbow disorders.3333, 52

Recent studies show that rapid, stereotypical repetitive, nearly simultaneous fine motor movements can degrade the sensory representation of the hand and may
lead to a loss of normal motor control of a targeted task, commonly referred to as focal hand dystonia or occupational hand cramps.\textsuperscript{53}

Repetitive movement is also studied during keyboard use were various muscle activity during typing has been evaluated through Electromyography (EMG) suggesting that MSDs in the upper extremities are related to excessive repetitive musculoskeletal loading.\textsuperscript{54}

Posture-postures away from neutral cause prolonged low level muscle contractions and changes in intervertebral disc pressures. Inappropriate posture can increase the risk of musculoskeletal disorder. In a study done in Iran showed a significant relationship of neck and back pain with high risk score in REBA. The most important reason for increased REBA score was unfavorable posture attained by the dentist \textsuperscript{55}. Trapezius myalgia is most commonly associated with static work in front of a VDU with a fixed posture. An investigation showed that presence of neck flexion greater than 20° while working in VDU can predict the presence or absence of neck pain.\textsuperscript{56} Microscope task requires similar Posture during sitting specially while using microscope, user bends their neck forward necessitating an increase in muscle effort of back of the neck causing proportional increase in the joint compression.

\textit{Posture during computer task}

Incorrect working posture may result in WRMSD.\textsuperscript{57,58} Prolonged computer task over period of time leads to frequent use of forward neck posture. Sustained forward flexed posture of the spine may increase cervical compression loading and this posture if associated with prolonged sitting could aggravate the neck pain.\textsuperscript{59}
Studies also have reported that awkward and extreme postures is one of the most common risk factors for musculoskeletal disorders.

Hunting et al (1981) reported effect of various posture on musculoskeletal discomfort in a cross sectional study on 162 computer workers. The author reported that ulnar deviation of the wrist greater than 20 degrees was associated with musculoskeletal symptoms and downward head tilt was associated with increased discomfort and clinical abnormality. Author also reported that greater keyboard height and working with hands and forearm supported was associated with decreased musculoskeletal discomfort in the neck, shoulder and forearm.\textsuperscript{44}

Duration of task and WRMSD - A relationship between the musculoskeletal problems and duration of computer use has been previously reported. Gerr and Marcus (2002) measured 20 different characteristics of the workstation lay-out and various working postures adopted by 632 computer workers. The subjects were followed for up to three years. The subjects documented in a diary each day of computer use and incidence of musculoskeletal symptoms. All subjects reported symptoms were examined for specific musculoskeletal disorders. This study reported the association between hours of computer work and hand arm disorders.\textsuperscript{60}

2.9 Evaluation of WRMSD

WRMSD can be evaluated using qualitative, semiquantitative and quantitative tools. The selection of a method for evaluation depends on the individual who is going to evaluate, characteristics of work to be assessed and availability of resources for collecting and analyzing the data. Qualitative analysis mainly uses checklist or
questionnaire to evaluate the risk at workplace. Checklist also provide consistent structure to analyze WRMSD present.

Mahdavi et al evaluated the risk of MSD among 172 female hair-dressers using one of the qualitative tool i.e. Rapid Entire Body Assessment (REBA) to evaluate the risk factors. This tool evaluated upper limb as well as lower limb postures, repetition, forceful exertion and coupling during various activities. Authors reported significant correlation between the REBA score and MSD at various body site. Awkward posture and prolonged standing time was found to be greatest cause of WRMSD.61

H. Mohammadi et al in a study on Iranian casting workers assessed the manual material handling (MMH) task with Snook tables and evaluated acceptable weights in MMH tasks. The Snook tables helps in finding safe weights limits and force for MMH task. It uses the collected data on weights and forces chosen by workers to determine the maximum acceptable limits for lifting.62

In a study on healthy industrial workers studied the relationship between revised NIOSH lifting equation (RNLE) and low back ache. It was a prospective study. The composite lifting index (CLI) was used as the main risk predictor. The author reported that the CLI of greater than two threshold value may help in predicting low back pain.63
2.10 Tools to measure upper quadrant functions and Quality of life

