A

DISSERTATION REPORT

ON

EVALUATION OF RISK RELATED TO MUSCULOSKELETAL DISORDERS ON BUILDING CONSTRUCTION SITES

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF

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IN
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BY

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UNDER THE GUIDANCE OF
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CERTIFICATE

This is to certify that the dissertation entitled **"Evaluation of Risk Related To Musculoskeletal Disorders On Building Construction Sites"** being submitted by **Arun Singh Dagur (2014PIE5033)** is a bonafide work carried out by him under my supervision and guidance, and hence approved for submission to the **Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur** in partial fulfillment of the requirements for the award of the degree of **Master of Technology (M.Tech.) in Industrial Engineering**. The matter embodied in this dissertation report has not been submitted anywhere else for award of any other degree or diploma.

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CANDIDATE'S DECLARATION

I hereby declare that the work which is being presented in this dissertation entitled **"Evaluation of Risk Related To Musculoskeletal Disorders On Building Construction Sites"** in partial fulfillment of the requirements for the award of the degree of **Master of Technology (M.Tech.)** in **Industrial Engineering**, and submitted to the **Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur** is an authentic record of my own work carried out by me during a period of one year from July 2015 to June 2016 under the guidance and supervision of **Prof. Awadhesh Bhardwaj** of the Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur.

The matter presented in this dissertation embodies the results of my own work and has not been submitted anywhere else for award of any other degree or diploma.

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ABSTRACT

Work related musculoskeletal disorders (WMSDs) are one of the most common causes of occupational injuries that appear in the various body parts of the body. These may produce in any type industry, working offices, libraries, vehicle drivers and construction work etc. The people in building construction are highly associated with tedious work like brick layering, plastering and other assisting work like manual handling of bricks, cements. They are compelled to carry out a large amount of physical and strenuous tasks which often lead to musculoskeletal disorders. This paper is aimed to investigate the self-reported Work-related Musculoskeletal Disorders (WMSDs) among building construction workers by random selected construction workers at different building construction sites. Firstly Quick Exposure Check (QEC) has been used to evaluate physical exposure of risk related to WMSDs among the workers. Further the standardized Nordic Musculoskeletal Questionnaire (NMQ) was used to measure the prevalence of risk related to WMSDs in various parts of body; raised from their work like brick layering, plastering and other assisting work like lifting of heavy load, pulling/pushing, carrying/transporting. A random sample of 100 people was selected from various construction sites. Obtained data were analyzed using SPSS software with some tests including chi-square test. The results of assessment of physical exposure to musculoskeletal risks by QEC technique showed that in 57% of the studied workers, the level of exposure to musculoskeletal risks was very high. The result of NMQ identifies the part of the body mostly affected by the pain are lower back, upper back followed by shoulder associated with intensive labour across the entire work groups. The result shows that most affected part in brick layering work is Lower-back pains followed by Upper-back pain, shoulder pain. In plastering, the Lower-back remains the most affected part followed by shoulder and Wrist. In assistants, most affected part is the Lower-back followed by shoulder, neck which the workers experienced. Therefore in order to reduce the risk of musculoskeletal disorders among building construction workers redesigning of the workplace and reducing the load carried by the workers are highly recommended. Use of hand trollies to carry heavy loads such as mixed cement, sand and bricks etc.

Keywords: work related musculoskeletal disorder, standardized Nordic musculoskeletal questionnaire, bricklayers, plasterers, assistants.

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ABBREVIATIONS

QEC	Quick Exposure Check
NMQ	Nordic Musculoskeletal Questionnaire
RULA	Rapid Upper Limb Assessment
REBA	Rapid Entire Body Assessment
FIOH	Finnish Institute of Occupation Health
OCRA	Occupational Repetitive Actions
WMSD	Work Related Musculoskeletal Disorder
OWAS	Ovako Working posture Analysis System
SI	Strain Index
DUE	Distal Upper Extremity
CTS	Carpal Tunnel Syndrome
NPF	Normalized Peak Force
ATA	Actual Technical Actions
RTA	Reference Technical Actions
CTEs	Certified Professional Ergonomists
VADE	Virtual Assembly Tool
NIOSH	National Institute for Occupational Safety and Health
OSH	Occupational Safety and Health
EN 1005 -3	European Standards, Safety of Machinery-Human Physical Performance Part 3

CHAPTER 1- INTRODUCTION

1.1 Background and Motivation

Work Related Musculoskeletal disorders (WMSDs) in the workplace have a huge impact, emerging as a growing problem in our modern societies (Yelin et al., 1990). They represent the second largest cause of short-term or temporary work disability after the common cold. Work-related musculoskeletal disorders (WMSDs) are responsible for injury in many working populations and are known as a vital occupational problem with increasing compensation and health costs, reduced productivity, and poorer quality of life (Karwowoski & Marras, 2003). Almost all work requires the use of the arms and hands. Therefore, most WMSD affect the hands, wrists, neck, elbows and shoulders. Work using the legs can lead to WMSD of the legs, ankles, hips, & feet. Some back problems also result from repetitive activities. Work-related musculoskeletal disorders (WMSDs) are a group of painful disorders of tendons, muscles, and nerves. Carpal tunnel syndrome, tendonitis, thoracic outlet syndrome, and tension neck syndrome are examples. WMSDs are reported to cause lost work time or absenteeism, transfer to another job, increase work restriction (Yelin et al., 1990) or disability than any other group of diseases with a significant economic toll on the individual, the society and organization as a whole. Findings of scientific research have identified psychosocial/organizational, physical, and individual occupational "risk factors" for the development of WMSDs. These studies have measured the stages of a diversity of factors across a range of occupations at different levels of risk, and examined their relations with the incidence (or prevalence) of MSDs for the populations concerned (Campo et al., 2008).

Moreover, WMSD is the most costly form of work disability. It was assessed that the cost of WMSD was nearly 215 billion dollars in 1995 in the United States; 26 billion Canadian dollars in 1998 in Canada, and 38 billion Euros in 2002 in Germany. India has been fighting with orthodox public health problems such as communicable diseases, high rate of population, malnutrition, growth, and insufficient medical care, apart from the occupational health problems. MSD is one of the major occupational health problems in India and estimates have shown that MSD adds to about 40% of all costs toward the treatment of work-related injuries. Decrease of certain types of movements and improvements in posture can result in reduced rates of WMSDs and in prolonged work lives. It is expected that this could be largely implemented to help reduction in Construction related Work-related Musculoskeletal Disorders (Yelin et al., 1990).

There are several tools which can be used to find the ergonomic risk of a particular job. Some tool takes more time than other, some disturbs the worker working and in some tool just videography the task can able to assess the risk. There are several tools in which prior training is necessary to apply the tools whereas others can be applied without prior training. So proper knowledge of the tool led us to find which tool can be applied in a particular task.

In order to get proper analysis of a specific task one may use more than one tool to analyse the task. This gives the proper information about the task whether it is at risk or no risk state. However confusion may arise if two tools give different results. Since there are many different tools i.e. Strain Index, Rapid Upper Limb Assessment, Rapid Entire Body Assessment, Quick Exposure Check, and Occupation Repetitive Actions checklist. But we have applied only QEC and Nordic Musculoskeletal Questionnaire in same situation of building construction sites to gain a better understanding of risk level among the workers and to find the prevelance of risk among the workers assosiated with building construction work.here is basic introduction to these tools.

- QEC: The Quick Exposure Check (QEC) (David et al., 2003, 2008; Li & Buckle, 1999) is posture-based. Combining the observer's assessment with the worker's reactions to closed questions, it permits MSD risk factors to the back, arms, neck and upper extremities at a workstation to be assessed. In addition to an overall score for the entire body (QEC General), this method provides a risk index for each directed area (back, shoulder-arm, wrist-hand and neck). The assessment takes posture, movement, effort, frequency and shift length into account along with psychosocial risk factors and exposure to vibration.
- FIOH: The Ergonomic Workplace Analysis method, established by the Finnish Institute of Occupational Health (FIOH) (Ahonen et al., 1989) offers a wide-ranging ergonomic analysis on 14 subject items: (1) Attention required, (2) Decision making, (3) Lifting, (4) Task restrictions (5) Accident risk, (6) Task content, (7) Working posture and movements (multiple body areas), (8) Personal contact and communication, (9)

Physical workload, (10) Workstation design, (11) Repetitiveness, (12) Noise, (13) Thermal environment and (14) Lighting. The (expert) allocates each item a grade on a scale of either four or five levels. Each level matches to a detailed condition designated by the method (i.e., a score of 5 shows a situation posing a risk to the worker's health, while a score of 1 shows acceptable and safe conditions). The workers estimate the same features of the workstation on a four-level scale (very good, good, poor and very poor). In this study, a total probable score out of 10 was established for each item by joining the worker's and the observer's assessments.

