ERGONOMIC RISK FACTORS AMONG WORKERS IN BUILDING CONSTRUCTION SITES IN MOMBASA COUNTY

STELLAH CHEROP NDIWA

MASTER OF SCIENCE

(Occupational Safety and Health)

JOMO KENYATTA UNIVERSITY OF

AGRICULTURE AND TECHNOLOGY

2019

Ergonomic Risk Factors among workers in building construction sites in Mombasa County

Stellah Cherop Ndiwa

Thesis Submitted in partial fulfillment for the Degree of Masters of Science in Occupational Safety and Health in the Jomo Kenyatta University of Agriculture and Technology

2019

DECLARATION

This thesis is my original work and has not been presented for a degree in any other University

Signature …………………………… Date: ………………………

Stellah Cherop Ndiwa

This thesis has been submitted for examination with our approval as University Supervisors.

Signature ………………………………… Date: …………………………

Prof. Erastus Gatebe

KIRDI, Kenya

Signature ………………………………… Date: ………………………

Dr. Andrew Mwenga

JKUAT, Kenya

DEDICATION

This work is dedicated to my parents Mr. and Mrs. Julius Masaranja who laid a foundation for me to pursue my education. To my husband Japhet B. Mumba and my sons Alvin, Lucas & Ethan, who stood with me in prayers and who taught me that with perseverance, humility and honesty I can achieve a lot. My heartfelt appreciation.

ACKNOWLEGMENT

I thank the Lord God Almighty for the grace, favor, and provision that He has granted me and the opportunity to attain to this level of educational pursuit.

My special thanks go to my supervisors Prof. Erastus Gatebe and Dr. Andrew Mwenga for the guidance they gave me when writing this thesis. Their critical comments and sound advice guided my revisions and clarified my vision of the final product of the study. Your availability and timely response were invaluable.

Special thanks to my husband, Mr. Japhet B. Mumba and sons (Alvin, Lucas and Ethan) for their financial and moral support, patience and understanding during the entire duration of my course.

Finally to all those who helped me in one way or another I say thank you and may God bless you all.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

ACRONYMS

CCOHS	Canadian Centre for Occupational Health and Safety
CTD	Cumulative Trauma Disorder
DOHSS	Directorate of Occupational Health and Safety Services
ERFs	Ergonomic Risk Factors
HSE	Health and Safety Executive
ILO	International Labor Organization
MMH	Manual Material Handling
MSDs	Musculoskeletal Disorders
MSI	Musculoskeletal Injury
NCA	National Construction Authority
NEMA	National Environment Management Authority
OSH	Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
OSHA 2007	Occupational Safety and Health Act 2007
PPE	Personal Protective Equipment
PATH	Posture, Activity, Tools and Handling
SPSS	Statistical Packages in Social Sciences
WHO	World Health Organization
WRMSDs	Related Musculoskeletal Disorders

DEFINITION OF TERMS

Accident and Injury: The terms accident and injury refer to separate phenomena, mutually interrelated as cause and effect (exposure and outcome) (Anderson, 1999). An accident is an unintentional, sudden unforeseen event, whereas injury is a collective term for health outcomes from traumatic events (Anderson, 1999)

Ergonomics: It is the study of work and the relationship of work to the physical and cognitive capabilities of people. It is fitting the job (tools, tasks, and environment) to the employee, instead of forcing the worker to fit the job.

Ergonomic Risk Factors (ERFs): Are the aspects of a job or task that impose a biochemical stress on the worker. ERFs are the synergistic elements of MSDs hazards

Health: Is a state of complete physical, mental and social wellbeing and not merely the absence of disease. This includes: The promotion and maintenance of physical, mental and social well-being of workers, Prevention among workers of ill-health caused by the working conditions, Protection of workers in their employment from risk resulting from factors adverse to health, Placing and maintenance of the worker in an occupational environment adapted to his physical and psychological equipment.

Musculoskeletal Disorder: These are injuries and disorders that affect the human body's movement or musculoskeletal system (i.e. muscles, tendons, ligaments and nerves)

Occupational Disease: It is a disease or disorder that is caused by the work or working conditions

Safety: A situation where one is not threatened in any way, that is physically and psychologically. A condition of being protected from occupational accidents and or health adherence**:** Refers to the extent to which secondary constructions have implemented the Ministry of Labor guidelines on safety (ILO, 2005)

Semi-skilled employee: Is an employee who is competent through training and or experienced to be employed in specific services.

Skilled employee: Is an employee who is competent through training and or experienced to be employed in all activities of job description.

ABSTRACT

Safety is, without doubt, the most crucial investment we can make. And the question is not what it costs us, but what it saves. Building construction activities are predominantly physical in nature and are usually executed in an uncomfortable environment at a fast pace. Construction work is ergonomically hazardous, as it requires numerous awkward postures, heavy lifting and other forceful exertions. This workplaces have a varying amount of stress on the musculoskeletal system (muscle, tendons, and ligaments) of the workers and increase the potential risk of work-related musculoskeletal disorders (MSDs). The main objective of this research was to evaluate Ergonomic Risk Factors (ERFs) in selected occupations; Carpenters, Painters, Plasters, Mason, Roofers, Steel fixers and Foremen in buildings construction in Mombasa County, Kenya. The target population in this study was 1,364 building construction workers drawn from the construction sites that were registered with NCA by the time of data collection. This was a descriptive cross-sectional study design. A Self-Reported Ergonomic Hazard Assessment checklist method was used. Stratified random sampling was used to obtain a sample size of 309. All the respondent were above 18 years and had worked in building construction for over one year. A standardized Nordic questionnaire was administered to collect data on ERFs from the respondents. Additionally, observation checklist was used to record workers activities on site. Data collected was subjected to statistical analysis. SPSS Version 20.0 was used to analyze quantitative data. Regression analysis was applied to determine the strength of the relationship between ERFs and the prevalence of MSDs. It was established that the majority of workers 97.1% are exposed to awkward posture and 90.3% exposed to manually handled materials. Back pain/waist pain with a Mean Score (MS) of 4.48 is the most affected body part, followed by general body aches and sore muscles & joints and at 4.43 and 4.45 respectively. It was also established that inappropriate work methods (41.7%) and faulty equipment (34.3%) and the major contributors to ERFs experience in workers. Additionally, the study established that 95% of the construction sites had no ergonomic program in place and 87% of the construction sites had no weight lifting restriction. Regression analysis established that there is a close relationship between ERFs and the occurrences of MSDs at 0.622 (62.2%). An increase in ERFs subjection will lead to a 70.9% increase in the occurrence of MSDs. Additionally, the regression model R square showed that 80.1% of the variation was explained. A Chi value of 0.773 (p=0.000) was obtained showing a strong relationship between ERFs and MSDs. From the study, it is evident that building construction work is not an ergonomically safe workplace. Therefore it will be important to implement ergonomic intervention at construction sites. Additionally, the study recommends the adoption of a more proactive and comprehensive management mechanism to enforce the existing safety and health regulations in construction sites. This should be achieved through regular training of all the workers with regards to ergonomic risk factors, and Work-Related Musculoskeletal Disorders and enforcement of both NCA 2011 and OSHA 2007 by the enforcement agencies.

CHAPTER ONE

INTRODUCTION

1.1 General Introduction

The construction industry is one of the most hazardous workplaces worldwide. This is more aggravated by its labour intensive nature and also the low level of mechanization. Ergonomics is a science discipline which is concerned with understanding the relationship between humans and social-technical system element (Colombini et al., 2000). In larger scope, ergonomics examines human behavioral, psychological and physiological capabilities and limitation. The goal of ergonomist is to achieve a balance between work tasks and the worker that will optimize productivity and, at the same time, preserve the safety and health of the employee. Construction is ergonomically hazardous, whose works typically require the adopting of awkward postures, lifting of heavy materials, frequent bending and twisting of body, working above shoulders height, manual handling of heavy and irregular-sized loads, working below the knee level, staying in one position for a long period and pushing and pulling of loads (Odunjo et al., 2015).

Job style conjointly provides a good impact with such factors like shift work, breaks, and meal schedules. These factors can result in injuries or related problems involving the tendons, muscles, or nerves which most of the problems may develop to musculoskeletal disorders (MSDs). Traditionally, people have been adaptive to workplaces and working environment but there is remarkably less attention given on how to fit workers to such workplaces. The increasing numbers of injuries caused by repetitive motion, awkward postures and use of excessive force has become an important factor in workplace safety, Hagberg et al., 1995). According to Hagberg et al., 1995, ergonomics and human factors are often used interchangeably in workplaces. They each describe the interaction between the employees and job demands.

The difference between them is ergonomics focuses on how work affects workers and human factors emphasize designs that reduce the potential for human error (Bongers et al., 2002). Risk and risk factors are common concepts used in safety and applied ergonomics literature. Risk includes a component of how likely or what the probability of an event is and the seriousness of the consequence or what the severity is if something does not occur. Risk implies a probability for injury and the odds of an injury are a function of the level of risk and worker exposure time. It is possible for workers at a site not to have injuries for a period of time. The absence of injuries does not imply the absence of risk. Therefore, Ergonomic risk factors are characteristics of a job that contribute to the creation of ergonomic stress on the body. Generally, the greater the exposure to a single risk factor or combination of risk factors, the greater the probability of an ergonomic injury or illness, also called Musculoskeletal Disorders (MSDs). Musculoskeletal disorders represent a group of conditions that affect the muscles, nerves, tendons, ligaments, joints, cartilage, or spinal a discs as a result of the occupational activities performed; which is not typically the result of a distinctive, singular event, but which are more gradual in their development (William et al., 2004). MSDs are considered by the World Health Organization (WHO) to be work related conditions because they can be caused by work exposures as well non-work factors. The construction trades have many risk factors that may cause WMSDs that are not always easy to identify. For examples are masons with back problems due to the repeated lifting of cement block, and carpenters with wrist problems due to repeated use of a hammer.

It should be noted that the construction industry is one of the largest industries in the World. The boom in construction is so wide spread that project delays and shortage in materials and labor are common (Becker et al., 2000). In 2002, about 1 in 5 construction workers worked 45hours or more a week. Construction workers may occasionally work evenings, weekends, and holidays to finish a job or take care of an emergency. This incredible growth has brought many inexperienced workers into the field Becker et al., 2000), which may be contributing to its relatively a high-injury rate compared to the manufacturing and service sectors

According to the International Labor Organization (2005), 160-270 million workers suffer from occupational diseases or accidents every year. The statistics of the Global Burden of diseases which has been developed by the World Health Organization (WHO), reported that muscular skeletal diseases (MSDs) contributes 37% of the disease burden which is attributable to occupational risk factors (Johnson et al., 2011). In the developed countries, mechanism had been introduced but various studies have shown that workers working in construction sites suffer greatly from musculoskeletal problems (Chung & Kee, 2000; Trevelyan & Haslani, 2001). Prevalence of MSDs has increased dramatically in the developing countries (Pandey & Vats, 2013). This might be as a result of poor mechanization and poor working environment for workers. Workers in construction sites are majorly exposed to ergonomic challenges (Samuels, et al., 2006). Construction work involves a very wide range of physical action from positions and posture that may not be ideal and could place workers at risk for accidents and injuries (Monoharan, et al., 2012). According to Sett *et al.,* 2008, construction industry occupy a prominent position on the frequency and severity of accidents, especially the type of damage caused to the workers, often permanent injuries, death and long period of absence from work.

The existing data show construction workers to be at significant risk of musculoskeletal injury, specifically related to the work they do (Schneider, 2001). A survey done by Labor, Health and Safety Fund (LHSF), 2006 showed that 40 percent of construction workers said “working while hurt” is a major problem. Working while hurt, reduces productivity (LHSF 2006). Many of the injuries that occur in the construction industry are due to the manual material handling that is required in the construction industry (Eastman Kodak Company 2004). Another contributing factor is that the workers’ bodies must be in awkward postures (such as bending or twisting the trunk). These positions can be work below the knees, work above the head, on their backs (Schneider, 2001). In construction industry, the job is always changing. There are new situations each day as the job or project progresses. These jobs vary from above the shoulder work, to below the knees work, and a variety in between. The surfaces that workers work on change all the time and also change throughout the day (Eastman Kodak Company, 2004).

Ergonomic injuries cause a lot of adverse effects to the entire working population including chronic pain, loss of income and productivity loss to industries, insurance, medical and compensation costs as well as suffering to one's dependents (Olson, 1999). Statistics available for occupational safety and health in construction industry shows that they are worse than other industry. Compared to other labor intensive industries, construction industry has reported high rate of injuries and fatalities (Hizne, 1997). It's reported as a one of the most hazardous and accident-prone working environments. In a study by Rwamamara et al., 2007, and Agumba et al., 2008, the study found out that construction workers experience two times more work- related injuries than other industry workers. When compared to other groups, construction workers show elevated risks of developing work-related musculoskeletal disorders (WMD) of the back, and the upper and lower extremities. This statement has also been echoed through a study carried out by Lehtola, 2008.

According to Bureau of Labor Statistics (BLS 2009) in terms of time away from work and loss of time, laborers in construction industry were placed fourth among other occupational groups in the year 2000 because of musculoskeletal injuries. Ergonomic injuries in construction work are among the most significant risk zones for construction workers (Hess *et al.*, 2004). More than 55% of construction injuries reported in the United States in 2003 is related to Musculoskeletal Disorders (MSDs) (Sobeih et al., 2009). According to the U.S. Bureau of Labor Statistics (BLS), the construction industry had the highest incidence rate of any U.S. industry from 1992 to 2002, for all recorded cases. The U.S. Bureau of Labor Statistics (BLS 2002) estimated that there are more than 226,000 lost-time injuries, requiring restricted work or lost work time, in construction each year. More than half of working construction workers suffers from occasional or frequent musculoskeletal complaints (Oude *et al.,* 2011)

Construction workers worldwide are reported to be more exposed to ergonomic risk factors and they face approximately 16% higher rates of MSDs than workers in other industries (Stattin *et al*., 2005). There is scarcity of Ergonomic injuries data in developing countries hence a challenge to categorically state the prevalence of ergonomic injuries across different sectors in developing countries. However, research conducted among construction workers representing six trades in the USA investigated inter alia, the extent to which fifteen job factors constituted a problem on a scale of: no problem; minor-moderate problem, and major problem. The top five ergonomic ‘problems’ found include: working in the same position for long periods (5.67); bending or twisting the back in an awkward way (5.46); working in awkward or cramped positions (5.00); working when injured or hurt (4.69), and handling heavy materials or equipment (4.63) (Zimmerman et al., 1997).

Additionally, on the findings of ergonomics study among South African construction management and workers, Smallwood concluded that repetitive movements, bending the back, use of force and awkward posture were common and constitute work related problems (Smallwood, 2008).

Developing countries like Thailand, Nigeria Tanzania and Kenya have experienced worst and ergonomic injuries are higher than in developed countries. As a basis for setting ergonomic intervention programs and ergonomic regulations, epidemiological data concerning the prevalence of musculoskeletal disorders are essential. In many industrialized countries, such information has become available through national occupational safety and health surveillance systems, workers compensation registers and individual epidemiological studies. But the corresponding information for most developing countries, Kenya being one of them is rare. This makes it difficult to quantify the problem and put necessary ergonomic intervention in workplaces to alleviate causes of work-related musculoskeletal disorders (Bao 2009)

However, the Kenyan government has enacted certain laws to address workers' safety in the construction industry and these include the Occupational Safety and Health Act (OSHA, 2007) the National Construction Authority (NCA, 2011) and the Work Injury Benefit Act (WIBA, 2007). For instance, the National Construction Authority regulations of 2014 require all contractors to be assessed in terms of skills and competence and only the competent ones issued with a certificate to participate in construction activities. This is a way to control quack constructors who risk the lives of employees and occupants with substandard buildings which has resulted to construction accidents in Kenya in the recent past (NCA, 2011). OSHA 2007 on the other hand in protecting workers' health and safety, states that every employer shall take necessary steps to ensure that workstations, equipment and work tasks are adapted to fit the employee and the employee's ability so as to avoid MSDs while WIBA 2007 advocates for compensation of workers injured while performing their duties if the cause of the injury or accident was as a result of negligence on the part of the employer.