*Visual analog scale (VAS)*

VAS is a tool measuring subjective characteristics. It measures the psychometric response. When responding to an item of VAS the respondents marks on 10 cm scale. The visual analog scales have superior metrical characteristics than discrete scales, thus a wider range of statistical methods can be applied to the measurement. VAS has been used extensively as an outcome measure. It has high test retest reliability (Reips UD 2008). Tashjian RZ et al (2009) conducted a study to see “minimal clinically important differences” (MCID) and Patient Acceptable Symptomatic State (PASS) for VAS measuring pain in patients treated for rotator cuff disease. The MCID and PASS were estimated to be 1.4 cm (P=.0255) and 3 cm (95% CI-22.69, 37.31) on a 10 cm VAS measuring pain, respectively.⁶⁴

Lars L Andersenl (2008) reported in a study on Forty-eight women with chronic neck pain who were involved in computer-intensive work. It was a RCT and subjects were assigned to three groups with one group receiving 10 weeks of specific strength training (SST) locally for the affected muscle. And second group received general fitness training (GFT) which included leg bicycling with relaxed shoulders, and another group was reference intervention (REF) group without physical activity. Change in intensity of neck muscle pain on 100-mm VAS was the main outcome measure. Study demonstrated that SST and GFT have significant effects on chronic neck muscle pain.⁶⁵
In another study Irmak A et al (2012) evaluated the effectiveness of the exercise reminder software program on office workers. Perceived level of pain, quality of life and work performance was used as an outcome measure. 39 healthy office workers participated in the study. Participants were randomly divided into two groups, intervention group and control group. VAS was used to evaluate the perceived pain among all of the participants in the beginning and at the end of the study. The intervention program was given for 10 weeks. Results of the showed that the intervention group had statistically significant (p<0.01) decrease in VAS scores and control group VAS scores remained the same. Authors concluded that such exercise reminder software programs may help to reduce perceived pain among office workers.66

Another study by Melinda Jaromi et al (2012) in nurses with chronic low back pain measured the effectiveness of a training program for spine (Back School). It was Single-blinded RCT with follow-up at six- and 12-months. Study group received education and ergonomic training as intervention once in six week for total period of 6 weeks. The control group received passive physiotherapy once a week for a period of six-week. Pain intensity and body posture were the outcome measures used. The pain intensity was checked with VAS. Body posture was analyzed with the Zebris biomechanical motion analysis system. Authors reported significant decrease in back pain intensity on VAS scale after the therapy in both groups however, intervention group showed significantly better results till year of follow up period.67
Neck Disability Index (NDI)

The neck disability index (NDI) is used to check perceived disability in patients with neck pain. The NDI contains 10 items, 7 items related to activities of daily living, two items related to pain, and one item related to concentration. Each item is scored from 0-5. The total score is expressed as percentage, with higher indicating greater disability. It has high internal consistency (cronbach α=0.92). Explorative analysis showed high loadings on items of work, driving, and recreational activities, measuring more of the physical aspect of pain disability.

Significant association was found between NDI and both components of SF-36. The scale also exhibit adequate sensitivity in showing the magnitude of change that occurred for patients in reaching towards their functional status.

Jette and Jette (1996) further substantiated the sensitivity to change by calculating the effect sizes for change in scores of both NDI and SF-36. NDI has excellent test retest reliability. The intraclass coefficient score for test retest reliability was 0.986.

Two studies have identified the minimal detectable change to say it as significant. Westaway (1998) identified the minimal detectable change as 5 (ten percentage points) in a group of 31 patients with neck pain. MCID, are more useful to clinicians. More recently Cleland and colleagues (2006), described the minimal clinically important difference for NDI to be 9.5 (19 percentage points) for patients with mechanical neck disorders.
Rattaporn Sihawong et al (2014) conducted a 12-month prospective RCT in healthy office workers with reduced neck flexion movement or neck flexor endurance. 567 healthy office workers were divided into either intervention (n=285) or control (n=282) groups. Intervention group received an exercise program in form of daily stretching exercise and muscle endurance training (two days in a week). Control group did not receive any intervention. Pain intensity, disability level, quality of life and health status was used as outcome measures. Disability was measured by the Neck Disability Index (NDI) and quality of life was measured by the Medical Outcome Study Short-Form Survey V.2.0 (SF36v2). Although the exercise programme reduced incidence of neck pain and increased neck flexion for office workers with reduced neck flexion, there was no significant difference in pain intensity, disability and quality of life and health status between the both groups.\textsuperscript{79}