- Strain Index (SI): (Moore & Garg, 1995) quantifies exposure to MSD risk factors for the hands and wrists. It offers an index that takes into account the level of perceived exertion, number of efforts, duration of effort as a percentage of cycle time, hand and wrist posture, work speed and shift length. Measurements of duration and frequency were attained from the time-motion study. The force required (perceived exertion) to do the job was evaluated by the workers using a perceived exertion scale (Borg, 1998).
- HAL: The Hand Activity Level (HAL) threshold limit values method calculates the risk to the hands and wrists. The calculation is based on the hand activity level and takes into account the repetition and duration of effort along with the Normalized Peak Force (NPF) of the hand, which is the relative level of effort on a 0 to 10 scale analogous to 0 to 100% of the applicable population reference strength. Task hand peak force was assessed using a perceived exertion Borg scale (Borg, 1998) and was normalized using the 5th percentile industrial female worker strength. The number of efforts per second and their duration as a percentage of cycle time were attained from the time-motion study
- OCRA: The OCRA index and OCRA checklist (Colombini, 1998; Occhipinti, 1998) is based on the ratio between Actual Technical Actions (ATA), obtained by evaluating the task, and Reference Technical Actions (RTA). The RTA value is attained by taking into account the frequency and repetitiveness of movements, type of posture, use of force, recovery period distribution and additional factors such as localized tissue compression and vibration. The OCRA method provides two separate indices (shoulder and elbow/wrist/hand) for each of the right and left sides of the body. The OCRA checklist has series

of questionnaire to be asked from worker on different issues to find the overall score and thereby risk.

- RULA: The Rapid Upper Limb Assessment method (RULA) (McAtamney & Corlett, 1993) delivers an overall score that takes into account postural loading on the whole body with particular attention to the trunk, neck, shoulders, arms and wrists. The overall score also considers the time the posture is held, the force used and the repetitiveness of the movement.
- REBA: The Rapid Entire Body Assessment method (REBA) (Hignett & McAtamney, 2000) method delivers an overall score that takes all the body parts into account (trunk, neck, legs, shoulders, arms and wrists). The overall score takes into consideration the similar additional factors as RULA as well as the quality of the hand-coupling.
- EN 1005-3: The European Standard, Safety of machinery Human physical performance Part 3: Recommended force limits for machinery operation is a general-purpose method that helps designers evaluate the risk related to force application during work. The acceptable force is obtained by applying numerous multipliers, i.e., duration, speed and frequency of actions, to a basic capability, which is denoted by the maximum capability of the 15th percentile worker. The EN 1005-3 standard was applied to the shoulder joint for the purpose of this study. The 3D SSPP software (version 5 and 6) from the University of Michigan Center for Ergonomics was used to obtain the population capability distribution parameters that in turn were used to obtain the basic value for the shoulder (i.e., the 15th percentile maximum moment for the target worker population; see EN 1005-3). The decreased valu was obtained by following the calculation steps using the standard’s proposed coefficients.

1.2 Selection of an Analysis Tool

A survey of Certified Professional Ergonomists (CPEs) was conducted by (Dempsey et al., 2005) to collect information on the forms of basic tools, direct and observational measurement techniques, and software used by practitioners. The inspiration for the survey was to better understand what types of tools and methods practitioners use, their views of these tools, and to possibly gain an understanding of the constraints or preferences that influence this selection. Reasons for using or not using a selection of tools were also surveyed. Of 578 surveys that were delivered to CPEs and Associate Ergonomics Professionals, 308 were reverted for a response rate of 53%. The respondents tended to be inclined towards physical ergonomics, as the survey mainly focused on this area of ergonomics. A high percentage of respondents reported using tape measures, video cameras, stopwatches and digital cameras. The most commonly used observational methods were those involving manual materials handling, whereas the most commonly used direct measurement tools were pinch and grip dynamometers and push/pull gauges. The frequency and type of software, checklists, and anthropometric data used are there (Dempsey et al., 2005).

Here QEC risk assessment tool has been used for this study because-

- It is a pen and paper based exposure assessment tool.
- Only observation based technique.
- Both observer and worker’s involvement.
- Worker’s assessment has more weightage so more practical tool.

1.3 Purpose of the Present Study

The purpose of the present study was to find out prevalence of risk related to musculoskeletal disorders using Nordic musculoskeletal questionnaire and physical exposure to the risk using Quick Exposure Check risk assessment tool on building construction work.

- Find out result of total population regarding musculoskeletal problems in different parts of body using NMQ.
- Determine the results of QEC tool resulting level of risk among the workers.
- Check the association between the QEC risk level and the prevalence rate of reported musculoskeletal problems by using Chi Square test of independence.
- Now find out the result related to prevalence of risk of different type of workers in building construction work like brick layers, plasterer and other assisting workers.

CHAPTER 2 - LITERATURE REVIEW

The ergonomic risk is always the concern of the industry due to worker safety as well as due to higher worker compensation cost. For this ergonomic risk must be assessed so that the high risk job can be identified and removed. This can be done by many methods but here we are taking the method Quick Exposure Check (QEC) to find out physical exposure of the risk related to WMSDS in building construction work and other method is Nordic musculoskeletal questionnaire to find out prevalence of risk related to WMSDs in building construction work. The matter content available on this topic is found to be highly scattered in literature. An attempt has been made in this chapter to present the matter content in a systematic manner under different sections as given below.

2.1 Quick Exposure Check (QEC)

QEC is new exposure tool which has been developed for health and safety practitioners to assess the exposure of risks related to work-related musculoskeletal disorders. The tool is based on the need of practitioners' for such type of tool and "state of the art" research findings. QEC has been tested, modified, assessed and validated based upon various practical tasks, with the help of up to 150 practitioners. The results of studies shown that the tool has a very high level of sensitivity and usability, and exhibits highly acceptable inter/intra-observer reliability. Field studies also indicate that this QEC tool is, reliable and applicable for a wide range of tasks. With a short period of training and some practice, assessment can normally be completed within 10 minutes for each task (Guangyan Li & p. Buckle, 1998).

The Quick Exposure Checklist (QEC) quickly measures the exposure to risks for work-related musculoskeletal disorders (WMSDs) (Li & Buckle, 1999). QEC is based on the practitioners needs and research on key WMSD risk factors. The tool is based on epidemiological evidence and investigations of OSH (Occupational Safety and Health) practitioner's aptitudes for undertaking assessments (David et al., 2008). The development of the tool involved a novel participatory approach and had input from approximately 160 health and safety practitioners. The development of action level was achieved by assessing a number of industrial tasks at the same time using the QEC and RULA and compare assessment score for both methods. The action level of QEC were then extracted from the corresponding RULA score (Brown & Li, 2003). The method has been published and is easily available in electronic form (David et al., 2003).

The QEC allows the four main body areas to be assessed and includes practitioners and workers in the assessment. Trials have determined its usability, intra- and inter-observer reliability, and validity which show it is valid to a wide range of working activities. The tool focuses mostly on physical workplace factors, but also includes the evaluation of psychosocial factors (David et al., 2008). About 150 practitioners have tested QEC and modified and validated it using both simulated and real tasks. QEC has a high level of sensitivity and usability and largely acceptable inter- and intra-observer reliability. Field studies confirm that QEC is applicable for a wide range of tasks. With a short training period and some practice, assessment can normally be completed quickly for each task. The construction validity ofvthe QEC is reported in (Li & Buckle, 1999). The tool is found to have a high sensitivity (the ability to identify a change in exposure before and after an ergonomic intervention), a good intra-observer reliability, and a practically acceptable inter-observer reliability (Li & Buckle, 1999).

This tool was used in Iranian sugar producing factory on 116 workers which were randomly selected from production workshops and included in the study. The highest prevalence of risk was reported in knees (58.6%) and the lower back (54.3%). In 99.1% of the workers, the level of risk related to physical exposure of MSD established with QEC was high and very high. Awkward postures, manual material handling, and long hours of standing were the major ergonomics problems. There was a very high rate of WMSDs in this industry. The level of exposure to WMSD risk factors was high and suitable corrective measures for reducing risk level among the workers were essential (choobineha et al., 1999).

In a major furniture manufacture located in Tehran, 500 workers were examined in the study. These workers were divided into various groups, including various production lines of water-heater, air ondition, electromotor production line, dunnage making hall, plastic hall, smithery, restaurant, store and supervisors, facilities, transportation, assembly of absorptive refrigerator and drivers. The results from NMQ and performing the evaluation tool QEC showed that, there was a significant relevance between outbreak of back pain in body and workgroups (P=0.005) and between the of pain in neck of workers and workgroup as well. A significant relevance of P=0.005 indicating that, the working in the above mentioned work-stations causes pain in both back and neck among the workers. Between other parts of the body and workgroup no significant relevance observed. The results from Quick Exposure Check (QEC) in one hundred working posture related to task have shown that 10% of them fall into first and second level of QEC risk level and 90% of them were categorized in third and fourth levels of QEC risk level (Mirmohamadi et al., 2004).

A study aimed to find out the risk of work-related upper-limb musculoskeletal disorders in cleaning workers during the work task of vacuuming in the facory. In total, 24 cleaning workers were observed while performing vacuum cleaning tasks in the normal condition of their employment in government schools, hospitality and commercial office space sectors. Risk of upper-limb musculoskeletal disorders was observed using observational assessment tools: Quick Exposure Check (QEC); the Rapid Upper Limb Assessment (RULA). Mean results concluded that cleaning workers who performing the task of vacuum cleaning are at the risk of work-related upper-limb musculoskeletal injury, regardless of whether they use a back-pack or canister machine. Government school cleaners experienced high risk of work-related upper-limb musculoskeletal disorders than workers in either the hospitality or commercial office space sectors (Bell & Steele, 2012).