Data available from Directorate of Occupational Health and Safety Services (DOHSS Kenya 2011) reports mostly on fatalities and major injuries among construction workers. Unfortunately, there are no properly documented data in Kenya on cases of ergonomic injuries among housing construction workers. For instance, according to DOSHS records, between 2005 and 2009, there were 7769 fatalities across all sectors. The same report indicated that the construction industry accounted for 16% of fatal accidents cases (DOHSS Annual Report, 2011). In Kenya, non-compliance of appropriate work methods such as working with vibrating machines, manual handling of materials, and awkward posture among others has been found to be prominent in most construction sites (DOHS Annual Report 2014). DOHS in their 2014 annual report reported 7,769 fatalities across all sectors in Kenya and 16% fatal accidents in the construction industry alone. In Mombasa in particular, due to the high demand for housing, safety standards have seen an upsurge of accidents in construction sites, thus the need for this study.

Although there is a lot of literature on the effects of ERFs among construction workers from most of the developed nations like across the European Union member states, and U.S. Such data is missing for most developing nations like Kenya. This means that building construction workers accident rates may be higher compared to that of developed countries. This research, therefore, was set to evaluate ergonomic risk factors in building construction sites among workers in Mombasa County. The target population in the study was 1364 building construction workers drawn from 30 housing construction sites that were registered with the National Construction Authority at the time of data collection (2017)

1.2 Statement of the Problem

Ergonomics is a science discipline which is concerned with understanding the relationship between humans and social-technical system element while ergonomic risk factors are characteristics of a job that contribute to the creation of ergonomic stress on the body (Colombini et al., 2000). Construction is a basic pillar for global competitiveness and foundational enabler to Kenya's Vision 2030. To some purpose it is said, the construction and their extent is economic indicator of all the country. It shows the level of development, also the state of the country. However, the big amount of works increases the number of accidents in construction sites. Occupational injuries continue to place tremendous burden on workers globally with an estimated 100 million occupational injuries occurring worldwide each year (Leigh 2011). Ergonomic risk factors that cause ergonomic injuries also referred to as musculoskeletal disorders remain prevalent and often result in a substantial burden of disability and high associated cost (Palmer 2015). In US for instance, Bureau of Labor Statistics (BLS) reported over 2.8 million cases of nonfatal occupational injury of which MSD accounted for 33%. ILO estimates that at least 60,000 fatal accidents happen in a year on construction sites around the world, despite there being set regulations on health and safety. Developing countries has also recorded very frequent injuries and risks associated with construction work. Jason 2008, stated that the risk is 3-6 times bigger. It should be noted that unemployment and poverty has driven majority of Mombasa County populace to working in construction sites despite having full knowledge of how risky the industry can be. Despite the steady growth in the construction sector, the industry is a very accident prone. Data available from Directorate of Occupational Health and Safety Services (DOHSS) indicates that in between 2005 and 2009, there were 7769 fatalities across all industry sectors. In 2011, construction industry accounted for 16% of fatal accidents (40 cases reported for hundred thousand (100,000) workers) and seven percent (7%) of non-fatal cases (DOHSS Annual Report, 2011).

Because of failed enforcement of risk management system and generally construction health and safety management, there are numerous accidents and incidences of fatalities in many construction sites (DOSHS, 2009). DOSHS states that most accidents in construction sites go unreported. In addition, most construction workers have no information and or training on matters of health and safety that is pegged to as their rights. Unfortunately in Kenya and Mombasa County in particular, there are no reliable data on accident cases in construction because most contractors do not report all the accidents (DOHSS Annual Report, 2011). Many workers have met their deaths in construction sites while others have become permanently crippled from construction related injuries. Further, laws on occupational safety and health are not strictly enforced. Safety rules in most construction sites do not exist and if they exist, the regulatory authority is weak in implementing each rule effectively. It is against this background that the study sought to evaluate ergonomic risk factors and musculoskeletal disorders in building constructions in Mombasa County through identification of the Ergonomic risk factors, establishing the prevalence of musculoskeletal disorders and establishing the status of health and safety management systems in construction sites.

1.3 Objectives of the study

1.3.1 Main objective

To evaluate Ergonomics risk factors in building construction sites in Mombasa County.

1.3.2 Specific objectives

1. To identify the Ergonomics Risk Factors (ERFs) in building construction sites.
2. To establish the prevalence of musculoskeletal disorders in construction sites.
3. To determine the awareness levels of Ergonomic risk factors by the construction workers.
4. To verify the extent of which health and safety management system in building construction affects the occurrences of ergonomic injuries.

1.4 Research questions

The research questions were developed to assist this research in articulating the ergonomic risk factors

1. What are the common ergonomic risk factors in building construction?
2. What is the level of musculoskeletal disorders in construction sites?
3. Are construction workers aware of these ergonomic risk factors?
4. What is the extent of health and safety management system in building construction?

1.5 Justification

Construction industry plays an important role in improvement of countries' economic growth. Despite its immense contributions to economic growth, construction industry has always been blamed for the high rates of accidents and fatalities; this issue has placed the construction industry among the industries with unreasonable rates of accidents, permanent and non-permanent disabilities and even fatalities (Hughes & Ferrett, 2011). Building construction workers are exposed to ergonomic risk factors while performing strenuous activities which include: awkward postures, lifting of heavy materials, frequent bending and twisting of body, working above shoulders height, manual handling of heavy and irregular-sized loads, working below the knee level, staying in one position for a long period and pushing and pulling of loads. All these risk factors contribute in causing ergonomic injuries to construction workers. Unfortunately, the status of ergonomics and ergonomic risk factors in Kenya and especially in Mombasa County in unknown. This hence necessitated this study to assist in filling the gaps and benefit institutions such as National Construction Authority, Directorate of Occupational Safety and Health (DOSHS) who are mandated in ensuring health and safety of workers are achieved Additionally, learning institutions which deals with health and safety matters and also developers will have insightful information on the matter of ergonomics hence preventing exposure and subsequent injuries.

1.6 Scope of the study

The scope of this study was limited to National Construction Authority registered sites at the time of date collection (2017) in Mombasa County. Construction sites were randomly selected and respondents selected were those who have been working in the industry for more than 4 years. The target group included workers both skilled and unskilled.

1.7 Limitation of the study

This research study is limited to the building construction projects, which means that the study has excluded the rail, roads, tunnels and bridges construction projects. It also relied on individual reports from workers which made it difficult to verify. It was also limited on different level of construction that dictates the number and types of workers on a given day and time.

1.8 Ethical consideration

The research was conducted after approval by Jomo Kenyatta University of Agriculture and Technology and also by the Ethics Review Committee of Pwani University (Appendix IV). Respondents were additionally issued with a consent form to sign (Appendix III) before filling in the questionnaires. The participation was voluntary and anonymous.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

In a study carried by Reese and Edison (2006), they reported that construction sites are regarded as accident prone areas with high risk and raises a lot health and safety concerns. These concerns might come from the surrounding operations such as construction methods ergonomic risk factors and heavy equipment movement.

As previously stated, Ergonomics is the study of workplace design, tools, environment, product, equipment, tool, environment and system which considers human beings physical and psychological capabilities and improves the work systems of productivity and effectiveness while assuring wellbeing and workers safety and health (Fernendez & Marley 1998). Ergonomics determines and relates information about human abilities, limitations, behavior and other workplace characteristics which may include design of machines, tools, jobs, the environment and the tasks to provide quality production in a comfortable safe manner.

Ergonomic hazards refer to physical stressors and workplace conditions that pose a risk of injury or illness to the musculoskeletal system of the workers (NIOSH 1992). Ergonomic hazards have a negative impact to the workers as well as to the developers. If these ergonomic hazards are poorly managed they may result to work related musculoskeletal disorders. To improve workers efficiency, safety and satisfaction, there should be a well-designed job (Grant, 1996). If work or equipment is not suitable to the worker, the worker experiences discomfort. If the workplace is ergonomically designed the workstation will be safe and comfortable for the worker. The principle goal of ergonomics is to make the job and workplace fit for the employee not vice versa (Al swaity & Enshassi 2005). Kroemer (2009) highlighted that ergonomic hazards may include awkward postures, forceful movements, repetitive, improper postures, improper designs and equipment. Ergonomics hazards may arise from poor job designs and organizational factors which include excessive work durations, excessive work rates, external pacing of work, less time to rest and lack of task variety (Luopajarvi, 1990).

The Canadian Centre for Occupational Health and Safety (CCOHS) defines a hazard as any source of potential damage, harm or adverse health effects on something or someone under certain conditions at work. A hazard is therefore anything that can cause harm or adverse effects. These may be chemical, biological, ergonomic, physical, or psychosocial. Examples of work related hazards include materials, substances, processes or practices which could cause harm or adverse health effect to a person depending on his or her work conditions. CCOHS on the other hand defines risk as the chance or probability that a person will be harmed or experience an adverse health effect if exposed to a hazard. It may also apply to situations with property or equipment loss (CCOHS 2009). Ergonomic risk factors are therefore the aspects of a job or a task that impose a biochemical stress on the worker. Ergonomic risk factors are the synergistic elements of MSD hazards. Ergonomic hazards can be classified into physical and cognitive ergonomic hazards. Physical ergonomics deals with the physical load on the human body when performing work activities. Physical ergonomics, deals with human physical and bio mechanical characteristics as they interact with physical activities (Karwowski & Marras, 2003). It deals with the human body's responses to physical and physiological stress. Example of physical ergonomics hazards include; working postures, working hours, works that require a lot of force and repetitive work. Although physical risk factors are important first-line risk factors, there are other plausible factors such as organizational and psychosocial factors that may provoke a disorder or indirectly influence the effect of physical risk factors (Hagberg et al., 1995). Cognitive ergonomics emphases on the appropriate between human cognitive abilities and limitations and the machine, task, and environment, organizational hazards and environment hazards which affect workers who operate at the place of work therefore these hazardous factors can influence occupational health discomforts of workers (Grant, 1996). This approach addresses problems such as attention distribution, decision making, formation of learning skills, and usability of human-computer systems, cognitive aspects of metal load, stress and human errors at work (Canas et al., 2010).

Construction work is hard work and construction workers feel the results. Falls are a major hazard. While construction represents about 8% of all workers, construction workers experienced nearly 50% (384) of the 770 fall fatalities that occurred across all industries in 2005 (BLS 2009). Falls are the leading cause of fatal injuries and the second most common cause of nonfatal lost work day injuries in construction

In a survey reported by Cook *et al.,* 1996, seven out ten construction workers from 13 trades reported back pain, and nearly a third went to the doctor for it. Construction work hence poses an immense challenge to the workers and general public in terms of Health and Safety (H&S) and ergonomics as workers become prone to a range of health, safety, and ergonomic hazards.

Worldwide occupational injury rates in construction are highest for all major industries (Lehtola et al., 2008). Unlike other industries such as manufacturing, construction is composed of a transient workforce (Dubois & Gadde, 2002) where project personnel from different cultures and backgrounds are expected to work together in a constantly changing work organization and structure. Construction is always risky because of outdoor operations, work-at height, complicated on-site plant machinery and equipment operation coupled with worker's attitudes and behaviours towards safety (Choudhry & Fang, 2008). From a practical point of view health and safety in construction is about using appropriate means to ensure workers are both safe and healthy. However, in a construction environment the situation is all the more challenging, where projects differ considerably in terms of size, location and complexity.

Health and Safety (H& S) plays an important part in safeguarding the wellbeing of employees in the workplace. By law the provision of safe and secure working environment is mandatory as outlined by Ofori (2010). However, Hamden & Awang (2015) argues that this may be obstructed by many factors such as the area or country. In developing countries the provision of safe and secure construction site is a huge challenge. For example, in Saudi Arabia being a developing country with a growing population therefore public infrastructure has been highly invested on. With such sudden growth, there is a major challenge on implementing Health and Safety practices in construction site. Calderwood & Crone (2015) reported that about 107 people were killed in Saudi Arabia construction site when scaffolding failed. Hamden & Awang (2015) acknowledges that weak Health and Safety practices and procedures in developing countries' construction sites have increased the number of fatalities. Ergonomic injuries will continue to be challenging issue unless effective measures are developed to deliver robust processes and procedures.

In South Africa, a series of research studies conducted investigated, inter alia, the frequency at which work problems were encountered (Smallwood 1997; Smallwood et al., 2000; Smallwood 2002). It was established that handling heavy materials, which achieved a ranking of third in South Africa, achieved a ranking of fourth and fifth in the respective US studies. Although the other respective top four ranked problems were not common to both South Africa and the USA, bending or twisting the back, which achieved a ranking of second in the USA, achieved a ranking of sixth in South Africa. Additionally, South Africa reported high in repetitive movements this is because South Africa is predominantly use masonry materials for walls, than a country that makes use of prefabricated framing and panels such as the USA. A trade-specific research conducted in the Western Cape, South Africa, among bricklayers, plasterers, painters, and their respective assistants, identified neglected ergonomics issues (Samuels et al., 2006). The problems include: bending and twisting of the body; reaching away from the body and reaching overhead; working in awkward positions; lifting and manually handling heavy and irregularly sized and shaped materials and components; working below knee level; and working while kneeling. Most of these activities also involved working at extreme ranges in challenging environments. A study conducted in Hyderabad, India by Remana & Satyanarayana (2005) identified the causes of non-traumatic injuries, where repetitive movements predominated, followed by awkward postures. In Kenya however, there are limited documented evidence on ergonomic risk factors and its effects.

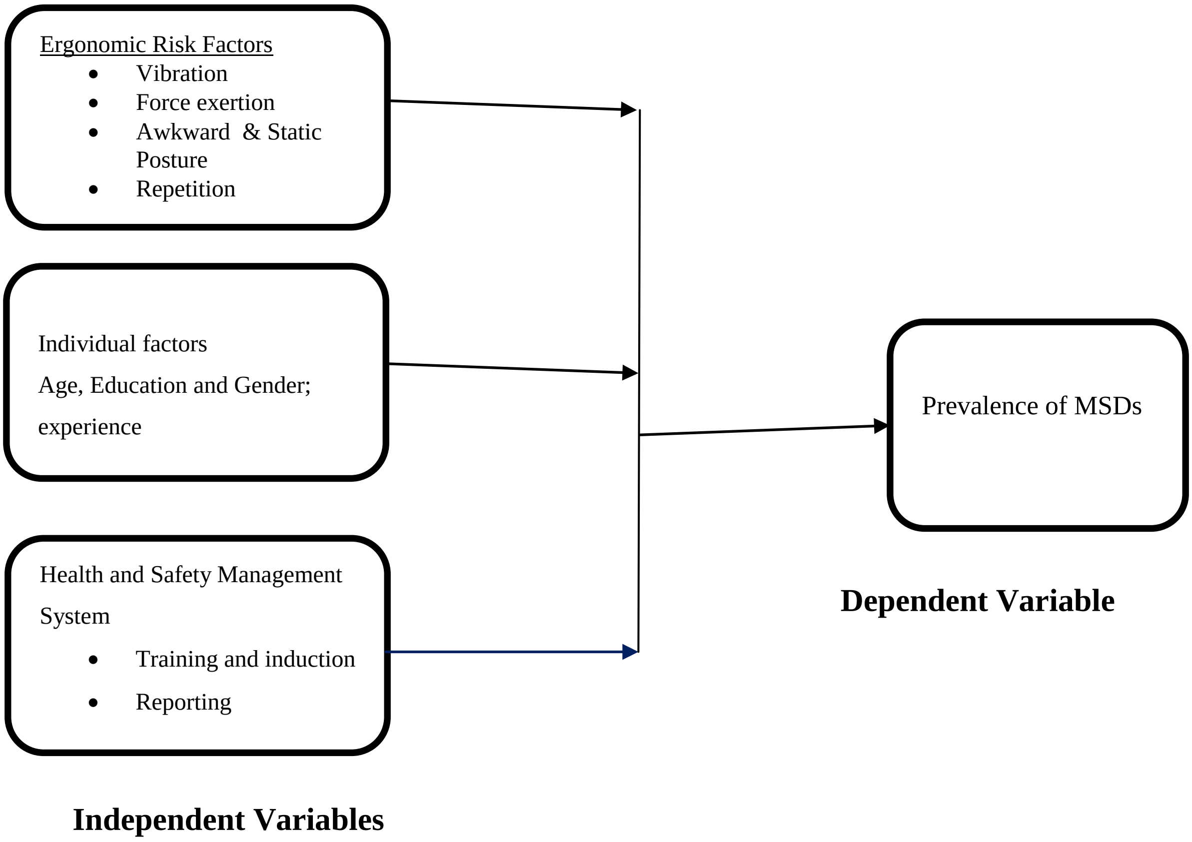


Figure 2.1: Conceptual framework (Source: Author, 2017*)*

The conceptual framework in Figure 2.1 shows the relationship between Ergonomic Risk Factors, safety culture, demographic dimensions and health and safety management and MSDs.