In another study Chao Ma et al (2011) compared the effects of biofeedback with active exercise and passive treatment in treatment of work-related neck and shoulder pain. It was a RCT with 3 intervention groups and a control group. In the biofeedback group, activity of upper trapezius (UT) muscles was analyzed bilaterally while performing computer work daily. In the exercise group, subjects performed unsupervised standardized exercise program daily. In the passive treatment group, moist heat and interferential therapy were applied to the participant’s necks and shoulders. An education booklet on office ergonomics was given to control group. VAS, NDI and surface EMG was used as an outcome measure which was introduced before and after the study. Authors reported significant reduction in pain scores and improvement in muscle activation of neck muscles in participants with neck and shoulder pain.\textsuperscript{80}
Disability of arm shoulder and hand (DASH)

The DASH was developed to assess the function status of upper extremity as well as to know the impact of the disorder. The DASH questionnaire has 30-item with each item having option of five item response. These 30 items assesses symptoms during: daily activities, recreation, self-care, sleep, sports, family care, occupation, socializing, and self-image. The test has a maximum score of 100. Higher scores indicate greater disability. It can be used one time or multiple time to determine changes over time. Discriminative validity has been determined. The DASH has been demonstrated to be a valid and reliable tool for both proximal and distal part of upper extremity. Thus can be used for proximal as well distal part dysfunction. The DASH has high correlation (> -0.75) with other measures of pain, function and disability. Test retest reliability and internal consistency of DASH was above 0.95.

The scale has optional modules also which are useful for athletes/performing artist, and working populations. The optional module consist of DASH work module comprising of four items asking about difficulties at-work. Items within the work module quantify the amount of difficulty while performing tasks related to work, based on physical ability. The DASH-W shows evidence of being a reliable and valid tool for measuring on-the-job difficulties (also known as presenteeism) among workers with shoulder or elbow injuries. This four-item module appears to work just as well as three other at-work disability measures. It has Reliability Coefficient (Cronbach's alpha) = 0.89.
Gummesson et al (2003) in a longitudinal study reported the construct validity of the DASH. DASH was evaluated in 109 patients underwent surgical treatment for a various upper-extremity conditions, by assessing preoperative-to postoperative (6-21 months) change in DASH score and calculated the effect size and standardized response mean. DASH was performed to check effectiveness of treatment following surgery for sub acromial impingement and carpal tunnel syndrome. effect size and standardized response mean was calculated. The authors reported that DASH can detect and differentiate small and large changes of disability over time. Minimally important change of 10-point difference in mean DASH score was considered as significant.

In this study the DASH demonstrated high Cronbach alpha values, indicating an excellent internal consistency which is adequate for group as well as for individual comparisons.  

Rasotto C, et al (2014) assessed the effectiveness of a physical activity program which was tailored and performed at work, to reduce the symptoms in upper extremities and neck. It was a RCT done in 68 metalworkers. Participants were randomly assigned to an intervention group (IG), and control group. VAS was used to measure pain and disability was measured by DASH. The tailored exercise protocol for 10-month was given. Intervention group showed benefits and reduction in DASH score was reported while no change was noted in control group. The authors revealed that DASH questionnaires were very useful, since it provided a more detailed information on functional status respect to on field evaluation. The study
indicated beneficial effects of workplace exercise which was tailored in workers exposed to high risk for WRMDs. Thus clinically significant reductions of pain symptoms and disability of neck and upper limb regions was noted.\footnote{84}

Sundstrup et al (2014) investigated the effect of 2 contrasting interventions in Slaughterhouses workers on pain and disability with upper limb chronic pain exposed to highly repetitive and forceful manual work. The conventional ergonomic training (usual care) was compared with resistance training. It was a randomized controlled trial. Average Pain intensity of shoulder, arm and hand in scale of 0-10 was the primary outcome, and disability (Work module of DASH questionnaire) as well as isometric muscle strength of shoulder and wrist were secondary outcomes. Results of the study reported more reduction in Pain intensity as well as improvement in disability, and muscle strength following resistance training than usual care. On DASH work outcome measure, Compared to ergonomic training work disability improved to a greater extent with resistance training.\footnote{85}