Check (QEC) tool was used in Gari-Frying Company while awkward posture was assessed using the arm reach ratio. 97.5% of workers complained of pain in the shoulder region, while QEC puts pains into region above shoulder/arm, back and the wrist. Results showed that stirring task in the company was very strenuous than loading and unloading and the sitting sideways posture as the most stressful posture. Also, overstretching was an identified risk factor among the workers under study since the deviate from the neutral position in an angle of $\theta=77.22°$ to the vertical. It was find out that the gari-frying process in company is very tedious and has some ergonomic risks like repetitive stress, awkward posture and other a risk of musculoskeletal disorders making the workers work in industry in discomfort (Samuel et al., 2013).

A cross-sectional study, 100 male employees (21-41yrs) using census sampling method participated among Workers of a Dairy Products Factory. Data were collected using Nordic musculoskeletal disorders questionnaire (NMQ) and QEC method for assessment of postures related to WMSDs during the work. Data were analyzed using statistical tests through SPSS. The results of assessment of physical exposure to musculoskeletal risks by QEC tool showed that in 52% of the studied population, the level of exposure to risks was in Action Level (AL) 1, 9% in Action Level 2, 30% in Action Level 3, and 9% in Action Level 4. Also, the getting revealed a significant relationship between the prevalence rate of risk and the risk level (low and high risk) achieved by QEC tool. Prevalence of symptoms of pain in different parts of the body had an association with age of worker, job experience of worker, shift working and BMI. Corrective measures seemed very essential in improvement of working condition in the studied workers in the factory (Zamanian et al., 2014).

There is a significant association between age, Body Mass Index and QEC risk level of musculoskeletal disorders occurrence (Abedini et al., 2012). Results of the QEC scores were found to be excessive for the shoulder/arm, wrist/hand and neck, whereas the scores for the back were found to be high for static use and moderate for moving (Bulduk et al., 2014).

Work-related musculoskeletal disorders, especially low back pain and neck pain cause substantial socio-economic losses to the workers. Professional drivers of buses and other vehicles are particularly at high risk for developing back and neck pain from long time sitting and vehicular vibration. This study assesses ergonomic exposure on the developmental risk of Work-related musculoskeletal disorders among bus drivers. A total of 280 male drivers with small body pain in any part of body were randomly selected for the study, and ergonomic information regarding the driver's seat was collected from a questionnaire. Then the exposure and risks related to WMSDs were assessed using Quick Exposure Check (QEC), Rapid Entire Body Assessment method (REBA), Rapid Upper Limb Assessment method (RULA) and Nordic Musculoskeletal Questionnaire (NMQ). The results of QEC showed that back and shoulder had very high exposure of risk related to neck and wrist. From NMQ, it was found that 26% of drivers problems in the neck, 24% in the back, 20% in the upper limbs, 6% in the knees and 4% in the ankles. This study finds out the risks of producing WMSDs among bus drivers. Exposure to unsafe ergonomic practices/conditions during the work and health risks among the workers was evident from the findings of the study. Ergonomic intervention measures with workplace health promotion activities need to be implemented in order to reduce the level of risk related to work-related musculoskeletal disorders among bus drivers. (Yasowant et al., 2015)

2.2 Standard Nordic Questionnaire

Standardised questionnaires for the investigation of musculoskeletal symptoms in an ergonomic or occupational health context are presented. It is shown in the Appendix I. The questions are forced choice variants and may be either self-administered or used in interviews. They focus on symptoms most often occur in an occupational setting. The reliability of the questionnaires has been shown to be acceptable. Specific characteristics of work strain are shown in the frequency of reactions to the questionnaires. (Kuorinka et al., 1987)

This study has considered the musculoskeletal problems associated with the use of pipettes through a questionnaire study of people. The groups are made of an exposed (i.e. pipette users) and a non-exposed (i.e. non-users) cohort. Eighty questionnaire responses were filled by pipette users and 85 were filled by non-usersvfrom six orga~sations; a response rate of approximately 55% for each user of the study cohorts. The reported occurrence of elbow and hand complaints [using the general version of the Nordic musculoskeletal questionnaire (Kuorinka et al, 1987)] was significantly large in the pipette user population as compared to the control population. There is an increase in the percentage of those people who has reporting hand complaints as the duration of the working period involving the continuous use of pipettes increases. Almost 90% of people in the highest exposure group (continuous use for more than 6Omin) reported hand complaints. Users identified a number of features which create plunger operated pipettes more problems to use: all of the female population which reported problems identified plunger operation as a design deficiency. Users also found out features of the general working environment which made the pipetting tasks more difficult. Finally this study concludes that a number of work-relatedvfactors may affect the efficiency and comfort of people performing laboratory tasks using pipettes. (David & Buckle, 1997)

The purpose of the study wa to assess risk factors in dentistry which may contribute to musculoskeletal disorders among the people. A Nordic questionnaire was used to find out common work tasks, and to estimate one year prevalence for troubles (65% for the body parts like neck/shoulder, 59% for the low back). In a field study working postures of people and electromyography (shoulder/neck) were registered during the three most common work tasks in dentistry. Prolonged neck flexion and upper arm abduction were found, as well as high static muscle activity levels (splenius and trapezius muscles). There is no difference between work tasks were found regarding postures, frequencies of movements of body parts or muscle activity. Alterations between the three work tasks do not establish sufficient variation to reduce musculoskeletal load on the neck and shoulders in dentistry (Finsen et al., 1998).

Reports in the literature have identified a need for internationally standardized and reliable measurements to analyse musculoskeletal symptoms. Screening of musculoskeletal disorders may serve as a diagnostic tool to evaluate the work environment. The Nordic general questionnaire is a standardized instrument used to analyse musculoskeletal symptoms in an ergonomic or occupational health context. Purpose: To translate and adapt a version of the Nordic general questionnaire into Brazilian Portuguese and evaluate its reliability. Method: The cross-cultural adaptation was performed according to internationally recommended methodology, using the following guidelines: translation; back-translation; committee review; pretesting. First, the questionnaire was independently translated into Portuguese by two teachers and one doctor, and a consensus version was generated. Second, two other translators performed a back-translation independently from one another. This version was then submitted to a committee, consisting of six specialists in the area of knowledge of the instrument, to evaluate its equivalence to the original instrument. The final version was pretested on 20 subjects randomly selected in an outpatient clinic. Reliability was assessed by a test–retest procedure at 1-day intervals using the Kappa coefficient in a group of 40 subjects. The Kappa agreement value were calculated for each one of the four questions of the questionnaire. The agreement among the same observers was substantial, varying from 0.88 to 1, according to the Kappa values. Results: these demonstrated strong agreement of the instrument, suggesting that the Brazilian version of the 'Standardized Nordic Questionnaire' offers substantial reliability (Barros & Allexandre, 2003).

Since 2002, in France's Pays de la Loire region, an epidemiologic surveillance system of work-related, upper-limb musculoskeletal disorders has been implemented to assess the prevalence of WMSDs and their risk factors in the working population. The survey was based on a network of occupational physicians and used the recommendations of a group of European experts (criteria document consensus). In 2002–2003, 80 of 400 OPs volunteered to participate. All people who participated underwent a training program to standardize the physical examination. Health status was checked by self administered questionnaire. Occupational risk factors were also checked by self-administered questionnaire. All people's exposure scores were computed for each anatomic zone by adding the risk factors which are into account by the criteria document. The most frequent disorders which produced was rotator cuff syndrome followed by carpal tunnel syndrome and lateral epicondylitis. The prevalence of work related musculoskeletal disorders increased with age and varied highly across economic sectors and occupations. More than half of the workers were exposed to at least 2 risk factors of WMSDs. According to the criteria document, a high percentage of WMSD cases could be devided as probably work related (95% in men and 89% in women age <50, and 87% in men and 69% in women ag >50). Nonspecific upper-limb problems and specific upper-limb MSDs are most common in the working population. These results of this study show the need to implement prevention programs in almost every sector to reduce the prevalence of WMSDs. (Roquelaure et al., 2006).

The Nigerian people are highly related with various type of work like block-making, building construction works, and manual farming, this is because there is country is mostly a labour-intensive. They are pressurized to carry out a large amount of physical and strenuous work. In this paper, it is aimed at finding self-reported Work-related Musculoskeletal Disorders (WMSDs) by randomly selected coworkers related to construction in one of the states in Nigeria. Results of the Nordic questionnaires and semi-structured interviews revealed that the workers have at many times experienced pain/discomfort which is produced from their work. A various type of the semi-skilled and unskilled workers who have a very little knowledge or no knowledge of the ergonomics risk factors inherent in their work, resort to taking of drugs like pain relievers very often to reduce the pains. The part of the body which are highly affected by the pains associated with intensive labour across the complete work groups is the lower back, after that the upper back and shoulders. Most of the skilled workers in their work were identified manual lifting of high loads and poor work environment as the major cause of the MSDs. The result of this study revealed a number of pivotal factors that need to be addressed in order to reduce Work-related Musculoskeletal Disorders among workers in Building Construction in Anambra State. These factors contains: redesigning of workplace to reduce the frequent bending and twisting of trunk by the workers, a high scale ergonomics risk factors awareness programmes to sensitize the semi-skilled and unskilled workers on the dangers of MSDs, as well as the dangers of drug abuse, reduction on the weight of mixed concrete, stone, and sands carried by the labourers, and there should be adequate and timely rest. (Harold et al., 2013)

CHAPTER-3 RESEARCH METHODOLOGY

3.1 Course of Action

- Selection of the various building construction sites is done where the study has to be performed.
- Standard Nordic questionnaire was filled by every worker to find is there any pain in the body of the worker or not.
- Worker's assessment form was filled by workers which are performing the task on the building construction site
- Observation of various task done
- By observation, observer's assessment form was filled
- Filling the Quick Exposure Check by the worker with the observer assistance and calculation of score was done for every task.
- SPSS software is used for getting results from NMQ questionnaire to find out the prevalence of risk related to WMSDs.
- Results of QEC tool also received from software to find out physical exposure to the risk related to WMSDs.
- chi square test has been used to determine the association of QEC risk level with the prevalence rate of reported musculoskeletal problems in building construction work.
- Results regarding different type of workers revealed from collected data.
- Analysis of result has been done to reduce the level of risk among the workers related to building construction site.