2.2.1 Ergonomic Risk Factors

Hazard as defined by the Canadian Centre for Occupational Health and Safety (CCOHS) is as any source of potential damage, harm or adverse health effects on something or someone under certain conditions at work. A hazard is thus anything that can cause harm or adverse effects. These may be biological, physical, ergonomic, chemical, psychosocial or safety. Work related hazards include materials, substances, processes or practices which could cause harm or adverse health effect to a person under certain conditions. Additionally, CCOHS defines risks as the probability or chance that a person will be harmed or experience an adverse health effect if exposed to a hazard. It may also apply to situations with property or equipment loss (CCOHS 2009).

Ergonomic risk factors are workplace elements (conditions) and actions, or a combination of both, which cause physical stress to the body, thus increasing the risk of WRMSD. These include forceful exertions, awkward postures, repetitive exertions, segmental and whole body vibration, contact stress, organizational factors, and environmental factors. Ergonomics Risk Factors (ERF) hence are situations that exist or created intentionally or unintentionally that could or might contribute to results contravene or against the principles or philosophy of ergonomics that could or might be harmful to the health and well-being of workers or users at work or after work. Risk factor exposure is an early warning of progressively more serious problems -physical signs and symptoms that can lead to serious injury. Long-term exposure to risk factors will reduce the quality of life. Every job carries risk.

2.2.1.1 Forceful exertions

Force is the quantity of exertion required by an individual to carry out a task or maintain control of tools or equipment. It therefore pertains to the amount of muscular effort required to perform a task. Greater force exertion results in an increased risk potential for WRMSD. High force has been associated with WRMSDs at the shoulder/neck, the low back, and the forearm/wrist/hand.

Muscles and tendons are often overloaded when a powerful (high) force is applied against the object (load).

A risk may also occur once a weaker (low) force is applied repeatedly (repetition) or unendingly over an extended amount of time (duration). Exerting high or low muscle force can interfere with circulation, lead to muscle fatigue and tissue damage. Tasks that require the use of higher force place higher mechanical loads on muscles, tendons, ligaments, and joints. Such tasks may cause muscles or fatigue more quickly. High forces may also lead to irritation, inflammation, strains, and tears of muscles and tendons. Muscles fatigue with increased exertion and need more time to recover. If soft tissue doesn't have time to recover, injury is likely to develop over a period of time. If the exertions are forceful enough, body tissues may be damaged immediately.

Forceful exertions embody forces exerted by muscles, like when lifting items, carrying loads, holding one position for a period of time, or employing a forceful grip. Workers at construction site need to be informed and trained on the way they should perform their duties when applying force in their activity. Lack of information regarding it can lead to damages to workers such as stress on the muscles, tendons and joints

2.2.1.2 Awkward & Static Posture

Posture is the position of a part of the body relative to an adjacent part as measured by the angle of the joint connecting them. Awkward postures refer to a situation where the body is under uncomfortable and away from neutral position. Static posture on the other hand is the situation where the entire body is kept for a long time e.g. staying in a same position for a long period of time without movement. It is considered as one of the most frequently cited occupational risk factors, Armstrong (1997). The goal is to maintain a neutral (natural) body posture throughout the job task. Neutral posture reduces the strain on working muscles and joints and keeps blood circulating, which enhances the body’s ability to remove toxins. Any posture that requires the body to move out of the neutral posture range is considered to be awkward posture.

Awkward postures are not always harmful. It is only when they are repeated frequently or performed for a long time. Awkward postures include bending, reaching, twisting, squatting, and kneeling (Straker et al., 1997; Huysmans et al., 2008). Mojtaba et al., 2013 found out that poor design in work area, poorly considered hand tools, pushing, pooling & carrying heavy load are some of the causes of awkward posture.

Posture angles are measured in terms of the number of degrees a specific joint deviates from the neutral position. Body landmarks for measuring angles are described in the American Academy of Orthopedic Surgeons' "Joint Motion Methods of Measuring and Recording" (1963). In work situations, posture can be measured by live (visual) observations, as well as through the use of still photographs, videotapes, goniometers or postural tracking equipment, and computerized data acquisitions systems. Aaras et al., (1988) present work supporting the notion that postural angles are an indicator of postural load and thus lead to WRMSDs (predominantly back pains) in occupational work situations.

2.2.1.3 Repetition

Repetition means creating a similar form of movements over and over (e.g. laying bricks). It refers to the frequency or number of similar exertions performed during a task. Repeated exertion, including the use of hand tools, has been frequently identified as a WRMSD risk factor. Repetitive tasks are tasks with cycle times less than thirty (30) seconds or tasks where 50% of the cycle is performing the same fundamental activities (Moore and Wells 2005). Kumar 2001 states that, the higher the number of repetitions, the higher the degree of risk of Muscular Disorder. However, there's no specific repetition limit or threshold value (cycles/unit of time, movements/unit of time) related to injury.

2.2.1.4 Vibration

Vibrations occur when an object oscillates or rapidly moves back and forth about its stationary point, sort of a swinging setup. Vibrations are defined by the frequency (how fast an item is moving) and also the magnitude or amplitude (the distance of the movement). (CCOHS 2009)

There are two kinds of vibration lead to musculoskeletal injuries which the construction workers may be exposed to it. These types are as follows: *Hand-Arm vibration*: This pertains to vibration applied to the hand/arms through a tool or piece of equipment. This can cause a reduction in blood flow to the hands/fingers (resulting in Raynaud’s disease or vibration white finger). Also, it can interfere with sensory receptor feedback, leading to an increase in the handgrip force needed to hold the tool. Furthermore, a strong association has been reported between carpal tunnel syndrome and segmental vibration. Measurements of the maximum amount of vibration available to the hand (such as “hazard level”) are performed using the “basicentric” system. Hand-arm vibration measurements and analyses should be performed according to ANSI S3.34, ACGIH-TLV, and NIOSH 89-106 recommendations and *Whole body vibration*: Caused by the vibration produced from driving the machineries such as wheel loader, grader, scraper, excavator, dozer, compactor single drum which can impose stress on the spinal tissues.

2.2.2 Environmental Risk factors

This refers to the prevailing conditions of the work environment and their adverse effect on the worker’s health. These include sources and levels of light that provide too much or too little illumination, cold and excessively warm temperatures (including snow, space heating), wind, and noise.

2.2.3 Age, Education and Gender

Various types of MSD have been identified amongst older worker groups varying from simple aches and pains, discomfort and tingling, sensations in the different regions of the body to overuse injuries and conditions (Palliser, et al., 2005; Pransky et al., 2005). Generally, studies report higher values for those who leave work due to disease compared to those who continue to work till retirement (Whiting, 2011). It should be observed that, between the ages of 51 and 62 years, the prevalence of musculoskeletal disorder may increase as much as 15% among workers, with more pronounced increases occurring physically demanding occupations like construction (Ilmarinen, 2004). Compared to the younger group, older individuals exhibited lower muscular strength, longer endurance time and slower development of local fatigue. The aging process involves many physical changes that can make construction work tasks more difficult for older workers. For example, physically demanding work may be difficult because of decreased cardiac output and reduced tolerance to physical activity. Older workers are also susceptible to losing muscle mass and to subsequent decreases in strength.

Women are increasingly moving into occupations once exclusively by men, such as construction industry. In such instances, physiological variation between women and men can translate into occupational hazards, as when women operate equipment designed for male counterparts of larger stature. Women in construction face a range of occupational risks. Although they make low percent as compared to their men counter parts in the construction industry, they are subjected to the same work environment as men. Most common causes of non-fatal injuries in women include: overexertion, contact with equipment and fall. While both men and women working in construction face many of the same risks, there are some unique issues that are of greater concern to women (CDC, 2012) Studies have shown that women have higher rate of sprain/strains than men. This is because women are mostly assigned repetitive tasks. Ill-fitting PPE have also contributed to women being subjected to health hazards.

Education, age and gender influence the determination of which populations obtain low-skilled occupation and exposure to WMSD related risk factors. In this study, gender and education status were among the factors with significant association in relation to WMSDs. Being a male and of low education status was associated with higher odds for WMSDs, and this was more prominent in the heavy versus light task workers. These findings have been documented in other studies (Pompeii L. et al., 2008; Rahman Z. et al., 2009) and could be due to differences in trade and employment status, as more educated male workers perform mainly supervisory and administrative duties.

On the other hand, the relation between ERFs and education is less clear and less documented. However most population based cross-sectional studies have reported higher prevalence of musculoskeletal symptoms with individual with low education compared to those with higher educational levels. Education has been considered to influence the occurrence of MSDs in three difference ways: the predictor of frequency, outcome and interventions of the MSDs (Doinne et al., 2001)

2.2.4 Safety Attitudes

In Kenya, traditionally, it is hard to change the attitude of Kenyans regarding the safety culture. Most workers due to being unskilled, have no information that legislation exists that allows them to be provided with the necessary safe working environments. For this reason therefore, many employees regard the provision of safe work environment as a privilege and not a right. Therefore workers just start working without assessing the safety of their working conditions. The ignorance of many workers has made the employers to abuse that privilege and thereby working without safety gear is usually a norm in many sites in Kenya.

It hence paramount that government and relevant authority to make effort in sharing information to workers that they have a fundamental right according to the new constitution and the recently amended OSHA 2007 to be provided with a safe working environment. Due to ignorance many of the workers are putting their lives at great risk on the construction sites because of lack of proper information and sheer disregard of the laid down safety guidelines. Therefore, there is a need for changing attitudes of people involved in construction projects.

2.2.5 Health and Safety Management

Effective health and safety management that provides a good basis for good performance is very crucial in any industry especially the construction industry. An effective health and safety management system will be achieved through the following principles, Hughes & Ferret, (2011).

2.2.5.1 Developing a health and safety policy.

This involves developing monitoring and reviewing standards needed to address and reduce the risks to health and safety produced by the organization. The policy should state the intentions of the organization in terms of clear aims, objectives and targets. There should be a health and safety policy statement of intent communicated in simple language so that it is understandable to all and posted on a clearly seen notice board throughout the workplace which should be dated and signed by senior officials to demonstrate management commitment to health and safety at the same time giving authority to the policy.

2.2.5.2 A well-defined management structure.

It must be supported from the top with staff involvement and participation and financial resources made available. Every individual must be clear about his responsibilities and limits.

2.2.5.3 Planning and implementation of performance standards, targets and procedures

The plan should be based on risk assessment methods to decide on priorities and set objectives for effective control and elimination of hazards and the reduction of risks.

2.2.6 Training and Induction

Training is a critical element of a successful occupational ergonomic program. Training is the acquisition of knowledge, skills, and abilities to perform more effectively (Blanchard & Thacker, 1999). The sole reason is to provide people with the skills knowledge abilities and tools to accomplish their designated responsibilities. Training and inductions in construction site workplace helps inculcate in employees a positive health and safety culture. The benefits that accrue from health and safety training have been studied and analyzed by several studies (Jannadi & Al-Sudairi, 1995). Smallwood (2008) however states that health and safety education and training are necessary to develop surface and core competencies. Surface competencies include knowledge and skills, which are relatively easy to develop – training being the most effective to realize these abilities.

Although several authors contend that there is a positive correlation between health and safety training and health and safety performance (Rowlinson, 2004; Smallwood, 2008), training not only constitutes an opportunity to communicate information to increase knowledge and awareness, but also to change behaviour. Furthermore, Lingard and Rowlinson (2005) state that it is necessary to assess training outcomes relative to training objectives.

Unfortunately, majority of construction workers have limited training on health and safety. In developed countries, this basic training can range from two hours to two (Sean, 2011). Most often, workers learn their trade through apprenticeship. They lack education, information and there is no health monitoring (Mitulla & Wachira, 2003). Additionally, most employers ignore health and safety issues which is reflected in the absence of basic requirements like helmets on working sites. Construction workers are exposed to serious hazards which sometimes lead to serious accidents like loss of limbs, eye sight, hearing impairment and even death (Wachira, 2000)

2.2.6.1 Influence of ergonomic training and awareness to employees

Application of ergonomics, result in improved working techniques, reducing human errors and accidents and increased efficiency (Patkin 1987). Poor work ergonomics can results to slow development of diseases such as Cumulative trauma disorders, repetitive strain injuries, musculoskeletal disorders and occupational overuse syndrome. If workers are aware of work tasks and equipment that do not include ergonomic principles in their design, workers may be able to report or complain if exposed to undue physical stress, strain, and overexertion which may include vibration, awkward postures, forceful exertions, repetitive motion, and heavy lifting. According to Annis & McConville (1996) the objective of this division of ergonomics is to create the best possible job situation to enhance the worker's physical and mental health, production efficiency, and product quality. Ergonomics awareness will help in recognizing ergonomic risk factors in the workplace and it is an essential first step in correcting hazards and improving worker protection. In a study which was conducted in Malaysia by Shameem *et al.*, (2001), industrial workers in Malaysia are were less educated and are ignorant of environmental and working standards, therefore they were not able to complain about work conditions. Bohr (2000) further reported that participants who received ergonomic training reported less stress and pain/discomfort than did those who had not received training.

Article 6(c) of the Occupational Safety and Health Act, (2007) states that it is the duty of the occupier/ employer to ensure the health, safety and welfare at work of all persons in the workplace, this involves the provision of such information, instruction, training and supervision as is necessary to ensure that health and safety at work of every person employed.

2.2.7 Explanation of development of WRMSDs

MSDs are multi-factorial in nature. Studies have been conducted in recent years which have established a basis for ergonomic risk assessments. In the last two decades, progress has been made in achieving better understanding of the causes of musculoskeletal injuries through research involving personal, biomechanical, and psychosocial work factors, as well as in understanding the relationship between the organization and quality of work area/task design and injury potential (Malchaire 2001; Stal et al., 2003). There also exists research relating musculoskeletal injuries to work tasks also exists (WorkSafeBC 2008; Keyserling 1992). The risk of sprains and strains in construction and the mechanisms of injury have been evaluated by WorkSafeBC (2008). Hess et al., (2010) discussed the ergonomic evaluation of masons laying concrete masonry units and autoclaved aerated concrete. Additionally, Entzel et al., (2007) developed best practices for preventing musculoskeletal disorders in masonry.

There are three models found in the ergonomics literature to describe the development of work-related musculoskeletal disorders. Claudon and Cnockaert (1994) presented a model showing that stress levels exceeding an individual’s functional capacity result in an increased risk of WRMSDs (Figure 2.3); Kumar

(2001) showed how MSDs develop as a result of multiple factors (genetic, anthropometry, biomechanical and psychological) (Figure 2.4). Armstrong et al., (1993) illustrated that work activities produce internal forces which act upon body tissues (dose), stimulating a biomechanical or physiological response which may limit the worker's functional ability (Figure 2.3).