In another study by Kitis A et al investigated the validity and reliability of the Turkish version the DASH. The author evaluated the WRMSDs of upper extremity in industrial settings and epidemiological studies. The study involved 240 industry workers with upper-extremity musculoskeletal complaints. Comparison of the overall and work component of DASH scores with SF-36 summary was done to measure the Construct validity. Results showed high Internal consistency of the DASH (Cronbach alpha 0.91). Excellent Test-retest reliability was found for overall DASH with ICC- 0.92.\footnote{86}
Short Function Form 36 (SF-36)

SF-36 is a generic measure for health-related quality of life (QOL) being used widely, consisting of 36 questions and measuring health in eight dimensions: physical functioning (PF), role limitations due to physical health problems (RP), bodily pain (BP), social functioning (SF), general mental health covering psychological distress and well-being (MH), role limitations due to emotional problems (RE), vitality, energy and fatigue (VT) and general health perceptions (GH). SF-36 has been adapted and translated into several languages and its validity and reliability established in several countries.\textsuperscript{87, 88}

Anderssan et al (2001) in a Cross-sectional study evaluated the effect and physical and psychosocial workplace factors and individual characteristics on neck and shoulder pain. 3123 workers from three textile plants, four food processing companies, five service companies and seven other manufacturing companies were included in the study. Video observations was used to evaluate physical risk factors, and psychosocial risk factors were evaluated with the job content questionnaire and health related QOL was assessed through SF-36 questionnaire. Results of the study reported that 7.0% prevalence of neck/shoulder pain among participants involved in repetitive work and 3.8% among the referents. Neck/shoulder pain showed strong association with reduced health-related quality of life. Health dimensions from the SF-36 revealed that more frequent complaints and clinical signs were associated with lower scores on all domains of health-related quality of life, especially those subscasces indicating somatic illness.\textsuperscript{89}
Antonio C Santos et al, in an open-label RCT (parallel groups) compared the efficacy of an educational program for primary prevention of WMSD. 101 clerical and production workers from a steel trading company participated in industry. The primary outcome was physical component domain of the quality of life (QL) measured by SF-36. Both the groups demonstrated improvements in some aspects of quality of life. Thus authors suggested that educational interventions improve workers health conditions.11

2.11 Ergonomic intervention and WRMSD

Interventions can be categorized as engineering, personal or administrative according to the control implementation hierarchy as recommended by NIOSH. 90 Studies related to Engineering interventions is defined as “engineered or physical manipulations of sources for occupational hazards or routes of exposure to them,” it mainly include computer mouse designs, alternative keyboard designs, tool redesigns and keyboard and mouse support systems,. 

Jacquie Ripat et al (2006), in a six-month prospective study (RCT) investigated the effect of alternate keyboards style in decreasing symptoms and improving functional status for participants with WRUED. Keyboards were different significantly in their activation force and key travel characteristics. The study reported reduction in symptom severity and improvement in functional status for participants in the study groups, which provides additional evidence for the beneficial effect of ergonomic keyboards in individuals with WRUED. The majority of participants were satisfied with their study keyboard.91
Studies related to Administrative interventions – These are “any management initiative which modified the work process or work exposure to reduce WRMSD stress,” such as job rotation or development of an ergonomics task.

Kuijer PP et al (1999) in a study compared the effect of job rotation for male employees who were working at refuse collection department. These employees were working as a street sweeper, as a driver or as a refuse collector before the job rotation was introduced. Every employee was asked to alternate between two of the three possible jobs during the day, after the introduction of job rotation i.e. refuse collecting/street sweeping, and refuse collecting/driving or street sweeping/driving. Two rotation groups (i.e. refuse collectors/street sweepers and street sweepers/drivers) and two non-rotation groups (i.e. refuse collectors and street sweepers) were compared. Perceived load, postural load and energetic load was used to measure the physical workload during a full working day. Result of the study showed that rotation of Job introduction resulted in significant decrease of the perceived load & energetic load and a minimal decrease of the postural load. 92

Another study by Vogel K et al (2013) on meat cutters evaluated the effects of ergonomics on the individual meat cutters and their work. The intervention included cutting down of knife work to 6 hours per day and additional implementation of job rotation with equal work period. Few tasks were added which was different from traditional meat cutting. A competence development plan for each meat cutter and easy adjustment of workplace height were introduced. In addition to reduction in the injury and absenteeism, reduction in perceived physical load was reported by the author. 93
Studies related to personal intervention- This includes intervention addressing behavior of worker, education and training. It mainly focuses on encouraging use of neutral posture which thereby reduces the risk of musculoskeletal disorders. Examples of this would be use of wrist splints, EMG biofeedback and on-job exercise programs.