3.2 Ergonomic Risk Assessment Tools Used

3.2.1 Quick Exposure Check (QEC)

The quick exposure check (QEC) rapidly examines the exposure to risks for work-related musculoskeletal disorders (Li & Buckle, 1999). The QEC General index includes the indices for all parts of the body (back, hand/wrist, shoulder/arm, neck). The percentage score is evaluated by dividing the overall assessment score by the maximum overall score (X/X_{max}). The authors of this general index suggest four categories of risk (Brown & Li, 2003). To allow comparisons with other methods, action levels 2 and 3 were combined to form one category (moderate). The “high” and “very high” risk categories proposed by the authors (Davidet al., 2008) for the QEC Hand/wrist and QEC Shoulder/arm indices were merged into a single “high” category, creating three risk categories. When more than one worker could evaluate a given workstation, the assessments were averaged to provide a single index for each.

QEC is based on the practitioners’ requirements and research on major WMSD risk factors (Bernard, 1997). About 150 practitioners have verified QEC and modified and validated it using both simulated and real tasks. QEC has a high level of sensitivity and usability and mostly acceptable inter and intra observer reliability. Field studies confirm that QEC is relevant for a wide range of tasks. With a short training period and some practice, evaluation can normally be completed rapidly for each task. QEC gives an evaluation of a workplace and of equipment design, which eases redesign. QEC helps to prevent many kinds of WMSDs from developing and trains users about WMSD risks in their workplaces.

3.2.1.1 Procedure for QEC

QEC uses five steps:

Step 1: Self-Training - First-time QEC users must read the “QEC User Guide” as shown in next section to understand the terminology and assessment categories that are used in the checklist. Experienced users can skip step 1.

Step 2: Observer’s Assessment Checklist - The QEC user (the observer) uses the “Observer’s Assessment” checklist in (Appendix III) to conduct a risk assessment for a particular task. Most checklist assessment items are self-explanatory. New users can refer the “QEC User Guide”. At least one complete work cycle is observed before making the assessment. If a job consists of a variety of tasks, each task can be evaluated separately. Where a job cannot simply be broken down into tasks, the “worst” event within that job when a certain body part in question is most heavily loaded should be observed. The evaluation can be carried out by direct observation or by using video footage (if the information about the “Worker’s Assessment” can be obtained at another time; see step 3).

Step 3: Worker's Assessment Checklist- The worker being observed must complete the "Worker's Assessment" checklist as shown in (Appendix II).

Step 4: Calculation of Exposure Score- Use the "Table of Exposure Scores" (Appendix III) to calculate the exposure scores for each task assessed as follows:

- Circle all the letters corresponding to the reactions from the "Observer's Assessment" and the "Worker's Assessment."
- Mark the numbers at the intersection point of every pair of circled letters. For example, for the exposure to the back, number 8 should be selected as score 1, corresponding to the assessment items A2 and A3.
- Calculate a total score for each body part.

Step 5: Consideration of Actions - QEC rapidly identifies the exposure levels for the back, shoulder/arm, wrist/hand, and the neck, and the method assesses whether an ergonomic intervention can effectively reduce these exposure levels. Preliminary action levels for the QEC, based on QEC and RULA (McAtamney & Corlett, 1993) evaluations of a variety of tasks, have been suggested (Brown & Li, 2003). The exposure level E is calculated as percentage rates in between the actual total exposures score X and the maximum possible total X_{max}. For manual handling tasks, $X_{max\ MH}$ = 176; for other tasks, X_{max} = 162.

$$E (\%) = X/X_{max} \times 100\%$$

The action level of QEC consists that exposure level < 40 % is considered at low risk by QEC. Range of exposure level ≥40% to <70% is said to be at moderate risk. Exposure level of QEC is found to be greater than 70 % then job is said to be at higher risk. The risk level along with the range of exposure level is shown in Table 1.

Table 1 - QEC action level

QEC range	QEC Risk Level	Description
≤40	Low	Acceptable
41-50	medium	investigate further
51-70	High	investigate further and change soon
>70	Very high	investigate further and change immediately

3.2.1.2 A Guide to the Use of the Exposure Assessment Tool - QEC

This exposure tool consists of 9 steps has been designed to evaluate the change in exposure to musculoskeletal risks before and after an ergonomic intervention.

Step 1 - Exposure assessment for the back: Back posture (A1-A3) - The evaluation for the back posture should be made at the instant when the back is most heavily loaded. For example, when lifting a box, the back may be considered under highest loading at the instant when the person leans or reaches forward to pick up the load.

- The back can be considered as *"Almost neutral"* (Level A1) if the person is seen to work with his/her back flexion/extension, twisting, or side bending less than 20°, as shown in Figure 1.

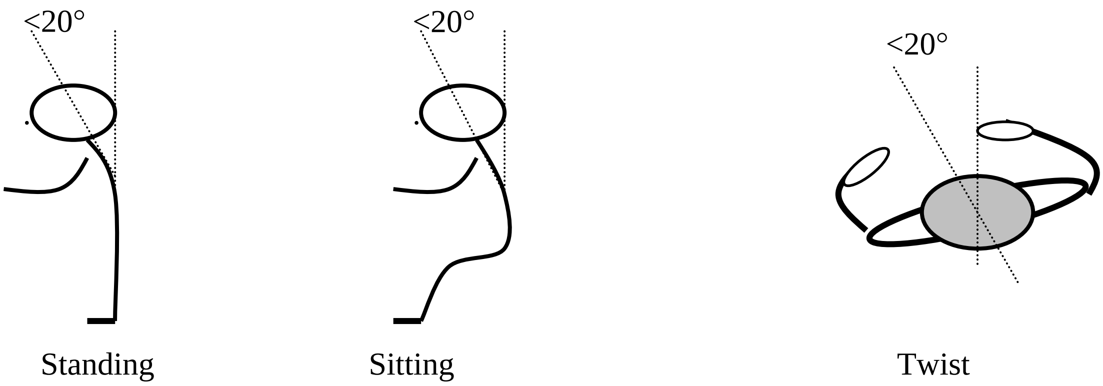

Figure 1 - Back is almost neutral

- The back can be considered as *"Moderately flexed or twisted"* (Level A2) if the person is seen to work with his/her back flexion/extension, twisting or side bending more than 20° but less than 60°, as shown in Figure - 2.

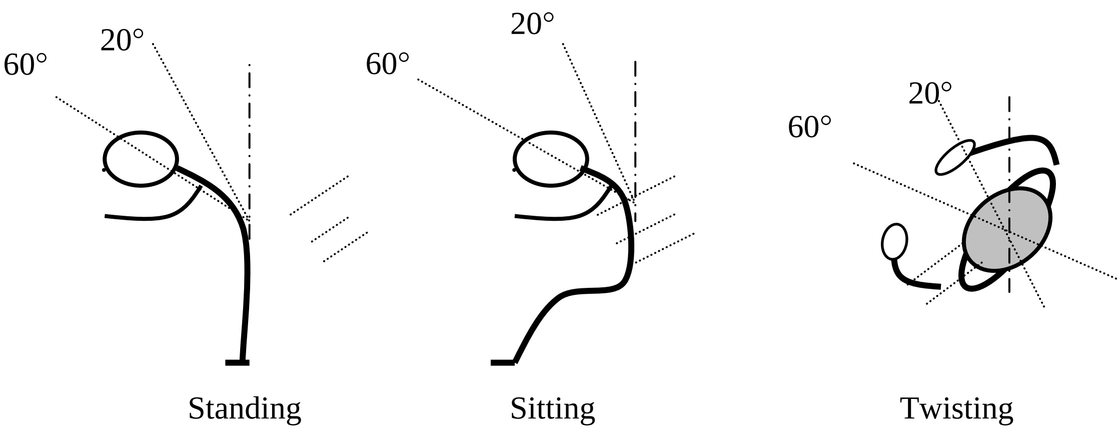

Figure 2- Back is flexed or twisted

- The back can be considered as *"Excessively flexed or twisted*" (Level A3) if the person is seen to work with his/her back flexion or twisting more than 60° (or close to 90°), as shown in Figure-3.