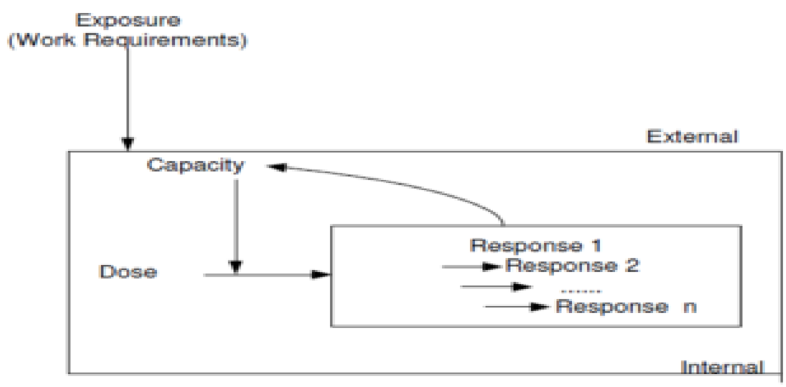


Figure 2.2: Risk factor dose-response model (Armstrong et al., 1993)

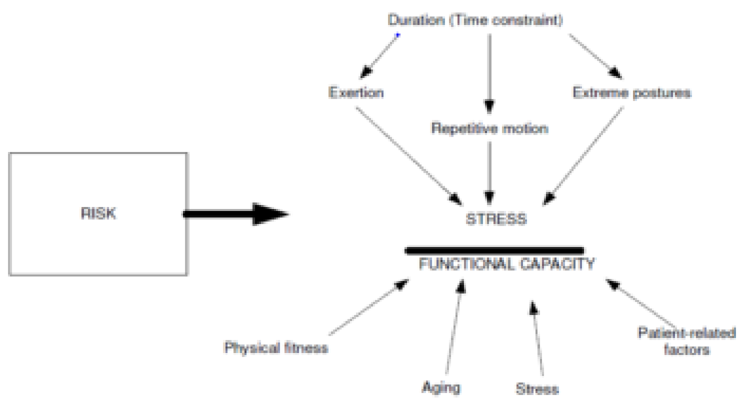


Figure 2.3: Risk factors for musculoskeletal disorders (Claudon & Cnockaert 1994)

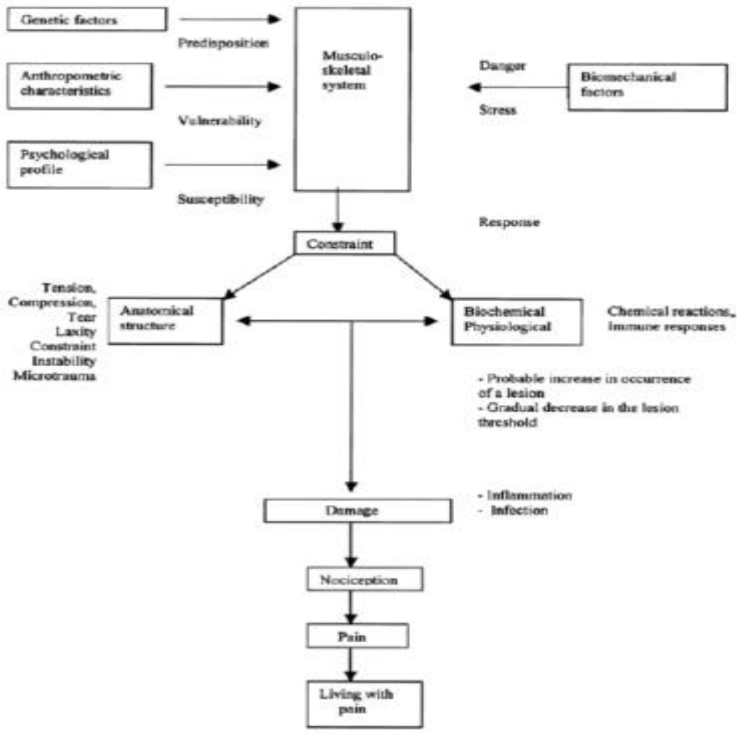


Figure 2.4: Multifactorial interactions resulting in musculoskeletal disorders (Kumar 2001)

2.3 Selected trades in the building construction

2.3.1 Mason

Masonry construction is one of the specialty trades with high risk of work related injuries. Masonry construction work is physically demanding and has high risk of work-related injuries. This is a result of performing heavy physical activities including erecting and dismantling scaffold, handling blocks/bricks and mortar, laying blocks/bricks, and grouting (David 2005; Spielholz et al., 2006). In brick masonry work, masons lay on average 1000 bricks per day (Schneider & Susi 1994). A mason needs to bend, lift, and twist to lay a brick/block. Laying this number of brick/block per day can cause a significant physical load and consequently musculoskeletal disorders (MSD) for masons. Masonry work involves significant physical demands (Hess et al., 2010). Van der Molen et al., (2009) found that the most demanding task of masons was one-handed repetitive lifting of bricks and two-handed lifting of blocks.

Masonry industry workers perform many different jobs and tasks. The work is physically demanding, involving stocking and laying of block and brick, stocking and setting of tile, mixing and stocking of mortar and grout, and assembling scaffolds (Choi et al., 2014). Lifting and carrying of materials is common, as well as repetitive motion, high hand force, reaching overhead, and bending of the back or neck, for certain tasks. These exposures can lead to WMSDs (David, 2005). Since Masons working with concrete masonry unit block have high rates of work-related musculoskeletal disorders associated with repetitively lifting and buttering heavy block, the focus of this paper is on the concrete and masonry workers.

2.3.2 Carpenters

Carpenters make up the largest number of construction workers (NIOSH, 2004). Carpenters take part in all phases of residential and commercial building construction. Thus, they are exposed to numerous chemical and physical factors (Lemasters et al., 1998). Carpenters are involved in framing and interior finishing activities, fabricating wooden forms for pouring concrete, and drywall and ceiling installation. During these activities, they will often work with tools held overhead or below waist levels, use hand held power tools in a forceful manner, perform manual hammering, grasp heavy lumber, and fasten forms.

Employment in carpentry requires the use of different body parts and, depending on the task, may require forceful use of the back and upper and lower limbs. Such work often entails the handling of power tools, or forceful repetitive gripping, twisting, reaching or moving actions. Carpenters require constant use of hand tools hence they have more hand and wrist problems. Work may occur in confined spaces or awkward positions, such as with the arms raised above shoulder level, or with awkward postures of the shoulder, arm and wrist.

Carpenters are found to have a higher prevalence of musculoskeletal abnormalities than white collar workers (Arndt et al., 2005). Carpenters roles that vary from trimming, use of hand held tools, house building tasks and form work subject them to the risk of musculoskeletal disorders. Ergonomic issues can result when using either hand or powered tools such as saws, hammers: the tool itself must be gripped and lined up with the task, at the correct orientation; the materials may require support during the process and the nature of the product can contribute to postural strain

2.3.3 Steel fixers

Iron work ranks among the top 10 most dangerous jobs in the world. Structural and reinforcing iron and metal workers are employed in all parts of the country, but most work in big towns, where the bulk of commercial and industrial construction takes place

Ironworkers place and install iron or steel girders columns, and other construction materials to form buildings, bridges and other structures. They also position and secure steel bars or mesh in concrete forms to reinforce the concrete use in building and major construction structures. Iron workers usually work outside in cold/hot weather conditions (BLS, 2009). Ironworkers usually lift and carry heavy loads, work in severely awkward positions in confined spaces or from keeling position. They use heavy vibrating pneumatic tools overhead requiring them to apply high force in static positions. Common MSDs associated the ironworkers are in back, shoulders, elbows, hand/fingers and knees (Buchholz et al., 2003; Choi et al., 2014)

2.3.4 Roofers

Roofing is one of the toughest work in the construction. Working on a roof can be dangerous. Working on roof is a high-risk activity because it involves working at height. Roofers like most trades in construction industry are at significant risk of musculoskeletal injury. The physically demanding nature of the work, awkward and static posture, and harsh outdoor environment explain musculoskeletal disorders are a common health issue in this trade (Pamela et al., 2007).

Roofers do heavy lifting, climbing, bending and kneeling. Roof work is physically demanding because of manual materials handling activity at different roof inclinations. Roofers experience greater feet/ankles discomfort and pain with an increase in slope (Choobineh et al., 2007). They work outdoors in all types of weather, particularly when making repairs. Workers risk slips or falls from scaffolds, ladders or roofs or burns from hot bitumen. Roofs can also be extremely hot during summer, causing heat related illnesses (BLS 2009). Musculoskeletal symptoms among roofers are strongly associated with work limitation, missed work and reduced physical functioning (Welch et al., 2009). Common MSDs involves back, shoulders, hand/fingers and feet/ankles.

2.4 Existing Workplace Ergonomic Legislation

In 1999, the U.S. OSHA proposed that industry employers establish an ergonomic standard which contained elements typical of successful existing ergonomic programs: management leadership and employee participation, job hazard analysis and control, hazard information and reporting, training, MSD management, and program evaluation. The inclusion of these elements would depend on the types of jobs being performed in the given workplace and whether or not an MSD covered by the standard had previously occurred. Employers would be required by the proposed rule to implement an ergonomic program for their jobs. This rule was signed into law in 2000, but was repealed by a ballot initiative in 2003 after concerted protests from the Chamber of Commerce and National Association of Manufacturers (Spielholz et al., 2006). The European legal requirements regarding MSDs include international conventions and standards, European Directives, and European standards. These directives and legislations oblige the employer to take the necessary measures to ensure the safety and health of their workers in every aspect of their work (Schneider *et al.,* 2010). In Canada, the approach adopted to address WRMSDs and perform workplace ergonomic analysis varies from province-to-province depending on the given legislation and guidelines.

There are four general approaches to workplace ergonomics which are adopted in Canada: Proactive Workplace Ergonomic Regulations, Reactive Workplace Ergonomic Legislation, Unenforceable Ergonomics Guidelines and No Workplace Ergonomic Guidelines or Regulations (Legislation, Regulations and Guidelines 2010; Manager's handbook-Canada labour code-part II 2010).

Countries such as the United Kingdom, Singapore and Hong Kong have adopted a self-regulatory approach to safety, whereby occupiers are required to develop, implement and maintain safety management systems (Ng et al., 2005). In Singapore, the construction site safety legislation is governed by the requirements stipulated under the Factories Act (Chapter 104). The regulation requires all occupiers of construction worksites, which have contract values of US Dollars 10 Million or more to implement a safety Management System for construction worksites (Teo and Ling 2006). In Finland, occupational safety is the responsibility of the employer, while the occupational safety and health are enforced by the Labor Inspection Service, an organization of the sate (Yranheikki and Savolainen 2000). In China, the ministry of construction takes the overall responsibility in overseeing the construction industry in which the roles include implementing the new strategies and policies such as preparing development programs, regulating construction markets and construction institutions and monitoring construction safety (Tam, 2004)

International Labour Organization (ILO) is the main body that sets the standards of health and safety and is based on International conventions and recommendations on occupational health and safety (ILO, 2002).

2.4.1 Legislations governing safety and health in construction sites in Developing Countries

Countries differ on how health and safety is achieved but generally all construction companies need to provide safe and secure working conditions for their workers.

However the delivery of safe and secure workplace in construction site is not the same worldwide. Construction development provides the necessary infrastructure needed to boost their economies to grow. Haupt et al., 2005 has indicated that construction reflects the level of economic development within a country. However, developing countries such as Kenya face a huge challenge in addressing the need of a very robust Health and Safety as this runs parallel to the socio economic stress as compared to developed countries. According to ILO (2013) the delivery of poor Health and Safety in construction sites within developing countries is as a result of a large turnover of workers: this is because the stakeholders are more concerned about completing the project. Furthermore, staff are not trained or inducted on issues regarding health and safety matters.

The constitution of Kenya 2010 states that every citizen is entitled to a clean and safe environment. Various laws have been passes that guarantee the safety of workers. These set regulations are enforced through the Occupational Safety and Health Act 2007 and National Workmen's Legislation (Cap 236). To start with, Kenya efforts have been made by different organizations to have these legislations in place. The factories Act Cap 514 which came operational on 1st September 1951 makes provision for the health, safety and welfare of people employed in factories and other places of work. The Act focuses on conditions of the factory, safety devices, machine maintenance, safety precautions in case of fire, gas explosions, electrical faults, provisions of protective equipment. (Nyakang'o 2007)

Occupational health and safety issues in Kenya are usually handled by the Ministry of Labour in the Department of Occupational Health and Safety (DOHS). In addition, there is also an Authority called National Environmental Management Authority (NEMA). The Authority is mandated to overseeing environmental issues in the country. In particular it oversees environmental issues in construction through the Environmental Impact Assessment (EIA). The EIA must be carried out by the project proponent to ensure safety and environmental guidelines are in place before any construction project commences. In addition, The National Construction Authority oversees the construction industry and it's governed by the National

Construction Authority Act of 2011. This therefore means Kenya has enough guidelines and regulations to streamline and mold the construction industry as regards to safety. However, the lack of proper and strict supervisory authority means that the policies exist only on paper.

2.4.2 The Occupational Safety and Health Act of 2007

The history of OSH in Kenya dates back to 1950, with the introduction of the Factories Act. In 1990 this Act was amended to the Factories and Other Places of Work Act, to enlarge its scope. The Occupational Safety and Health Act No.15 of 2007 repealed the Factories Act Cap 514. The Factories Act was meant to "make provisions for health, safety and welfare of persons employed in factories and other places of work, and for matters incidental thereto and connected therewith." In the year 2007, the Occupational Safety and Health Act was enacted which is seen as moving from the regulated style on safety and health to a self-regulated style of management. It is therefore noteworthy that the enactment of the Occupational Safety and Health Act marked a big step towards moving from a reactive approach to safety and health at the work place to a more proactive attitude to workers welfare.

The Occupational Safety and Health Act 2007 aims at securing the safety, health and welfare of workers and the protection of persons other than the workers against risks to safety and health arising out of, or in connection with, the activities of persons at work. The Occupational Safety and Health Act 2007 sets objectives to promote and improve occupational safety and health standards. In Part II the general duties are laid down in the Act, and are supported by other requirements in the Act, codes of practice and regulations.

The general requirement for employers to consult and co-operate with safety and health representatives and other employees is part of the employers' general duty under the Act.

Additionally, employees are required to co-operate with employers in safety and health matters so that employers are able to meet their responsibilities. The Act also provides for the election of employee safety and health representatives and the formation of workplace safety and health committees. Safety and health committees are made up of employer representatives and safety and health representatives, or employee representatives if the workplace has no safety and health representatives. The Act encourages employers and employees to resolve safety and health issues in a spirit of cooperation, using procedures developed through consultation. The Act places emphasis on workplace consultation between employers and employees, and safety and health representatives, if the workstation has any.

OSHA 2007 has also stipulated out the matter of ergonomics in the workplace. Part VIII of the Act states that: Machinery, equipment, personal protective equipment, appliances and hand tools used in all workplaces shall comply with the prescribed safety and health standards and be appropriately installed, maintained and safe guarded: Every employer shall take necessary steps to ensure that workstations, equipment and work tasks are adapted to fit the employee and the employee’s ability including protection against mental strain; Every manufacturer, importer and supplier or an agent of a manufacturer, importer and supplier of the machinery and equipment referred to in paragraph (1) shall ensure that the equipment complies with the safety and health standards prescribed under this Act and shall provide adequate and appropriate information including hazard warning signs and an employer shall not require or permit any of his employees to engage in the manual handling or transportation of a load which by reason of its weight is likely to cause the employee to suffer bodily injury.

Additionally, OSHA 2007 part XIII states; if any person is killed, or dies, suffers any bodily injury, in consequence of the occupier or owner of a workplace having contravened any provision of this Act, the occupier or owner of the workplace shall, without prejudice to any other penalty, be liable to a fine not exceeding one million shillings or, to imprisonment for a term not exceeding twelve months; and the whole or any part of the fine may be applied for the benefit of the injured person or his family or otherwise as the Minister may determine.

2.4.3 Work Injury Benefit Act 2007

This is an Act of parliament that was ascended to provide for compensation to employees for work related injuries and diseases contracted in the course of their employment and for connected purposes. Every employer shall obtain and maintain an insurance policy, with an insurer approved by the Minister in respect of any liability that the employer may incur under this Act to any of his employees. (Government of Kenya, 2007)

Consequently, the NCA, 2011 states that every contractor should be registered with the authority and have a clear board erected at the construction site indicating the name of the contractor. This is in effort to controlling unqualified contractors, thus improving workers' safety.

2.5 The Impact of Ergonomics to Construction sites

Impact on business in terms of lost working time due to sickness absence is an immediate impact of ergonomics to construction. Injuries cause construction delays, cost overrun and sometimes ruin the reputation of the organization, and losing the confidence among workforce (Wang et al., 2006). It can cause dissatisfaction among stakeholders, be uncompetitive when tendering by government authorities. In 2014/15 an estimated In most construction sites large number of tasks are million working days (full-day equivalent) were lost in the working days lost per worker. Workplace injury and ill health impose costs: both financial (healthcare cost) and non-financial (loss of life and loss of quality of life). Heinrich, 1983 has divided the total cost of accident into direct and indirect cost. Direct cost is the tangible cash involvement (medical, insurance, compensation) (Everett et al., 1996) and indirect cost is all other cost which has contributed to the incident (Hinze, 2005). Indirect costs are invisible but huge in amount (13). According to ILO (ILO, 2011), global estimates of direct and indirect costs for accidents are USD 2.8 trillion equivalent to 4% of the annual global GDP (Leigh, 2011).