In a study by Mogens (2013) effect of strength training at workplace was evaluated on neck, back and upper extremity among laboratory technicians. It was Cluster-randomized controlled trial on 537 industrial laboratory technicians. Group 1 performed supervised strength training for 6 months (round one) and group 2 performed supervised strength training for next six months (round two). The outcome measures used were pain intensity (0–9) in the, neck, back and upper extremity and DASH. Author found that strength training for specific muscles at the workplace can lead to significant long-term reductions in back and upper extremity pain as well disability reported from DASH. Also the improvement seen during training phase with supervision was maintained for 6 months post intervention.94

In a review by McGorry and Courtney(2006) evaluating the effectiveness of worksite exercise program, results were similar to previous study noting exercise alone is not effective enough in preventing WRMSD. Authors also suggested that exercise should be included as a part of more comprehensive ergonomic program approach to control WRMSD including engineering and administrative control.95
“Multiple component” program – this included studies having more than one type of intervention. Components of this programs includes workstation redesign, tool modification, task modification, job rotation, training on ergonomics to reduce biomechanical exposure.

Michael Feuerstein et al (2010) reported in a study done on 53 interpreters (symptomatic and asymptomatic) who were working at the National Technical Institute for the Deaf. The intervention included eleven 1.5-hr group sessions which was designed to reduce musculoskeletal overexertion, improve the ability of workers and educate workers and supervisors. The 10-week intervention, which integrated ergonomic, work organization, workrelated and individual psychosocial, work style and exercise components were incorporated. Following 3 years of intervention program authors reported 69% reduction in upper extremity musculoskeletal complaints. Sessions included orientation that provided background on the WRMSD and associated work disability, fitness training which include flexibility and strength training, job stress management and pain management, self-assessment and relapse prevention.96

Another study by Darragh et al (2008) evaluated the effect of ergonomics intervention on the microscope workers in a quasi-experimental study. Fifty-one microscope workers were included in the study. The study had three groups – education training group, education only and control group. The participants were assigned to one of the three group. The body positioning and design of workstation was evaluated before and after the intervention. The result demonstrated
improvement in body positioning and workstation design in education training group to other two groups. Author concluded that participatory approach along with individual focused training and feedback are more helpful and important component of ergonomics training.\textsuperscript{97}

In a review by Lincolnet al (2000) to evaluate interventions for the primary prevention of work-related carpal tunnel syndrome (CTS), twenty-four studies meeting the inclusion criteria were reviewed. The intervention focused on the studies was engineering intervention, personal intervention and multiple component intervention. Engineering interventions incorporated in the study was alternative keyboard and mouse designs, wrist supports, keyboard support, and tool redesign. Personal interventions included training regarding ergonomics, wearing of splint, EMG biofeedback, and job site exercise programs. Multiple component interventions included workstation redesign, an ergonomics task, job rotation, and ergonomics training. The author reported that multiple component programs were more effective in reducing incidence of CTS. But, due to potential confounders the results were inconclusive.\textsuperscript{98}
2.12 Summary of the literature review

- MSD are one of the major causes of pain and reduced quality of life among global population.
- Mechanism of WRMSD is thought to be repeated micro trauma at cellular level of muscle, tendon and nerves.
- Working groups and occupation involving static muscle work, prolonged static loads, or extreme of working postures involving the neck and shoulder muscles are at increased risk for neck and shoulder MSDs.
- Main risk factors for work related musculoskeletal disorder can be categorized under one or combination of Force, Posture Repetition and Duration of task.
- WRMSD is not only prevalent in computer professionals but, various health professionals like sonographers, endoscopist, surgeons, ophthalmologist, dentist etc. also reported to be suffering from this disorder.
- DASH, NDI etc. are among various standard tools to measure function following musculoskeletal disorder.
- Interventions such as personal, engineering and administrative according to the implementation hierarchy as recommended by NIOSH are among some of effective intervention at managing the WRMSD.