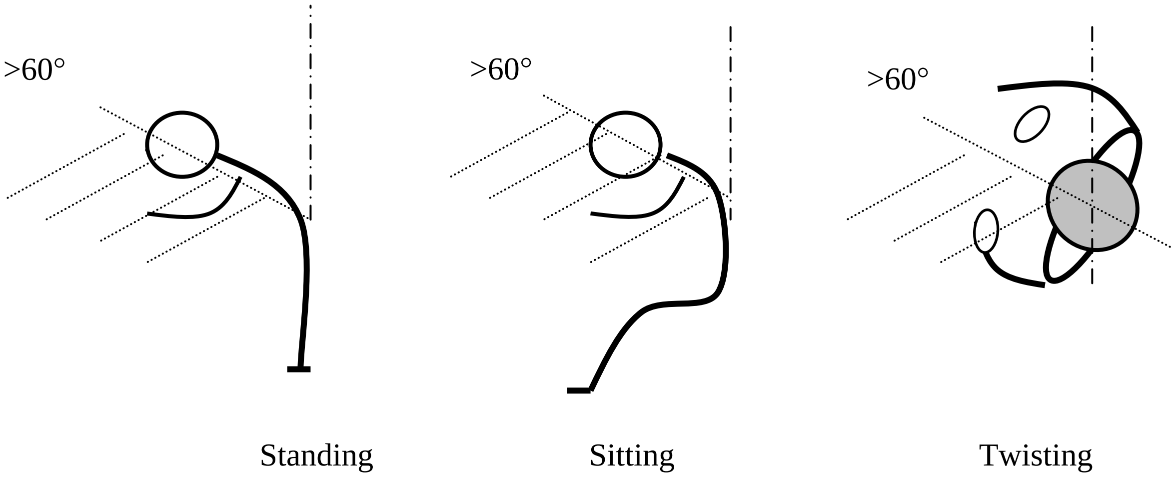

Figure 3 - Back is excessively flexed or twisted

Step 2 - Exposure assessment for the back: Back Movement (B1-B5)

- For manual material handling tasks, assess B1-B3. This refers to how frequently the person needs to bend, rotate his/her back when doing the task. Several back movements may happen within one task cycle.
- For tasks other then manual handling, such as sedentary work or repetitive tasks executed in standing or seated position, ignore B1-B3 and assess B4-B5.

Step 3 - Exposure assessment for the shoulder/arm: posture (C1-C3) – Evaluations should be made when the shoulder/arm is most heavily loaded during work, but not necessarily at the same time as the back is evaluated. For example, the load on the shoulder may not be at the highest level when the person bends down to pick up a box from the floor, but may become greater afterwards when the box is placed at a higher level.

Step 4 - Exposure assessment for the shoulder/arm: Movement (D1-D3) - The movement of the shoulder/arm is regarded as

- "Infrequent" if there is no regular motion pattern.
- "Frequent" if there is a regular motion pattern with some short pauses.
- "Very frequent" if there is a regular continuous motion pattern during work.

Step 5 - Exposure assessment for the wrist/hand: posture (E1-E2) – This is evaluated during the performance of the task at the point when the most awkward wrist posture is adopted, include wrist flexion/extension, side bending (ulnar/radial deviation) and rotation of the wrist around the axis of the forearm. The wrist is considered as "*almost straight*" (Level E1) if its movement is restricted within a small angular range (e.g. <15°) of the neutral wrist posture (Figure-4). Otherwise, if an obvious wrist angle can be observed during the performance of the task, the wrist is considered to be "*deviated or bent*" (Level E2, Figure-5).

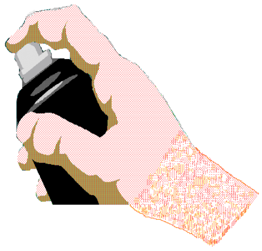

Figure 4 - Wrist is almost straight

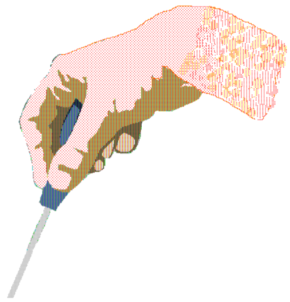

Figure 5 - Wrist is deviated or bent

Step 6 - Exposure assessment for the wrist/hand: movement (F1-F3) - This refers to the movement of the wrist/hand and forearm, apart from the movement of the fingers. One motion is counted every time when the same or similar motion pattern is repeated over a set period of time (e.g., 2 minutes).

Step 7 - Exposure assessment for the neck - The neck can be considered to be "*excessively bent or twisted"* if it is bent or twisted at an obvious angle (or more than 20°) related to the torso.

Step 8 - Worker's assessment of the same task - After the observer's assessment is made, ask the workers to reply the questions as shown in the Appendix III. Explain the meaning of the terms to him/her when required.

Step 9 - Calculation of the total exposure scores - The total exposure scores can be achieved by combining the assessments from the 'observer' (A-G) and the 'worker' (a-e) as shown in the Appendix III. Confirm that the correct combined scores have been determined before adding them into the total.

3.2.2 Standard Nordic Questionnaire

Standardised questionnaires for the investigation of musculoskeletal symptoms in an ergonomic or occupational health context are presented. It is shown in the Appendix I. The questions are forced choice variants and may be either self-administered or used in interviews. They focus on symptoms most often occur in an occupational setting. The reliability of the questionnaires has been shown to be acceptable. Specific characteristics of work strain are shown in the frequency of reactions to the questionnaires. (Kuorinka et al., 1987)

3.2.2.1 Structure of the Questionnaires

The questionnaires consist of structured, forced, binary or multiple choice variants and can be used as self-administered questionnaires or in interviews. There are two types of questionnaires: a general questionnaire, and specific ones focusing on the low back and neck/shoulders. The aim of the general questionnaire is simple surveying, while the specific ones permit a somewhat more thoughtful analysis.

The two main purposes of the questionnaires are to serve as instruments (1) in the screening of musculoskeletal disorders in an ergonomics framework, and (2) for occupational health care service. The questionnaires may provide means to assess the outcome of epidemiological studies on musculoskeletal disorders. The questionnaires are not meant to give a basis for clinical diagnosis. Screening of the musculoskeletal disorders may serve as a diagnostic tool for assessing the work environment, workstation and tool design. The incompatibility of the user and the task or the tool has been shown to relate to the musculoskeletal symptoms. The localisation of symptoms may expose the cause of loading. The occupational health service may use the questionnaire for many purposes e g, for diagnosis of the work strain, for follow-up of the effects of improvements of the work environment, and so on.

3.2.2.2 General Questionnaire

The general questionnaire was designed to answer the subsequent question: "Do musculoskeletal troubles happen in a given population, and if so, in what parts of the body are they restricted?" With this consideration in mind, a questionnaire was made in which the human body (viewed from the back) is divided into nine anatomical sections. These sections were carefully chosen on the basis of two criteria: regions where symptoms incline to accumulate, and regions which are different from each other both by the respondent and a health surveyor. The intended choice of the back feature of the body leaves gaps when disorders are situated in the frontal part of the shoulder or on the flexor side of the upper limbs. This choice has been made because many possible causes of pain in the front part of the body (abdominal and thoracical pains, etc.) might intermix with the musculoskeletal pain in the upper thorax. Primary observations seem to point out that this choice does not significantly modify the response rates. The verbal questions deal with each anatomical area in turn, and inquire whether the respondent has, or has had, troubles in the respective area during the preceding 12 months, whether this pain is disabling and whether it is on going.

3.2.2.3 Special Questionnaires for Low Back, Neck and Shoulder Symptoms

The two specific questionnaires focuses on anatomical areas in which the musculoskeletal symptoms are most common. These questionnaires investigate more deeply into the analysis of the respective symptoms and contain questions on the duration of the symptoms over past time i. e., entire life, last 12 months and previous 7 days. The main widening in these questionnaires is that they examine more thoroughly the severity of the symptoms in terms of their effect on activities at work and during leisure time, and in terms of total duration of symptoms and sick-leave during the previous 12 months.

3.2.2.4 The usage of the questionnaire

A critical question that arises is whether the questionnaires can provide useful information which can be used in decision-making in occupational health practice. Various studies have shown that response distributions are different for different occupational groups (Jonsson and Ydreborg, 1985) and that the differences are related to the estimated workload. In some studies the questionnaires have revealed a high prevalence of symptoms and disorders in certain anatomical regions which clearly correlate to the local physical demands (e g, Brulin et al, 1985).

The questionnaire has been structured for computer analysis. Routine analysis of various statistical epidemiological programmes can be applied. The dichotomy of the response alternatives may require special consideration (see, for example, Fleiss, 1973).

In the opinion of the project group the questionnaires provide useful and reliable information on musculoskeletal symptoms. This information either gives rise to further in depth investigation or gives hints for decision-making on preventive measures.

3.2.2.5 Limitations of the Questionnaires

The general limitations of questionnaire techniques also apply to these standardised questionnaires. The experience of the person who fills out the questionnaire may affect the results. Recent and more serious musculoskeletal disorders are likely to to be remembered better than older and less serious ones. The environment and filling out situation at the time of the questioning may also influence the results. From an epidemiological viewpoint, it is obvious that this type of questionnaire is most pertinent for cross-sectional studies with all the connected limitations.