2.6 Ergonomic Controls

Whether you use a shovel, keyboard, hammer or lathe you encounter ergonomic risk factors. Ergonomic controls are used to help fit the workplace to the worker. They seek to place the body in a neutral position and reduce the other ergonomic risk factors. These controls must accommodate the widest range of personnel. Controls therefore that reduce a risk factor focus on reductions in the risk modifiers (frequency, durations or magnitude). By limiting exposure to the modifiers, the risk of an injury is reduced.

When a manual task risk factor has been identified, it is important to determine what is causing it. In order to eliminate or minimize the risks, controls should be aimed at modifying the work area, tool, load, and method of handling and/or the way the work is organized. Ergonomics control should be fully integrated into procedures, equipment and design of work. This will ensure health and safety requirements are satisfied as well as benefiting the quality of service and output. Controlling exposure to ergonomic hazards is fundamental in occupational safety.

Ergonomic controls have three main categories: engineering controls, where the risk is engineered out of the environment (through design, tools, hoists, or other equipment changes), administrative controls, such as changes to policies or procedures (for example, lifting techniques, pre-shift stretching, or job rotation), and personal protective equipment (PPE). Similar to controls in the safety industry, the desired control that typically shows the greatest result is an engineering control. For any control implemented, training component may be necessary to ensure that the workforce is utilizing the control properly and effectively reducing the risk. Training workers will show your commitment to injury prevention and ensure the tool is being used as intended by the manufacturer’s specifications.

National Institute for Occupational Health and Safety (NIOSH) risk control guidelines for ensuring a safer workplace include: (i) elimination; (ii) substitution; (iii) engineering controls; (iv) administrative controls; and (v) Personal Protective

Equipment (PPE). These controls are placed from the most effective/desired to the least effective. These controls are shown in **Figure 2.5** from the most effective to the least effective.

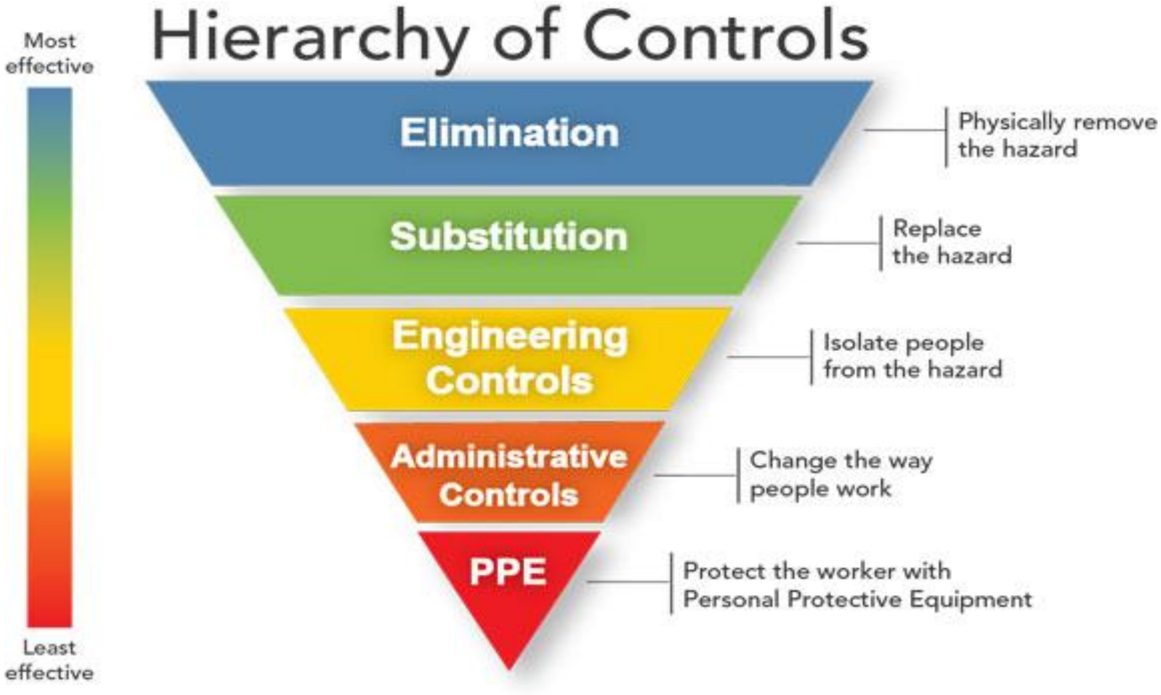


Figure 2.5 Hierarchy of Ergonomic Hazards Controls (Source; NIOSH, 2016)

2.6.1 Elimination and Substitution:

As shown in **Figure 2.5**, these are the most effective controls; however, they are also the costliest to implement on an existing system. This is because major changes in equipment and procedures may be required in order to eliminate or substitute the hazard. This method may be inexpensive, however, if applied at the activity design or development stage. This method is most synonymous with the Prevention through Design technique (PtD).

In the case that elimination is not practical or sufficient, appropriate steps must then be performed in order to reduce the risk through the control method of substitution. Substitution can be used with workplace hazardous materials and work processes. The substitution of work processes can include changing process procedures to provide workers with a safer workplace and reduced exposure to hazards. An example of this could include using pneumatic tools rather than using manual tools in a manufacturing process to reduce the demanding manual work involved. These are the most effective controls; however, they are also a costly to implement on an existing system.

2.6.2 Engineering Controls

These types of measures control exposure to risk by removing the hazard or providing a protective barrier between the worker and the hazard. These are typically very effective, as they act on the source of the hazard and control employee exposure to it without relying on the employee to take self-protective action or intervention. Examples include changing the handle angle of a tool, using a lighter weight part, using automated equipment, and providing a chair that has adjustability. These measures usually entail a high initial cost when compared to that of administrative controls and PPE. However, in the long term, operating costs are usually lower, and they may lead to cost savings and increased productivity in other areas of the process. Engineering controls are the heart of ergonomics: changing the workplace to fit the worker. The design should accommodate a wide range of people assigned to the task.

2.6.3 Administrative Controls

These are changes in the way work in a job is assigned or scheduled that will reduce the magnitude, frequency, or duration of exposure to ergonomic risk factors. It hence deals with how work is structured. Re-organization of working hours and rest breaks can reduce the magnitude of stress experienced by workers. Increasing the frequency of breaks specifically adding extra breaks in addition to a lunch break benefits workers with no decline in productivity and tends to increase workers performance (Faucett et. al., 2007). Frequent short breaks have a positive effect on fatigue development in the neck and shoulder region whereas when workers only take a lunch break they do not necessarily have a significant recovery of perceived fatigue (Bosch et. al., 2011, Faucett et. al., 2007).

Administrative controls are less effective than engineering controls, require ongoing supervision to ensure they are followed and maybe forgotten under stressful conditions, such as when trying to meet deadlines, or when there are fewer staff available to do the work. Rather than controlling the risk directly, administrative controls generally manage the risk by reducing the time that workers are exposed to the risk by relying on worker behaviour. Administrative controls are best used as part of a comprehensive control strategy, or in the interim while longer-term design controls are being developed. Examples of administrative controls include:

2.6.3.1 Proper maintenance and Housekeeping

Proper housekeeping can reduce or eliminate awkward posture associated with extended reaches, bending or twisting, when handling materials, tools or other objects. Floor surfaces should be kept free of slipping or tripping hazards.

2.6.3.2 Job rotation and enlargement

This involves rotating workers through different jobs to rest the different muscle groups of the body, reduce repetition, and reduce mental demands.

2.6.3.3 Work scheduling

Work scheduling can help avoid excessive overtime or extended workdays. It should take into account the fact that shift work can cause fatigue and thereby increase the risk of ergonomic related injury.

2.6.3.4 Sufficient breaks

Instituting work-rest cycles with adequate recovery time can reduce fatigue and risk of ergonomic related injury. Short work/break cycles are best to reduce fatigue.

2.6.3.5 Work practice

Work practices focuses on the way work is performed. For example, modifying work procedures and practices to ensure that neutral working posture and safe working techniques are used

2.6.4 Training

A well educated workforce will lead to healthier workforce. According to Armstrong (2000), safety training includes the rules and provides information on potential hazards and how to avoid or minimise them. This type of preventive program is done through: induction course; transfer to new job or change in working methods; refresher course and training should be provided to deal with aspects of health and safety to employees.

Workers require instructions and training to enable them to carry out their work safely. Training on handling of emergency situations should be conducted regularly to keep the workforce informed. Workers should be trained to take up tasks based on ability. When operating equipments the workers should be able to read signs and follow instructions. All accidents in the work place should be reported, analyzed and investigated. Employees should be trained to report to their supervisors and employers in their turn should report to authorities. A record should be kept for daily first aid treatments, exposures and accidents. According to Tayyari & Smith (1997), training and education are an effective way of increasing awareness of ergonomics issues and resolving problems before injuries occur. Ergonomics education allows supervisors and employees to understand work related hazards with a job.

2.6.5 Personal Protective Equipment (PPE)

It is considered as the least effective hazard control. In the event that no engineering or administrative control has been making a significant effect on reducing or eliminating hazards, then PPE should be used to ultimately protect the worker from potential hazards and risks. PPE is a last resort mechanism in the hierarchy of hazard controls. PPE may include but is not limited to safety glasses, hearing protection, breathing apparatuses, face shields, safety shoes or boots, gloves, and helmets. PPE may be utilized when engineering controls are not feasible or are in the process of being developed, when safe work practices do not provide sufficient protection, and in the case of an emergency (Stromme, 2004).

PPE does not eliminate the hazard or reduce the time of exposure. PPE simply reduces the amount of hazardous exposure by placing a barrier between the hazard and the worker. The most effective method of reducing or eliminating ergonomic hazards is to fix the hazard, not the worker through engineering and administrative controls.

Proper PPE requires supervisory and personnel actions by identifying and selecting the type of equipment needed, proper fitting for correct use, training, inspections and maintenance (Manuele, 2008). PPE can also increase hazards for the workers in different conditions when being used excessively. According to Stromme (2004), there is a greater risk of problems developing with using PPE improperly or in a manner unsuited to its design and purpose. This can be worse than using no protection at all. Manuele (2008) has a similar view to Stromme (2004) in that PPE may be necessary in many different occupational settings but is the least effective way to reduce the exposure of hazards and risks in the workplace.

2.7 Ergonomic Research Methods

Periodical ergonomic risk assessments and proactive ergonomic practices need to be standardized in order to ensure safe construction workplaces. This will help identify and eliminate exposure to risk factors, ensure safer working conditions, and improve occupational health and safety (OHS) compliance, thereby reducing the occurrence of WRMSDs and, consequently, its adverse implications in terms of productivity and cost. Additionally, adopting an approach of prevention through design (PtD) early on in the task design phase will reap greater benefits. This therefore, explains the need to integrate ergonomic assessment applications for daily building construction work activities. Due to the multi-factorial nature of WRMSDs, many studies have been conducted in recent years providing a basis for ergonomic risk assessments. The prevalence of WRMSDs has resulted in the development of various techniques for assessing work, such as Rapid Upper Limb Assessment (RULA, McAtamney & Corlett 1993); Rapid Entire Body Assessment (REBA, Hignett & McAtamney 2000); Ovako Working posture Analysis System (OWAS, Karhu et al., 1997); Quick Exposure Check (QEC, Li and Buckle 1998); University of Michigan 3D Static Strength Prediction program (3DSSPP, University of Michigan 2003); ERGOBUILD (Nussbaum et al., 2009); 3DSSPP/AutoCAD PC model (Feyen et al., 2000); and Ergonomic Workload Stress Index (EWSI, Chen et al., 1994). Some of these methods have proven generic applications (REBA, RULA, OWAS, QEC), while others may be applicable to specific industries or task types (ErgoCheck, ERGOBUILD, 3DSSPP, 3DSSPP/AutoCAD PC model). Generally, that the degree of ergonomic risk largely depends on the nature and environment within which each task is executed. Each ergonomic assessment methodology is developed based on certain rationale and designed for specific work variables and conditions. Ergonomic assessment techniques can be categorized into four main groups: (a) checklists, surveys and reports, (b) observation-based methods, (c) computer applications, and (d) direct measurement methods. Due to the above challenges and the rising cases of accidents and incidences at construction work sites, there was need for his research.

CHAPTER THREE

METHODOLOGY

3.1 Research Design

The study used descriptive and cross-sectional design. Descriptive design attempts to gather quantifiable information that can be used to statistically analyze a target audience or particular subject (Benard, 2012). It's used generally to describe a phenomenon and its characteristics. It is an important design because participants are observed in a natural and unchanged environment (Grime et al., 2002). On the other hand cross-sectional design was used by the researcher to make inferences about the population of interest. In this research therefore, it was used by the researcher to evaluate the ergonomic risk factors in construction sites as well as their effects. The research design hence focused on gaining an understanding of the ergonomic risk factors in construction industry and its relation to Musculoskeletal Disorders in Mombasa County.

3.2Study Population

The target population was 1364 construction workers from National Construction Authority registered building construction sites carrying out both commercial and residential building construction in Mombasa County area at the time of data collection (2017). The study targeted employees working on permanent, temporary and casual basis. The population comprised of site managers, skilled and unskilled laborers. Workers selected were those who have been working in the construction site for more than one year and have consented to provision of information to the researcher. For this reason, the researcher targeted a population from the selected four (4) sub-counties in Mombasa County (**Table 3.1**)

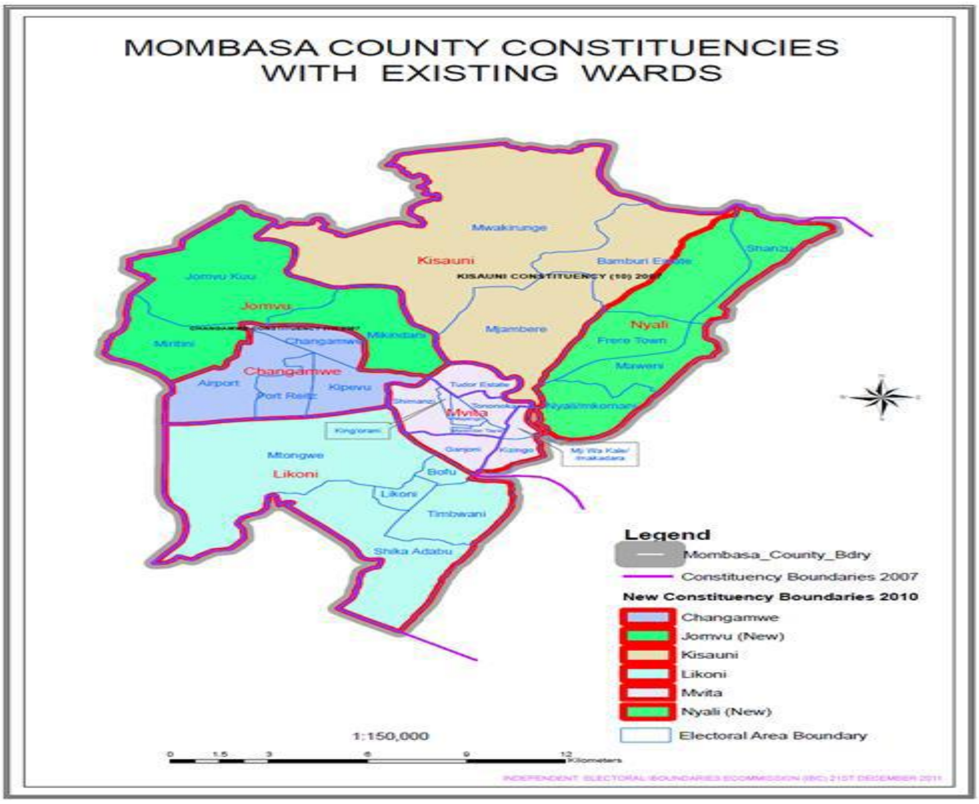


Figure 3:1: A Map of Mombasa County (IEBC, 2011)

Table 3.1: Registered construction Sites in Mombasa County

Sub-County	Number of Registered Building Construction sites	Total numbers of workers
Kisauni	27	916
Changamwe	12	298
Nyali	5	78
Jomvu	7	72
Total	**51**	**1364**

3.3 Sample and Sampling Frame

Sampling frame as defined by Cooper and Schinder (2000) is a list of all the elements from which a sample is drawn and is clearly related to the frame. In this study, stratified random sampling and simple random sampling was used with specification on job categories and level of construction. According to Cooper and Schinder (2000), a stratified random sample is a population sample that requires the population to be divided into smaller groups, called “strata”. Random samples were taken from each stratum, or group.

From the selected sub-counties, 1364 workers from the registered building construction were divided into 5 strata based on the job cadre/task performed. They included: carpenters, roofers, mason, steel fixers and site managers. These group formed both the skilled and unskilled workers. Then random sampling was used in each stratum. Yamane (1967 p. 886) provides a simplified formula to calculate sample sizes. This formula was used to calculate the sample sizes.

A 95% confidence level and P=.5 are assumed for **Equation 1**

$$n = \frac{N}{1 + N(e)2}$$

Equation 3.0: Yamane (1996:886): Sample size determination

Where *n* is the sample size, N is the population size, and e is the level of precision. When this formula is applied to the above sample, we get **Equation 3.1**.

$$n = \frac{1364}{1 + 1364(0.05)2}$$

n= 309

Equation 3.1: Yamane (1967): Sample size

For specific trade to be incorporated in the research, each population for each trade was subjected to the following equation:

Specific trade sample size=Trade population/Total population x Sample size

Equation 3.2: Selected trade Sample size

The sample size for each trade is therefore shown in **Table 3.2**.

Table 3.2: Sample frame and Sample size

Cadre	Target Population	Sample size
Carpenters	365	82
Roofers	250	57
Mason	600	136
Steel fixers	109	25
Supervisors/foremen	40	9
Total	**1364**	**309**

Therefore 309 subjects form an ideal sample size for the study. According to Nkpa, (1997) for a population running into hundreds, the sample size should be 50%; the researcher therefore aimed at least for 50% subjects in each group as reflected in **Table 3.2**. Simple random sampling was used in each category, with each subject having a known non-zero chance of being selected. **Table 3.3** shows specific job group based on the sampling strategy that was adapted for this study.

Table 3.3 Sample size per specific work category in each sub-county

Sub-County	Code	Supervision/ foremen	Carpenters	Roofers	Mason	Iron workers	TOTAL
Kisauni	A	3	42	24	102	9	**180**
Changamwe	B	3	28	16	15	7	**69**
Nyali	C	1	8	9	10	5	**33**
Jomvu	D	2	4	8	9	4	**27**
Total		**9**	**82**	**57**	**136**	**25**	**309**

3.4 Data Collection Procedure and instruments

In order to achieve ergonomic risk factors evaluation, identifying ergonomic risk factors related to building construction and determines, the prevalence of ergonomic injuries, the researcher adopted a Checklist, Survey, and Report Technique. This is a Self-Reported Ergonomic Hazard Assessment method that is designed to suit daily construction work-related activities and ensure a comprehensive body part ergonomic evaluation. The assessment checklist was administered to the participants included questions regarding job task perceptions, work history, and anthropometric information. The field of subjects for the study included carpenters, masons, plasters, roofers, painters, foremen and steel fixers. To define the body parts pertinent to this study, the human body was divided into six (6) general segments (movement areas): (i) neck (ii) arms and shoulder, (iii) hands/wrist, (iv) upper-back, (v) lower-back, and (vi) legs. This allows for observations of risk exposure to these parts and also paves way to a correlation of risk exposure to response. The values assigned to the body part postures (Appendix II) represent risk scores relative to each work posture.

The researcher also took video for observation and analysis over a period of 8 weeks (March 12- May 7, 2017 with an average of 3 hours observation per week). This video data was collected over an extended period of time in order to ensure that the data was not biased and was a good representation of the normal process. A standardized Nordic questionnaire (Appendix 1) was also used. Additionally, secondary data was collected through review of existing records from sites and DOSHS offices.

3.5 Data Collection Procedure

The researcher contacted contractors from the sampled construction sites and arranged convenient and appropriate times when workers will be available for questionnaires to be administered. Most workers were available during the lunch break time. A self- report checklist was distributed to the construction workers.

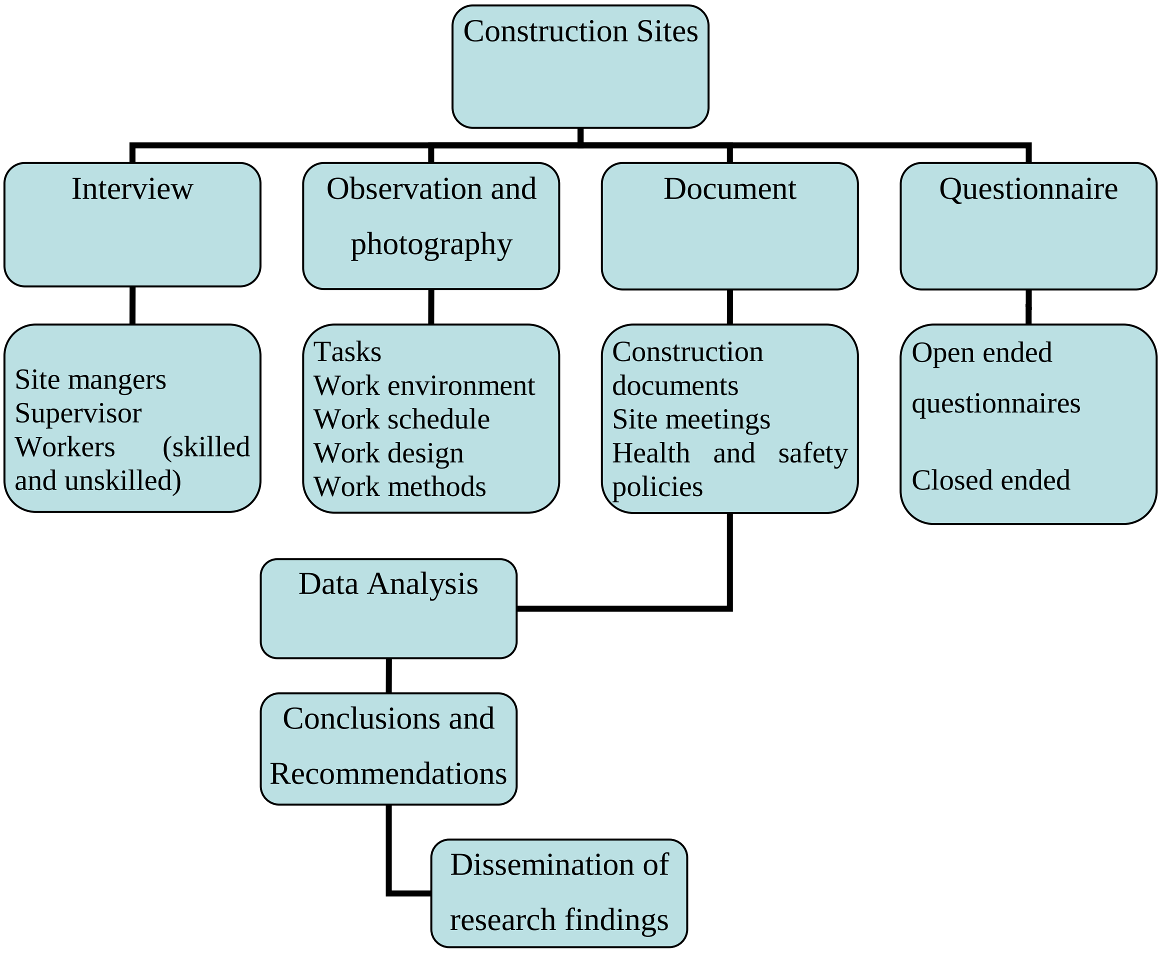


Figure 3.2 Data collection procedure and tools. (Source: Author, 2017*)*

3.6 Pilot study

The purpose of pilot testing is to assess the clarity of instrument that is validity and reliability of each of the items in the instrument as well as suitability of the language used in the instrument (Babbie 2004) Pilot study enabled the researcher outline the weakness and strength so as to apply appropriate action prior to the actual study. Pilot testing was conducted among 20 workers from randomly selected on four construction sites in Mtwapa area, in Kilifi County.

3.7 Validity and Reliability of data collection instruments

Validity and reliability of data collection instruments is essentially to minimize bias in the study findings. Reliability refers to the source of consistency, dependability and stability of the instrument used for data collection. On the other hand validity is concerned with accuracy, effectiveness or trustworthiness of the interpreted data (Kothari 2004). The reliability and variability of the research instruments is determined by the consistency of the research results. In order to ensure reliability of the data collection instruments, the researcher carried out pilot test by randomly selecting four building construction sites in Mtwapa area in Kilifi County, conducted observation, administered the questionnaires and observed the response to see if the questions were understood, and if the answers given were relevant to the study. Corrections were made with observed weakness in data collection instruments.

3.8 Data analysis

Data collected from the assessment checklist administered to the participants that included questions regarding job task perceptions, work history, and anthropometric information. Data was analyzed and summarized based on the study objectives. Data was analyzed using the SPSS software (SPSS) Version 20.0.

The monitoring was categorized according to the following five (5) ergonomics risk factors

i. Repetition: Daily tasks requiring repeated neck, shoulder, elbow, or wrist use repeatedly for more than 3(three) hours per day without other risk factors or for more than two (2) hours daily with wrist bent in flexion >30°, extension >45°, plus high forceful hand exertions.
ii. Awkward postures: Shoulder, neck, back, or knee postures maintained for four (4) or more hours during a normal day shift.
iii. Repetitive motion: Conditions requiring the use of the heel/base of palm as hammer > once per minute, >2 hours total/day or use of knee as hammer > once per minute, 2 hours total/day.

iv. Lifting hazard: Lifting hazards were assessed based on the average weights lifted by the worker, the frequency of lifts, and position of the worker's hands while performing the lift.

CHAPTER FOUR

RESEARCH FINDINGS AND DISCUSSION

4.1 Response Rate

309 (100%) questionnaires were distributed to the targeted group. The questionnaires were distributed to the workers on convenient basis in each site. The different sample from different construction sites in this study was a representative of the population of workers in each particular construction site. The respondents were randomly picked from each group based on specific tasks they performed. They include: site managers, carpenters, masons, roofers and iron workers.

Out of the 309 (100%) questionnaires distributed, 220 (71.2%) copies were returned and had the questions responded to correctly. Eighty nine (89) responses were invalid owing to inconsistency in the responses and were discarded. The remaining two hundred and twenty (220) responses were included in the analysis and provided useful information for the survey.

According to Mugenda Mugenda (2003) a recommended minimum of 50% response rate is adequate. In addition, Babbie (2007) suggests that in research a response rate of at least 50 per cent is considered adequate for analysis and reporting and a response of 70 per cent is very good. Hence the research 71 per cent was appropriate for data analysis.

The demographic characteristic is a vital component in this study. The gender, age, education and number of years worked in the building construction industry were captured to assist the researcher in arriving the research objectives. Table 4.1 shows the distribution of respondents' gender, age, education level and years worked in the building construction industry.

Table 4.1: Summary of the Socio-demographic data of respondents

Variables	Trait	Frequency	Percent (%)
Gender	Female	12	5.5
	Male	208	94.5
Age (Years)	19-29	88	40
	30-39	80	36.4
	40-49	38	17.3
	50-59	10	4.5
	60 and above	4	1.82
Experience (Years)	1-4	60	27.3
	5-9	123	60
	10-14	25	11.4
	15-19	8	3.4
	20 and above	4	1.8
Education	Never attended school	11	5
	Primary	79	35.91
	Secondary	105	47.73
	Tertiary/college/University	25	11.36

4.2 Demographic Information

4.2.1 Participant's Gender

From **Figure 4.1**, majority of the respondents were male [208(94.5%)] while female were very few [12(5.5%)]. This is because most construction work is strenuous and requires strength that's why it attracts more males than females as seen in this study. (Bernard, 2010). This explains the low rate of women employment in the housing construction industry. This can also be explained by the culture in community's stereotyping men as being superior than women and hence preferring construction work to male rather than female (Bhagwat *et al*., 2009). Kimeto (2014) in his study on safety provision among tea factory workers reported that male workers in the factories were high (75.0%) compared to their female counterparts (25.0%). Hard work with high occupational risk is usually done by men according to Jeanne (2007). Men are known to take high risk in order to provide for their families especially during economic hard times hence the high number of men working in construction sites. Coastal culture ensures that women are assigned lighter duties hence the number of women in the construction industry in Mombasa County.

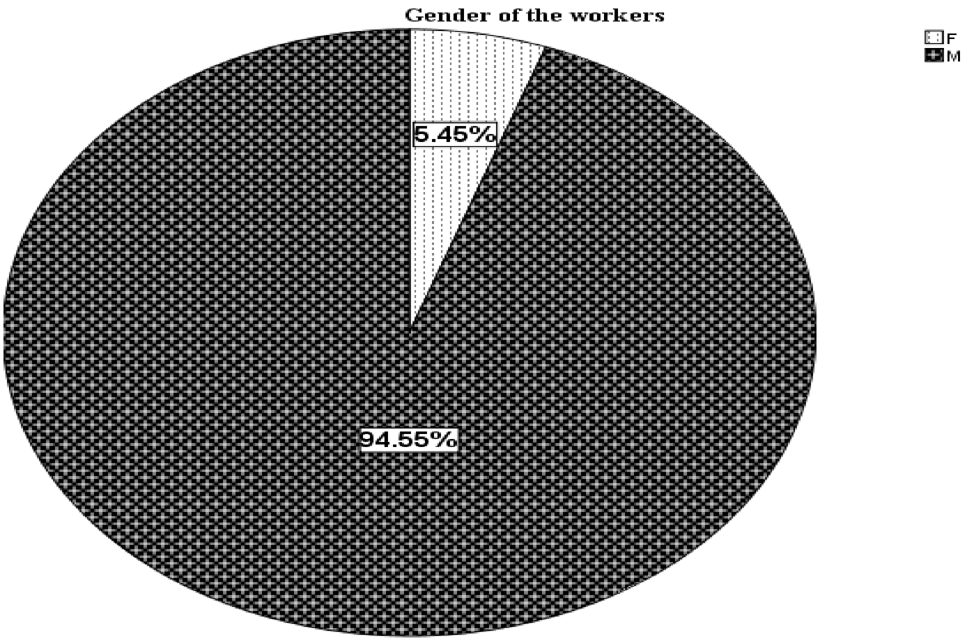


Figure 4.1 Gender of the Respondents

4.2.2 Respondents' age

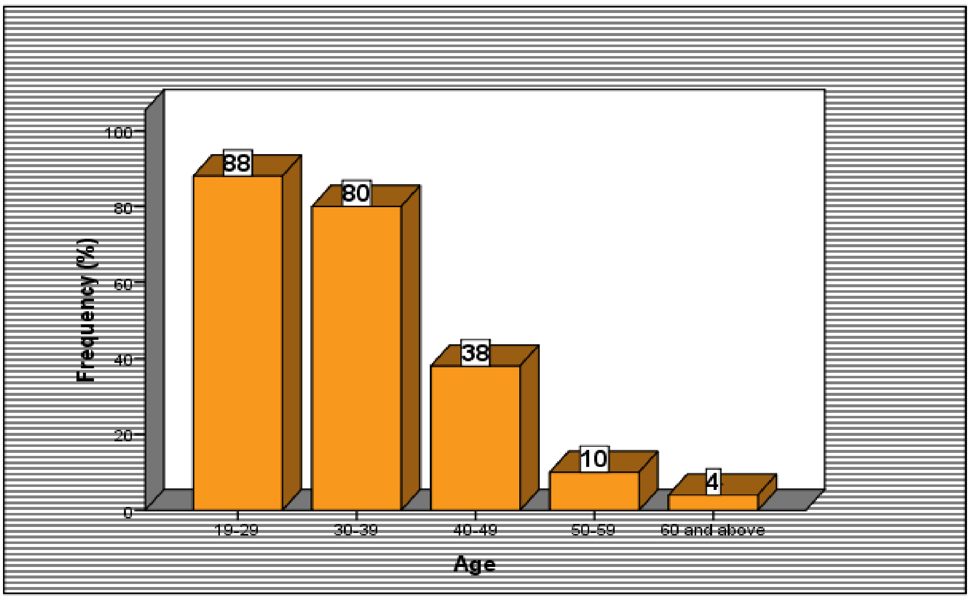


Figure 4.2 Respondents age

From the findings, 27(88%) respondents were aged between 19-29 years, 8(80%) were between 30-39 years, 78(38%) were between 40-49 years, 60(10%) were between 50-59 years, and only 23(4%) were over 60 years (**Figure 4.2**). This result can be related to several studies that were conducted by Khairuzzaman et al., in 2014 that gave similar findings. They found out that majority of construction workers fall between 26-30 years. This can be attributed to the fact that the youth are more energetic and physically fit to perform strenuous activities as opposed to the aged population (Williams *et al.*, 2011). Additionally, one can deduce that workers older than 50 years are few on site as they are considered old because working in construction sites requires a lot of energy. This aged population has a declined physical fitness and low cognitive abilities (memory, reaction time) (Kowlaski et al., 2005). Additionally, these aged populaces are prone to injuries and fatalities. A study done in Nepal by Acharya in 2014 came up with similar results stating that middle class workers have obligation of raising young families that they need to provide basic needs.