3.3 Data Collection

All the data that has been used here was collected on various building construction sites that is located in Jaipur district in Rajasthan. The main works on the construction site are brick layering, plastering and other assisting work like mixing sand and cement, delivering bricks to workstation etc. Prior to data collection, the analyst: (a) observed the subject for several cycles; (b) determined fundamental tasks of the job; and (c) confirmed with the worker that the selection of tasks was indicative of "normal operations."

The fundamental tasks of the job were identified using an expansive definition of a task. In order to perform data collection in an efficient manner, motions that were similar in level of exertion, speed or repetition, and risk to the affected body region as perceived by the analyst were combined into one task. Motions that were fundamentally different were assigned different task numbers.

The total no. of worker is taken 100 for calculation of results regarding musculoskeletal problems among the workers. The entire worker was subjected to Nordic questionnaire to determine the occurrence of pain in the body. The entire task was first video recorded and keeping in mind the presence of ergonomist when using a video camera did not significantly change the way workers perform their job. The entire work was observed to fill the QEC form related to observer’s assessment and

QEC form regarding the worker's assessment was filled by workers with the assistance of observer and score was calculated for all the tasks.

Figure 6 – Assisting work on building construction site

Figure 7 – Plastering work work on workplace

3.3.1 Assumptions During Data Collection

- The workers replied in the Nordic questionnaire is absolutely true. No fake answers were given by workers in the questionnaire.
- The presence of observer on the site did not significantly change the way worker performs their jobs.
- The worker performs at same performance level at all the time of a day/night (whether it is before tea/after tea, before lunch/after lunch etc.)
- The building construction sites chosen data collection represents the work of all building construction industry.
- There were no significant difference between the workers participated in the study to the workers who declined to participate.
- Physical attribute of the worker has no effect on the workers performing the same task.
- The data given by worker to the observer for the filling of QEC was absolutely true.

CHAPTER-4 DATA ANALYSIS

4.1 Classification of Score into Risk Level

The score that we obtained by the different methods cannot be compared unless they are converted to the output which can be compared. The score of all the tools that were applied was classified into three categories of risk i.e. low, medium, high and very high. The ambiguity of three, four and five level classification was converted to three level classifications by the author (Chiasson et al., 2012). All the score is converted to the four category risk level to find our result of QEC method is shown in Table 7.

Table 2 – QEC risk level with description

QEC range	QEC Risk Level	Description
≤40	Low	Acceptable
41-50	medium	investigate further
51-70	high	investigate further and change soon
>70	Very high	investigate further and change immediately

4.2 Chi Square Test for Independence

The test is applicable when you have two categorical variables from a single population. It is used to determine whether there is a significant association between the two variables. The null hypothesis is that the variables are not associated: in other words, they are independent. The alternative hypothesis is that the variables are associated, or dependent. The main requirements of Chi Square test are:

- The sampling method is simple random sampling.
- The variables under study are each categorical.
- If sample data are displayed in a contingency table, the expected frequency count for each cell of the table is at least 5.

This approach consists of four steps: (1) State the hypotheses, (2) Formulate an analysis plan, (3) Analyse sample data, and (4) Interpret results.

Step 1 State the Hypotheses - Suppose that Variable A has *r* levels, and Variable B has *c* levels. The null hypothesis states that knowing the level of Variable A does not help you predict the level of Variable B. That is, the variables are independent.

H_0: Variable A and Variable B ar independent.

H_a: Variable A and Variable B are not independent.

The alternative hypothesis is that knowing the level of Variable A *can* help you predict the level of Variable B.

Step 2 Formulate an Analysis Plan - The analysis plan describes how to use sample data to accept or reject the null hypothesis. The plan should stipulate the following elements.

- Significance level. Often, researchers choose significance levels equal to 0.01, 0.05, or 0.10; but any value between 0 and 1 can be used. Here analyst has taken significance level of 0.05.

- Test method. Use the Chi-Square test for independence to determine whether there is a significant relationship between two categorical variables. It can be done by SPSS statistics software or with the help of charts and formula used as given below.

Step 3 Analyse Sample Data - Using sample data, find the degrees of freedom, expected frequencies, test statistic, and the P-value associated with the test statistic.

- Degrees of freedom - The degrees of freedom (DF) is equal to:
  - DF = (r - 1) * (c - 1)
  - Where r is the number of levels for one categorical variable, and c is the number of levels for the other categorical variable.

- Expected frequencies - The expected frequency counts are computed separately for each level of one categorical variable at each level of the other categorical variable. Compute r * c expected frequencies, according to the following formula.
  - $E_{r,c} = (n_r * n_c) / n$

- where $E_{r,c}$ is the expected frequency count or level *r* of Variable A and level *c* of Variable B, n_r is the total number of sample observations at level r of Variable A, n_c is the total number of sample observations at level *c* of Variable B, and n is the total sample size.

➢ Test statistic - The test statistic is a chi-square random variable (X^2) defined by the following equation.

- $X^2 = \Sigma [(O_{r,c} - E_{r,c})^2 / E_{r,c}]$
- where $O_{r,c}$ is the observed frequency count at level *r* of Variable A and level *c* of Variable B, and $E_{r,c}$ is the expected frequency count at level *r* of Variable A and level *c* of Variable B.

➢ P-value - The P-value is the probability of observing a sample statistic as extreme as the test statistic. Since the test statistic is a chi-square, use the Chi-Square Distribution Calculator to assess the probability associated with the test statistic. Use the degrees of freedom computed above.

Step 4 Interpret Results - If the sample findings are unlikely, given the null hypothesis, the researcher rejects the null hypothesis. Typically, this includes comparing the P-value to the significance level, and rejecting the null hypothesis when the P-value is less than the significance level.

In this problem the association between risk level and the any reported pain in any part of body is determined using Chi Square test for independence. In order to carry out Chi Square test PASW statistics 18(SPSS software) is used. The level of significance is taken to be 0.05. The Null Hypothesis and Alternative Hypothesis taken in this case are:

H_o= There is no association between the QEC risk level and the prevalence rate of reported musculoskeletal problems of the workers.

H_a = There is association between the QEC risk level and the prevalence rate of reported musculoskeletal problems of the workers.

4.3 Association between the QEC risk level and the prevalence rate of reported musculoskeletal problems of the workers

For association between the QEC risk level and the prevalence rate of reported musculoskeletal problems of the workers, The QEC method is applied to the task of building construction sites and score is found for all the tasks and then score is converted to the risk level.

Table 3 - Case processing summary for QEC risk level and Nordic questionnaire analysis

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
QEC_Risk_Level * Nordic_Questionnaire_analysis	100	100.0%	0	0.0%	100	100.0%

Chi Square test for independence is then applied in order to determine the association between the QEC risk level and the prevalence rate of reported musculoskeletal problems of the workers. The case processing summary as shown in Table 3 analysis shows all the 100 cases were valid.

Table 4 - Cross tabulation for QEC risk level and Nordic questionnaire analysis

			Nordic_Questionnaire_analysis		Total
			No Pain	Pain	
QEC_Risk_Level	high risk	Count	19	24	43
		Expected Count	13.3	29.7	43.0
		Residual	5.7	-5.7	
		Std. Residual	1.6	-1.0	
	very high risk	Count	12	45	57
		Expected Count	17.7	39.3	57.0
		Residual	-5.7	5.7	
		Std. Residual	-1.3	.9	
Total		Count	31	69	100
		Expected Count	31.0	69.0	100.0

The Crosstabulation between QEC risk level and Nordic questionnaire is shown in the Table 4. Crosstabulation shows count and expected count for high low and moderate category. Moreover it gives residual which is the difference between count and expected count and standardised residual which is the conversion of residual into Z score. The significance of standardised residual is that it tells which cell is the significant contributor for giving the significant result.

In the Table 10 of Chi Square test results SPSS tells us that 0 cells have expected count less than 5 and the minimum expected count is 13.33. The sample size requirement for the chi-square test of independence is satisfied for QEC method.

Table 5 - Result of Chi Square test of independence for QEC checklist

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	6.132[a]	1	.013		
Continuity Correction[b]	5.098	1	.024		
Likelihood Ratio	6.122	1	.013		
Fisher's Exact Test				.017	.012
Linear-by-Linear Association	6.071	1	.014		
N of Valid Cases	100				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 13.33.

b. Computed only for a 2x2 table

The probability of the chi-square test statistic (Chi-square=6.132) was p=<0.001, which is less than the alpha level of significance of 0.05. The null hypothesis that there is no association between the QEC risk level and the prevalence rate of reported musculoskeletal problems of the workers is rejected.

The alternate hypothesis that there is association between the QEC risk level and the prevalence rate of reported musculoskeletal problems of the workers is supported by this analysis.

CHAPTER-5 RESULT and DISCUSSION

The total number of workers studied on various building construction sites are hundred. There are mainly three types of works on building construction sites; brick layering, plastering and other assisting work done by labours like mixing of cement and lifting and delivering of cement to bricklayers and plasterers.

5.1 Results for total workers

QEC tool has been used to obtain physical exposure to the risk related to musculoskeletal problems. The result of QEC tool has been shown in below table – 6.