4.2.3 Years worked in construction industry

The study established in the study majority of the respondents (98%) had work experience of between 1 and 14 years and only 2% had worked for over 20 years. This means that workers retire early due to the nature of construction work and also due to injuries and or disabilities arising from the work. This sentiment has been proved by Brenner and Ahem (2000) who found out that the construction industry has high levels of early retirement due to permanent disability. The numbers of years a laborer has spent on the building construction site are attached to the safety on the building construction site. This is because the more years a worker has been to construction site working reflect the number of safety and health programs and or training they have been subjected to. Fitzgerald et al., 1997 also found out that experience enable workers avoid ERFs in their work sites hence they get accustomed to proper working methods and hence avoidance of ERFs and MSDs. Therefore, the more the experience of the workers, the less error are expected to make, hence the safer the work.

In normal circumstance, employees tend to work for shorter period of time in construction industry due to hazards associated with the trade. This sentiments has been echoed by ILO 2013 that demonstrated that the more a worker has experience, the more they are conscious of their work environment and prone to accidents and incidences at work places.

4.2.4 Educational level of the Respondents

This study established that 5% of the construction workers had never attended school while 83.6% had attained basic education (primary and secondary) **(Table 4.1).** The education level of workers determines the decision one is prone to make and also how they will understand safety instructions (UNESCO 2005). Education promotes the development of the knowledge, skills, understanding, values and action required to create a safe work environment which will ensure prevention of ERFs and MSDs occurrences. As established in the study, majority of the construction workers lack specialized training hence will be engaged by the owners of the project to do menial duties (carrying construction materials) that does not require specialized skills. Education plays a critical role in determining the level of awareness in work environment. Different researchers have pointed out the impact of education level on health and safety risk management. Mombeki (2006) observed that employees with a low level of education found it difficult to interpret contract documents and health and safety laws. This therefore leads to a poor understanding of many issues concerning the health and safety of workers. Phoya et al., 2011 on the study on the perception of risk of site managers and workers at construction sites in Tanzania observed that those with higher education are more aware of health and safety risks than those with a low level of education. In this study, slightly less than half (41%) of workers had just basic education which is a risk factor bearing in mind the kind of work they undertake and split decisions in case of an emergency.

4.2.5 Workers terms of employment

Terms of employment were permanent, temporary or casual among the construction workers as shown in **Figure 4.3**. The finding of this study showed that 133 (60.45%) of the respondents are employed as casual, 72 (32.73%) were on temporal terms and only 15 (6.82%) being on permanent terms. Casual workers performed manual work such as carrying construction materials and water. Construction industry in many cases employs site managers and foremen on permanent basis. Contractors in most cases tend to invest in training for their permanent staff unlike those in casual terms. According to Proulx (2013), training increases knowledge on health and safety and hence reducing accidents and mishap in the construction sites. This hence show that majority of workers who are casual are unfortunately not trained.

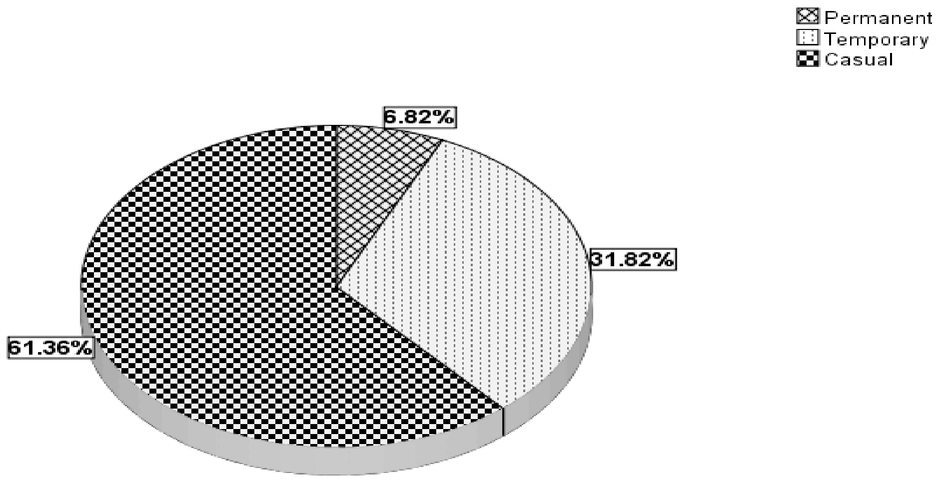


Figure 4.3 Workers terms of employment

4.3 Identification of ERFs in building construction sites

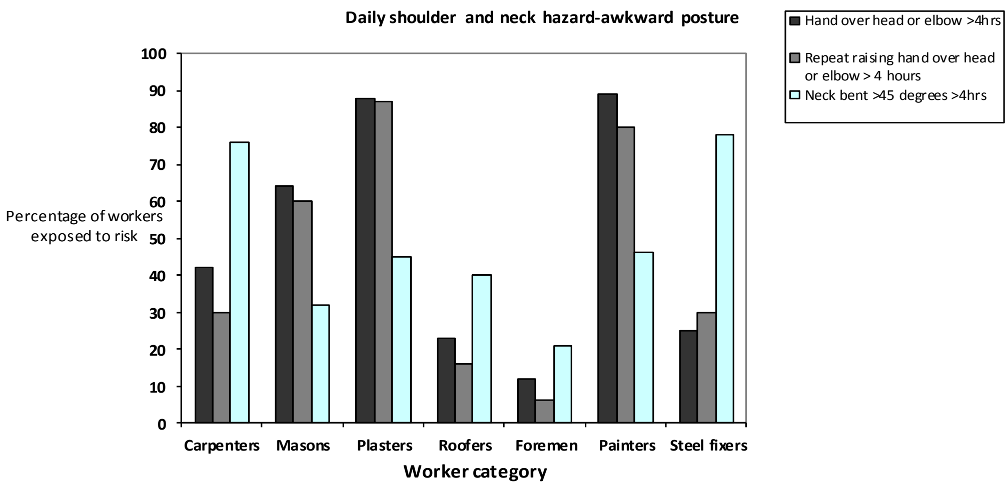


Figure 4.4 Percentage of workers indicating daily exposure to awkward shoulder and neck posture

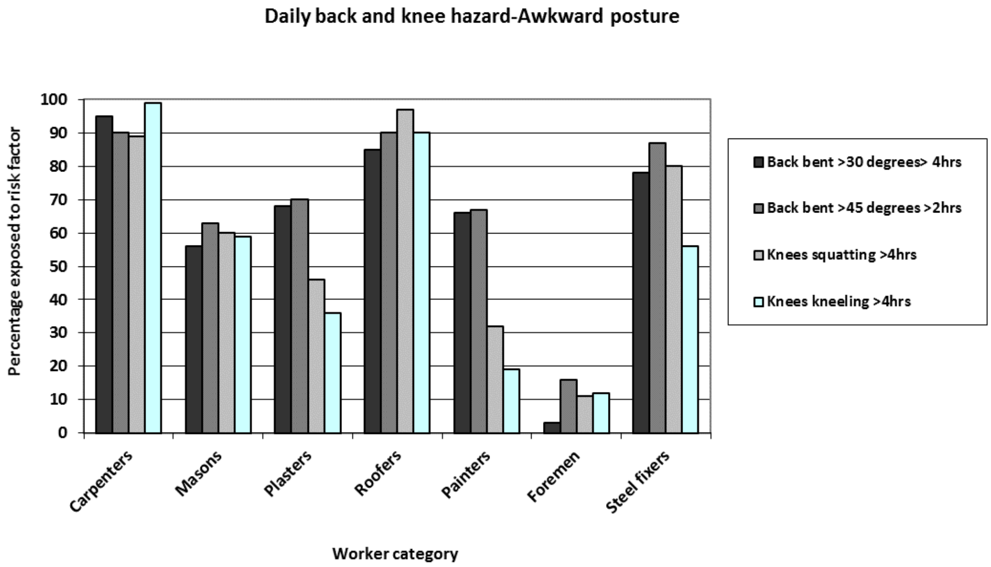


Figure 4.5 Percentage of workers indicating daily exposure to awkward back and knees posture

Plate 4.1: Construction worker working in an awkward posture

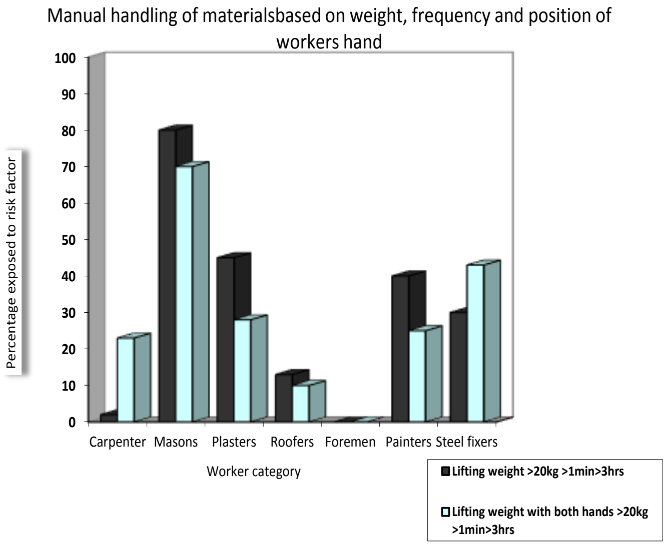


Figure 4.6 Percentage of workers indicating weight lifted

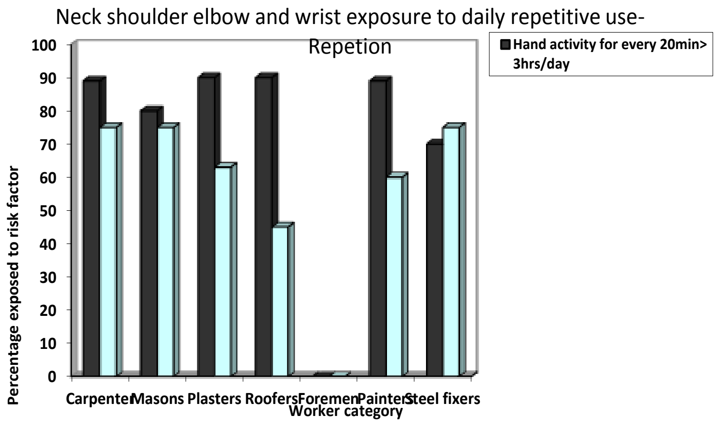


Figure 4.7 Percentage of workers indicating repeat impact on hands and neck

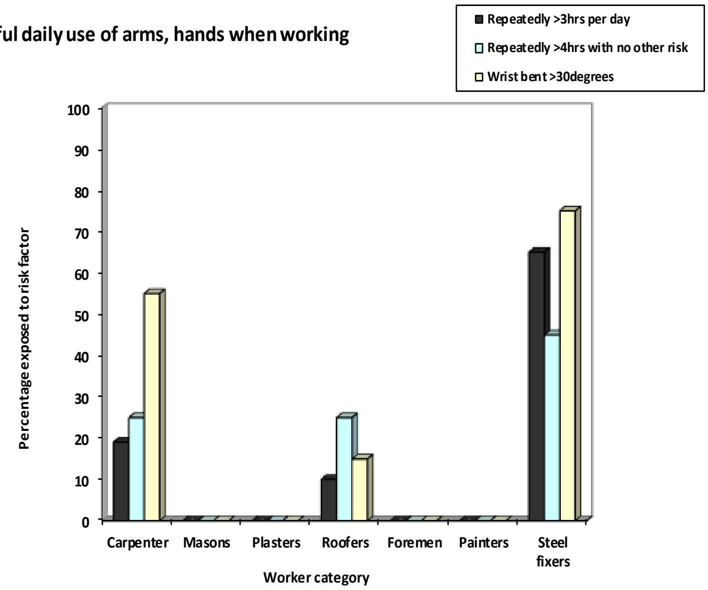


Figure 4.8 Percentage of workers indicating hand force exertion

Plate 4.2 Workers in awkward posture and without PPE

From **Figures 4.4-4.8** above, the study established the following information based on each of the ergonomic hazard classes:

i. Awkward postures

Except for the foremen, all respondents checked off high daily exposure to postures involving bending the neck > 45^o for > 4 hours total (**Figure 4.4**). Hand over head or elbow was recorded high in painters, plasters and mason. Additionally, Steel fixers, carpenters, plasters and painters indicated considerably high levels of repeated raising hand over head for more than 4 hours. Plasters, painters and masons recorded checked high levels of neck bent above $45^{0.}$ Postures requiring the back to be bent >30^o in 4 hours daily was checked by all the workers though minimum in foremen, (**Figure 4.5**). Daily ergonomic hazards affecting the back and knee was checked off by all carpenters, masons, plasters, roofers, painters, foremen and steel fixers (Figure 4.5). Foremen and painters recorded minimum effects from knees kneeling for > 4hours

ii. Manual handling of materials

From **Figure 4.6**, all worker categories recorded some impacts associated with manual lifting of construction materials except foremen. Masons and plasters recorded high levels of lifting weight of above 20 kg for over 3hrs. Painters and steel fixers also checked off exposure the risk.

iii. Repetitive motion

Figure 4.7 shows that repeated impact involving hand activity for every 20 minutes and for >3hours. All worker categories except foremen checked off. They also checked high rate of lifting objects for every 20 minutes.

Based on the results from the checklist administered to the workers, the majority of workers graded their job tasks within the hazard zone for ergonomic risk. A correlation between the results from the assessment of perceived hazard exposure and the results from onsite observation (**Figure 4.4 and Figure 4.5**) confirms that the majority of the participants are working within the hazardous range for WRMSDs.

iv. Forceful exertion

Figure 4.8 shows that Steel fixers, roofers and carpenters are exposed to forceful exertion through hand, wrist, and arm tasks involving gripping of objects for more than 4 hours per day. These workers category checked off daily tasks requiring that the wrist be bent in flexion > 30° for more than 3 hours total**. Plate 4.2** shows workers exposed to this risk.