Table 6 - Results of the Quick Exposure Check (QEC) among the total Workers in this Study

QEC Risk level	Calculated exposure corresponding to risk level (%)	No. of cases (out of 100)	Percentage (%)
Low risk	≤40	0	0
Medium risk	41-50	0	0
High risk	51-70	43	43
Very high risk	>70	57	57

Result of QEC tool shows that among the total workers; 53 percent of workers are at very high risk so according to QEC risk level description; immediately action should be taken and there should be change in their working postures and working conditions so that risk level of workers can be reduced. Results shows that 43 percent of total workers are at high risk so further investigation is necessary and changes should be there soon.

Nordic Musculoskeletal Questionnaire has been used to give the prevalence of the risk among the total workers on building construction sites. Below table shows the result of NMQ among the total workers related to WMSDs.

Table 7- Result of NMQ for total population: the affected parts of the body and the frequency of occurrence

Affected body part	No. of occurrence out of 100	Percentage (%)
Neck	22	22
Shoulder	37	37
Elbow	18	18
Wrists	22	22
Upper back	39	39
Lower back	52	52
Thighs	5	5
Knees	18	18
Ankles	8	8

Result of NMQ shows that among the total worker; 52 percent of workers are associated with lower back pain, 39 percent of total worker have pain in upper back, followed by 37 percent of worker having pain in shoulders. Tables show that 22 percent people have pain related to neck and wrist. Problem of pain related to knee and elbow is 18 percent workers. Minimum number of problems are regarding to ,thighs of body which is related among only 5 percent workers on building construction sites.

5.2 Results for brick layers:

QEC tool has been used to obtain physical exposure to the risk related to musculoskeletal problems. The result of QEC tool has been shown in below table

Table 8 - Results of the Quick Exposure Check (QEC) among the brick layering Workers

QEC Risk level	Calculated exposure corresponding to risk level (%)	No. of cases (out of 30)	Percentage (%)
Low risk	≤40	0	0
Medium risk	41-50	0	0
High risk	51-70	23	76.7
Very high risk	>70	7	23.3

Result of QEC tool shows that among the brick layering workers; 23.3 percent of workers are at very high risk so according to QEC risk level description; immediately action should be taken and there should be change in their working postures and working conditions so that risk level of workers can be reduced. Results shows that 76.6 percent of total workers are at high risk so further investigation is necessary and changes should be there soon.

Nordic Musculoskeletal Questionnaire has been used to give the prevalence of the risk among the total workers on building construction sites. Below table shows the result of NMQ among the total workers related to WMSDs.

Table 9- Result of NMQ For bricklayers: the affected parts of the body and the frequency of occurrence

Affected body part	No. of occurrence out of 30	Percentage (%)
Neck	1	3.3
Shoulder	10	33.3
Elbow	5	16.7
Wrists	4	13.3
Upper back	13	43.3
Lower back	17	56.7
Thighs	1	3.3
Knees	2	6.7
Ankles	3	10

Result of NMQ shows that among the brick laying worker; 56.7 percent of workers are associated with lower back pain, 43.3 percent of total worker have pain in upper back, followed by 33.3 percent of worker having pain in shoulders. Problem of pain related to knee and elbow is 6.7 and 16.7 percent respectively among the brick layering workers. 13.3 percent of people have pain regarding to their wrist. Tables show that 3.3 percent people have minimum pain related to neck and thighs.

Figure 1 – Brick layering of the wall on building construction site

In the above diagram we can see that angle of bending of lower back is 97.72 degree which is very high that is main cause of the WMSDs among the workers. There is continuous movement of shoulders during work done by brick layering on building construction sites. There is continuous twisting of upper back portion of body causes pain regarding upper back in bricklayers. Manual handling of load produces stress over upper back and shoulders of workers.

5.2 Results for plasterers:

QEC tool has been used to obtain physical exposure to the risk related to musculoskeletal problems. The result of QEC tool has been shown in below table

Table 10 - Results of the Quick Exposure Check (QEC) among the plastering Workers

QEC Risk level	Calculated exposure corresponding to risk level (%)	No. of cases (out of 30)	Percentage (%)
Low risk	≤40	0	0
Medium risk	41-50	0	0
High risk	51-70	17	56.7
Very high risk	>70	13	43.3

Result of QEC tool shows that among the plastering workers; 43.3 percent of workers are at very high risk so according to QEC risk level description; immediately action should be taken and there should be change in their working postures and working conditions so that risk level of workers can be reduced. Results shows that 56.7 percent of total workers are at high risk so further investigation is necessary and changes should be there soon.

Nordic Musculoskeletal Questionnaire has been used to give the prevalence of the risk among the total workers on building construction sites. Below table shows the result of NMQ among the total workers related to WMSDs.

Table 11- Result of NMQ For plasterer: the affected parts of the body and the frequency of occurrence

Affected body part	No. of occurrence out of 30	Percentage (%)
Neck	7	23.3
Shoulder	12	40
Elbow	8	26.7
Wrists	9	30
Upper back	4	13.3
Lower back	17	56.7
Thighs	1	3.3
Knees	3	10
Ankles	2	6.7

Result of NMQ shows that among the plastering worker; 56.7 percent of workers are associated with lower back pain, 40 percent of total worker have pain in shoulders, followed by 30 percent of worker having pain in wrists. Problem of pain related to knee and elbow is 10 and 26.7 percent respectively among the workers. 13.3 percent of people have pain regarding to their upper back. Tables show that 3.3 percent people have minimum pain related to thighs.

Figure 9 – plastering the wall work on building construction site

In the above diagram we can see that angle of bending of lower back is 84.75 degree which is very high that is main cause of the WMSDs among the workers. There is continuous movement of shoulders during work done by plasterers on building construction sites. There is continuous twisting of wrist of body causes in plasterers. Manual handling of load produces stress over upper back and shoulders of workers.

5.2 Results for assisting workers:

QEC tool has been used to obtain physical exposure to the risk related to musculoskeletal problems. The result of QEC tool has been shown in below table

Table 12 - Results of the Quick Exposure Check (QEC) among the assisting Workers

QEC Risk level	Calculated exposure corresponding to risk level (%)	No. of cases (out of 40)	Percentage (%)
Low risk	≤40	0	0
Medium risk	41-50	0	0
High risk	51-70	3	7.5
Very high risk	>70	37	92.5

Result of QEC tool shows that among the assisting workers; 92.5 percent of workers are at very high risk so according to QEC risk level description; immediately action should be taken and there should be change in their working postures and working conditions so that risk level of workers can be reduced. Results shows that 7.5 percent of total workers are at high risk so further investigation is necessary and changes should be there soon.

Nordic Musculoskeletal Questionnaire has been used to give the prevalence of the risk among the total workers on building construction sites. Below table shows the result of NMQ among the total workers related to WMSDs.

Table 13- Result of NMQ For assisting workers: the affected parts of the body and the frequency of occurrence

Affected body part	No. of occurrence out of 40	Percentage (%)
Neck	14	35
Shoulder	15	37.5
Elbow	5	12.5
Wrists	9	22.5
Upper back	12	30
Lower back	18	45
Thighs	3	7.5
Knees	13	32.5
Ankles	3	7.5

Result of NMQ shows that among the assisting worker; 45 percent of workers are associated with lower back pain, 37.5 percent of total worker have pain in shoulders, followed by 35 percent of worker having pain in neck. Problem of pain related to knee and upper back is 32.5 and 30 percent respectively among the workers. 22.5 percent of people have pain regarding to their wrists and 12.5 percent assisting worker have pain in elbows. Tables show that 7.5 percent people have minimum pain related to thighs and ankles.

Figure 10 – Mixing of cement by assisting worker on building construction site

Since Major problems regarding lower back, shoulder, neck and upper back. In the figure 10; u can see that angle of bending of lower back is 66.63 degree which is very high. So we can conclude the various reasons of musculoskeletal problems among the assisting workers on building construction site. The main reasons are listed below-

- Shoulders have continuous movement with manual handling of load during mixing of cement which causes pain
- Lower back is highly bent with repetitive motion.
- Weight of mixed cement supplied by worker to bricklayer and plasterer is very high which produces high stress on shoulders and upper back
- Labours put large weight on their neck during supply of bricks , cement and sand; causes pain regarding neck

CHAPTER -6 CONCLUSION

In this study prevalence of risk to work-related musculoskeletal disorders among the building construction workers was evaluated using Nordic questionnaire, consisted of questions related to the pain raised in different parts of body among the building construction workers due to their respective tasks and physical exposure to risk of musculoskeletal disorders was evaluated using ergonomic risk assessment tool, Quick Exposure Check (QEC). Three type of tasks were studied i.e. brick layering, plastering and other assisting work such as mixing of sand and cement by labours, lifting and pulling of bricks and cement by labours, carrying mixed cement to bricklayers and plasterers. The association of QEC risk level with the prevalence rate of reported musculoskeletal problems in building construction was evaluated using Chi Square test for independence. The results reveal that there is a significant association between QEC risk level and prevalence rate of reported musculoskeletal problems. The result of Quick Exposure Check shows that most of the workers are at very high level of risk. However the result of Nordic Musculoskeletal Questionnaire shows that main body parts which are highly associated with pain are lower back, upper back and shoulders. The individual result shows that most affected part in brick layering work is Lower-back pains followed by Upper-back pain, shoulder pain. In plastering, the Lower-back remains the most affected part followed by shoulder and Wrist. In assistants, most affected part is the Lower-back followed by shoulder, neck which the workers experienced. The results of this study revealed a number of pivotal factors that needs to be addressed in order to reduce work-related musculoskeletal disorders among workers in building construction work. These factors include frequent bending and twisting of lower back and upper back of body which lead to pain among the workers.

Therefore in order to reduce the risk of musculoskeletal disorders among building construction workers redesigning of the workplace and reducing the load carried by the workers are highly recommended. Use of hand trollies to carry heavy loads such as mixed cement, sand and bricks etc. could reduce the stress developed over shoulders, neck, upper back and lower back among the labours.

6.1 Future scope

Since I have taken only two ergonomic tools in this study; there are many ergonomic tools which can be taken to evaluate risk related to musculoskeletal disorders among the workers. After using many tools to access risk among the workers; one can compare the results of these tools; one can find out best method to evaluate level of risk among building construction workers. There is scope of redesigning the workplace so that workplace will be worker-friendly and frequent bending of trunk can be reduced. One can design the tools which are more easy to use by workers.

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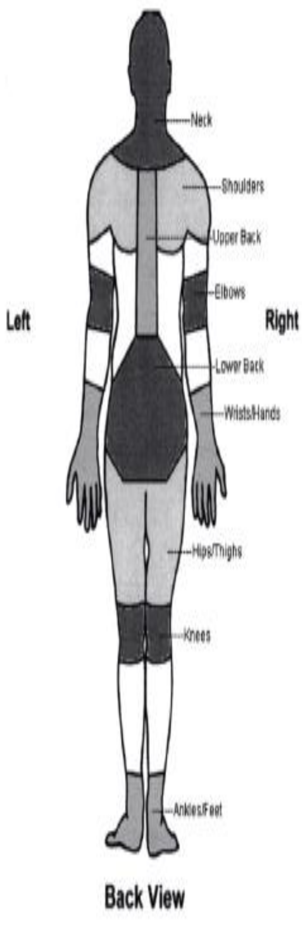
APPENDIX I - STANDARDIZED NORDIC QUESTIONNAIRE

Name________________________________ Immediate Supervisor: ______________ Date: __/__/__

Job Title: ________________ Section: ______________ Gender: M F Age: ____ Height: ___ ft.___ in. Weight: ____

How long have you been doing this job? ___ years ___ months On average, how many hours do you work each week? ___



To be answered by everyone		To be answered by those who have had trouble			
Have you at any time during **the last 12 months** had trouble (ache, pain, discomfort, numbness) in:		Have you at any time during the **last 12 months been prevented from doing your normal work** (at home or away from home) because of the trouble?		Have you had trouble at any time during **the last 7 days?**	
Neck □ No	□ Yes	□ No	□ Yes	□ No	□ Yes
Shoulders □ No	□ Yes, right shoulder □ Yes, left shoulder □ Yes, both shoulders	□ No	□ Yes	□ No	□ Yes
Elbows □ No	□ Yes, right elbow □ Yes, left elbow □ Yes, both elbows	□ No	□ Yes	□ No	□ Yes
Wrists/Hands □ No	□ Yes, right wrist/hand □ Yes, left wrist/hand □ Yes, both wrists/hands	□ No	□ Yes	□ No	□ Yes
Upper Back □ No	□ Yes	□ No	□ Yes	□ No	□ Yes
Lower Back (small of back) □ No	□ Yes	□ No	□ Yes	□ No	□ Yes
One or Both Hips/Thighs □ No	□ Yes	□ No	□ Yes	□ No	□ Yes
One or Both Knees □ No	□ Yes	□ No	□ Yes	□ No	□ Yes
One or Both Ankles/Feet □ No	□ Yes	□ No	□ Yes	□ No	□ Yes

***Based on the Nordic Questionnaire**

APPENDIX II - QUICK EXPOSURE CHECK

Job title: ________________ Task: ________________ Worker's name: _______________

Part A: Observer's Assessment

Back

When performing the task. Is the back

A1: Almost neutral?

A2: Moderately flexed or twisted or side bent?

A3: Excessively flexed or twisted or side bent?

For manual handling tasks only: *Is the movement of the back*

B1: Infrequent? (Around 3 times per minute or less)

B2: Frequent? (Around 8 times per minute)

B3: Very frequent? (Around 12 times per minute or more)

Other tasks: *is the task performed in static posture most of the time? (Either seated or standing*)

B4: No

B5: Yes

Wrist/Hand

Is the task performed

E1: With almost a straight wrist?

E2: With a deviated or bent wrist position?

Is the task performed with similar repeated motion patterns

F1: 10 times per minute or less?

F2: 11 to 20 times per minute?

F3: More than 20 times per minute?

Shoulder/arm

Is the task performed

C1: At or below waist height?

C2: At about chest height?

C3: At or above shoulder height?

Is the arm movement repeated

Dl: Infrequently? (Some intermittent arm movement)

D2: Frequently? (Regular arm movement with some pauses)

D3: Very frequently? (Almost continuous arm movement)

Neck

When performing the task. is the head/neck bent or twisted excessively?

G1: No

G2: Yes, occasionally

G3: Yes, continuously

Part B: Workers assessment

- **What is the maximum weight handled in this task?**

a1: Light (5 kg or less)

a2: Moderate (6 to l0 kg)

a3: Heavy (11 to 20 kg)

a4: Very Heavy (More than 20 kg)

- **How much time on average do you spend per day doing this task?**

b1: less than 2 hours

b2: 2 to 4 hours

b3: more than 4 hours

- **When performing this task (single or double handed), what is maximum force level exerted by one hand?**

c1: Low (e.g. Less than 1 kg)

c2: Medium (e.g. 1 to 4 kg)

c3: High (More than 4 kg)

- **Do you experience any vibration during work?**

d1: Low (or no)

d2: Medium

d3: high

- **Is the visual demand of this task -**

e1: Low? (There is almost no need to view fine details)

e2: High? (There is a need to view some fine details)

- **Do you have difficulty keeping up with this work?**

f1: Never

f2: Sometimes

f3: Often

- **How stressful do you find this work?**

g1: Not at all

g2: Low

g3: Medium

g4: High

Table of Exposure Scores

Exposure to the **Back**

	A1	A2	A3	Score 1	B1	B2	B3	Score 2	b1	b2	b3	Score 3
a1	*2*	*4*	*6*		*2*	*4*	*6*		*2*	*4*	*6*	
a2	*4*	*6*	*8*		*4*	*6*	*8*		*4*	*6*	*8*	
a3	*6*	*8*	*10*		*6*	*8*	*10*		*6*	*8*	*10*	
a4	*8*	*10*	*12*		*8*	*10*	*12*		*8*	*10*	*12*	

				Score 4				B4	B5	Score 5	Total score for the back = Sum of scores 1 to 5
b1	*2*	*4*	*6*		*2*	*4*	*6*	*2*	*4*		
b2	*4*	*6*	*8*		*4*	*6*	*8*	*4*	*6*		
b3	*6*	*8*	*10*		*6*	*8*	*10*	*6*	*8*		

Exposure to the **Shoulder/arm**

	C1	C2	C3	Score 1	D1	D2	D3	Score 2	b1	b2	b3	Score 3
a1	*2*	*4*	*6*		*2*	*4*	*6*		*2*	*4*	*6*	
a2	*4*	*6*	*8*		*4*	*6*	*8*		*4*	*6*	*8*	
a3	*6*	*8*	*10*		*6*	*8*	*10*		*6*	*8*	*10*	
a4	*8*	*10*	*12*		*8*	*10*	*12*		*8*	*10*	*12*	

				Score 4				Score 5	Total score for shoulder/arm = Sum of scores 1 to 5
b1	*2*	*4*	*6*		*2*	*4*	*6*		
b2	*4*	*6*	*8*		*4*	*6*	*8*		
b3	*6*	*8*	*10*		*6*	*8*	*10*		

,Exposure to the **Wrist/hand**

	F1	F2	F3	Score 1	E1	E2	Score 2	b1	b2	b3	Score 3
c1	*2*	*4*	*6*		*2*	*4*		*2*	*4*	*6*	
c2	*4*	*6*	*8*		*4*	*6*		*4*	*6*	*8*	
c3	*6*	*8*	*10*		*6*	*8*		*6*	*8*	*10*	

				Score 4			Score 5	Total score for the wrist/hand = Sum of scores 1 to 5
b1	*2*	*4*	*6*		*2*	*4*		
b2	*4*	*6*	*8*		*4*	*6*		
b3	*6*	*8*	*10*		*6*	*8*		

Exposure to the **Neck**

	G1	G2	G3	Score 1	e1	e2	Score 2	Total score for the neck
b1	*2*	*4*	*6*		*2*	*4*		= Scores 1+ 2
b2	*4*	*6*	*8*		*4*	*6*		
b3	*6*	*8*	*10*		*6*	*8*		

Worker's evaluations

d1	d2	d3	f1	f2	f3	g1	g2	g3	g4	(Worker's evaluation) Total
1	*4*	*9*	*1*	*4*	*9*	*1*	*4*	*9*	*16*	

Back: ________ Shoulder/arm: __________ Wrist/hand :___________ Neck: _____________

PLAGIARISM DETECTION CHART

Work Related Musculoskeletal disorders

ORIGINALITY REPORT

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