Exposure to physical activities at workplaces, workplace environment, and use of tools and materials affect workers in many different occupations and are strongly associated with injury risk (Chau et al., 2009). These exposures may include forceful exertions involved in manual handling; awkward postures of the neck, back, and lower extremities; repetitive motions; contact stress; and segmental and whole-body vibration. A study by Paguet, Punnett, and Buchholz (1999) on an ergonomic assessment of manual handling of materials reported that the highway construction workers were frequently observed in heavy manual materials handling activities involving at least 13.5 kg. Holmstrom et al., (2003) noted that low back pain caused by musculoskeletal disorders has been estimated to affect one third of construction workers at some time during their employment period. Additionally, any population of working construction workers, more than half suffer from occasional or frequent musculoskeletal complaints and the lower back is the major complain (Oude et al., 2011)

4.4 Prevalence of MSDs among construction workers

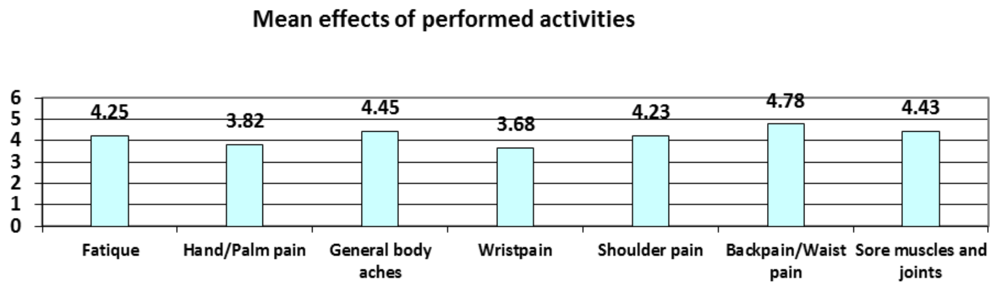


Figure 4.9 Extent performances of activities on construction site

With the activities listed in **Figures 4.4-4.8**, the respondents perceived their effect on the physical nature of construction workers in **Figure 4.9**

A mean score (MS), was computed for each activities and its effects to enable interpretation of the percentage responses to the five point scale: minor extent (1); near minor extent (2); some extent (3); near major extent (4) and major extent (5). It is notable that the sore muscles and joints, back pain / waist pain, shoulder pain, fatigue, falls within the range $>4.20 \leq 5.00$ (between a near major / major extent). Furthermore wrist pain, hand / palm pain, falls between $>3.40 \leq 4.20$ (between some extents to a near major extent).

Plate 4.3: Worker working on knees

Plate 4.4: Workers carrying heavy materials

The study revealed a similar findings as Oude et al., (2011) who established that construction workers from occasional or frequent musculoskeletal complaints. In addition, a similar study by Latza (Latza 2000) revealed that back pain is most frequently injured or reported in construction sites. This result can be concluded as being attributed to manual handling when performing tasks. **Plates 4.3 and 4.4** show some of the tasks performed by construction workers that result in muscular injuries. These tasks are ergonomically hazardous as they subject the workers body to muscle strain and eventually MSDs.

4.5 Relationship between ERFs and MSDs

Table 4.2 ERFs association to MSDs

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t-value	P value
(Constant)	.622	.142		5.369	.000
ERFs association to MSDs	.709	.036	.798	18.569	.000

a. Dependent Variables: Musculoskeletal disorders occurrences

From the **Table 4.2**, the equation $Y=\beta_0+\beta_1X_1+\varepsilon$ will be interpreted as:

$Y=0.622+0.709X_1+\varepsilon$ where

$=0.622+0.709X_1+0.05$

Where:

Y=Occurrence of MSDs

β_0= Constant

β_1=performance

X_1=independent variable (Ergonomic Risk Factors that causes MSDs)

E= error of estimate at 95% confidence level

The regression equation 0.622+0.709X1+0.05 established that that with a constant variable of MSDs occurrences, Ergonomic risk factors that result in MSDs in workers will be at 0.622. With the constant exposure of workers to ergonomically unfriendly work conditions, the risk factors that workers are exposed to will result to a 0.709 raise of the occurrences of MSDs This indicated that a unit change in ERFs subjection with result to MSDs irrespective of workers experience.

4.5.1 Regression Model summary

Table 4.3 below which is the model summary in provides the R, R^2, adjusted R^2, and the Standard error of the estimate, which can be used to determine how well a regression model, fits the data. R Squared is the fraction of the variation in dependent variable (Musculoskeletal disorders occurrences) that can be accounted for by independent variables ERFs in construction work. In this case R-Square shows that 80.1% of variation was explained. This indicates that in the current study, the independent variables were significant in causing MSDs.

Table 4.3 Regression Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.768[a]	.801	.798	.410

a. Predictors: (Constant), ERFs association with MSDs

4.5.2 Chi Square test

The Chi square was calculated to test the significance of relationship between ERFs and occurrences of MSDs. The Chi Square obtained value was 0773 (Table 4.4). From the study, all listed ERFs was found to have a significant relationship with the occurrence of MSDs in construction workers. Workers in the construction work are hence subjected to work conditions that affects their work performance and hence health. There is therefore need for measures to address the ergonomic risk factors that immensely affects the workers' health status.

Table 4.4 Chi Square test

Value	Asymp. Sig.	Df
.773[a]	.000	1

4.5.3 Odds Ratio for women vulnerability to Ergonomic Risk Factor injuries

Table 4.5 Odd ratio for men and women vulnerability to ERFs

	Yes	No	Total
Women	**a 10**	**b 2**	**H_1 12**
Men	**c 20**	**d 188**	**H_0 208**

To calculate the risk ratio, we first calculate the risk rate for each group. Here are the formulas:

(i) a ⁄ a+b

(ii) c ⁄ c+d

(i) 10/(10+2)= 10/15

=0.833

=83.3%

(ii) 20/(20+188)= 20/208

=0.10

=10%

Ratio hence =0.833/0.10

8.33

Thus, women at the construction sites are 8.33 times as likely to develop injuries associated to Ergonomic risks factors as men at the construction sites. This is not surprising as construction industry is male dominated and research undertaken in Singapore on construction fatalities between June 2006 - May 2008 showed that 100% of the deceased workers were male (Tam et al., 2004). Previous studies suggested that that male workers were represented heavily in severe and fatal accidents than female workers and injuries to female workers were mild and moderate consequences (Ling et al., 2009; Lopez et al., 2006). This pattern was believed to be reflection of the differences in tasks undertaken by male and female workers on construction sites. The global participation of women in the construction sector over the century has risen as observed by U.S Bureau of Labor Statistics (2012). The negative consequences for health and safety are more severe in women than in men where social burden is higher in the social context where they form about 62%. Construction work is a problem for women as it involves handling of materials and tools which may not been suited for women (Schneider and Susi, 1994). High physical work demands are considered the ergonomic risk factor for work-related injury disorders (Kaminskas & Antanaitis, 2010). Manual handling of materials in different awkward postures increases the risk of women injury disorders (Marras et. al., 1993).

4.6 Extent of health and safety management system

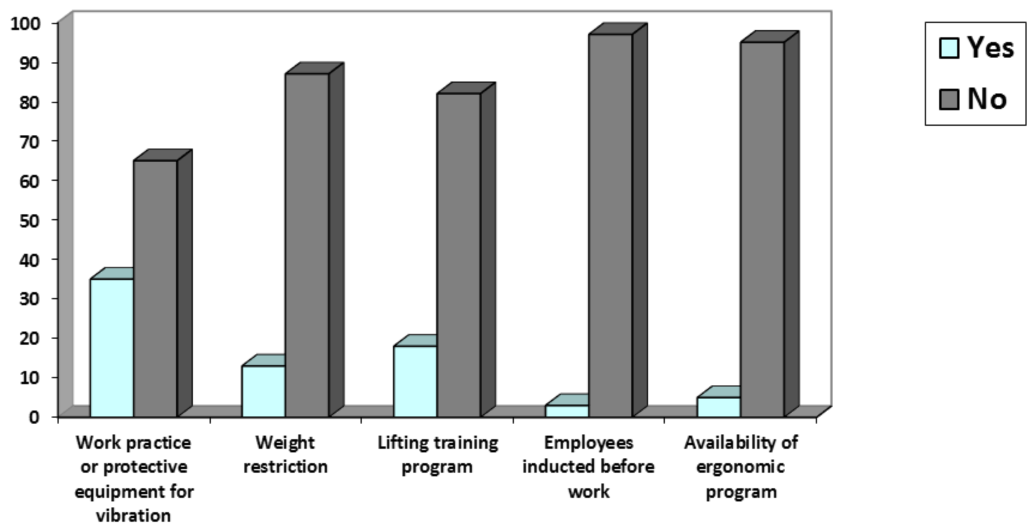


Figure 4.10 Ergonomics program in construction workplace

Figure 4.10 above gives the responses from the foremen on the availability of the ergonomic programme to their employees. It was noted that 95 % of the construction sites do not have an ergonomic programme in place, 18% ascertained that there is lifting programme in place for their workers. 87% does not have weight restriction while 35 % of the respondents have a work practices and protective equipment for vibrations. The research found that the respondents perceived that construction activity hampers the physical nature of construction workers. These findings clearly indicate that there is a need to reduce the onset of the WMDs among the construction workers.

Thus based on the findings and the fact that construction is a project based industry is an important contextual issue, when attempting to manage a dynamic changing work environment such as a construction site, it should be borne in mind that there is need to be in place of an appropriate safety structure to deal with the changing nature of the project.

Plate 4.5 Typical construction site

Enhancing organizational safety culture and workplace safety climate can have positive impacts on work environment and safety performance (Mohamed, 2003; Zhou et al., 2008; Oh & Sol, 2008). Therefore safety through design in reducing the onset of the ergonomic injuries among the construction workers is a fundamental principle of both ergonomics and occupational safety and health. The practice of ergonomics in the workplace is premised on designing the job and the workplace to meet the capabilities and limitations of the construction worker (Hecker et al., 2006; Mroszczyk, 2007; Ajayi & Thwala 2012a).

4.6.1 Awareness level of ergonomic risk factors

Figure 4.11 shows that 160 (72.73%) of the respondents in this study were not aware of the ergonomic risk factors and their effects that result to injuries from working in the construction sites with only 60 (27.27%) stating otherwise

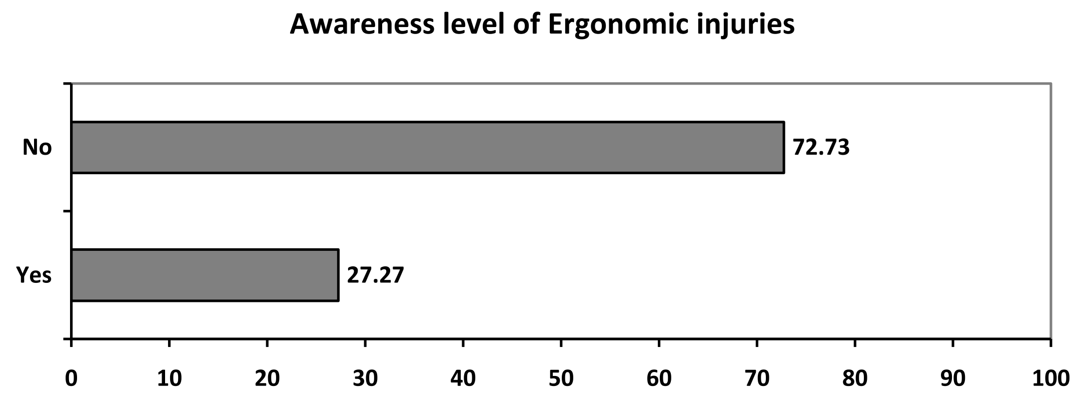


Figure 4.11 Knowledge of ergonomic risk factors and their effects

In a study done by Nabila (Nabila et al., 2014), for Malaysia construction workers, it was concluded satisfactorily that most construction workers are aware of the existence of ERFs and their consequent effects. It was however stated that despite awareness, there was still lack of implementation of ergonomic programs in construction sites. Most participants appreciated the knowledge and relation between the task and effects to their bodies. From all the visited sites workers are aware of effects of dust, excessive noise and heat, ergonomic hazards. Majority of the sites 71% experienced manual handling of construction materials as well as vibration and excessive noise as a result of the stage at which the construction site is at. Accidents are caused by unsafe practices due to poor safety culture, poor attitude towards safety, lack of adequate knowledge and skills in health and safety (Muchemedzi et al., 2006). A study done by Muchemedzi et al., 2006 established that majority of the accidents don’t just happen, instead, people who perform unsafe acts and creates unsafe conditions cause accidents to happen and hence accidents. A study done by Ahmed & Smith in United Arab Emirates (2010) showed that 52.9% of the workers knew the hazards on sites. It can hence be concluded that most construction workers

(72.73%) are fully aware of the existence of ERFs and hence can be deduced that because of the employers' daily target and pressure from society for these construction workers to provide, they end up ignoring the fact that exposure to these ERFs leads to MSDs hence subjecting themselves to tasks and work methods that can cause body injury

4.6.2 Cause of accidents in the construction sites

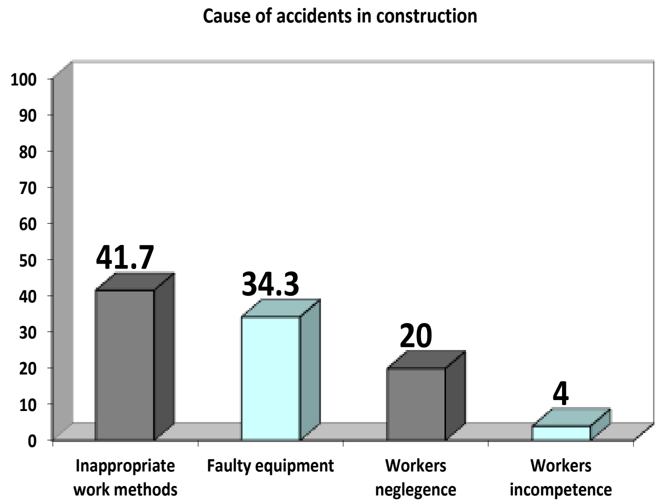


Figure 4.12 Causes of accidents in construction sites

According to this study, 92(41.7%) respondents mentioned that inappropriate work methods was the main cause of accidents in the construction sites, 44(20%) mentioned workers negligence, 75(34.3%) mentioned faulty equipment and 9(4%) mentioned workers incompetence. The appropriate selection of work methods to be used during execution of construction project is major determinant of productivity and health and safety of workers. Hence, appropriate work methods are the main factor affecting workers health and safety as well as their productivity (Thomas 2010). Safe work methods are the employers' ways of identifying and controlling health and safety hazards and risks. It's important for an occupier to train his workers on appropriate work methods to avoid incidences of accidents occurrences.

Just like safety plans, safety methods must be reviewed regularly to make sure they remain effective (Steve, 2013)

4.6.3 PPE availability in construction

From the study, majority 65.3% (144) of the respondents were provided with PPE by their employer. Only 11.6% of workers were using correctly the provided PPE. However not all of the workers with provided PPE were using them citing harsh climatic condition of the coastal region. Plate 4.6 clearly shows a worker without PPE on his daily activity. Kenya OSHA, 2007 states that every employer shall provide and maintain for the use of employees in any workplace where employees are employed in any process involving exposure to wet or to any injurious or offensive substance, adequate, effective and suitable protective clothing and appliances, including, where necessary, suitable gloves, footwear, goggles and head coverings. Additionally, it states that an employee shall at all times wear or use any protective equipment or clothing provided by the employer for the purpose of preventing risks to his safety and health. An employee who contravenes the provisions of this Act commits an offence and shall, on conviction, be liable to a fine not exceeding fifty thousand shillings or to imprisonment for a term not exceeding three months or to both (OSHA, 2007). Mombeki, (2006) in his study on compliance on 70 construction sites in Tanzania showed majority of workers never wore PPE, using the excuse of loss of productivity. Kamalamma et al., 2007 recommends that there is need to train workers on the use and importance of PPE. This means that majority of the construction sites and workers in Mombasa County are working against the provision. This therefore subjected the workers to ergonomic risk factors. Plate 4.7 and 4.8 are examples of workers without PPE

Plate 4.6 Roofer working without appropriate PPE

Plates 4.7 and Plate 4.8 Workers without PPE

4.6.4 Breaks/Rotation during construction work

Table 4.6 indicates most respondents 193 (87.8%) take break during the day and only 27 (12.2%) do not take breaks. On further enquiry it was established that breaks are only granted by the supervisors/developers during lunch hour and work resumes thereafter. These workers reported that in most days they work between 10-12 hours a day. According to the Labor Act 2007, workers are required to work for 8 hours a day. Working long hours continuously without any break causes fatigue as well as safety and health problems. Fatigue impairs workers ability to perform; it affects judgment, productivity, work efficiency and quality (Roger 2004). Fatigue may even lead to serious occupational accidents resulting in injury to workers and even loss of lives.

Table 4.6 Breaks taken during work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	193	87.8	87.8	87.8
	No	27	12.2	12.2	100.0
	Total	220	100.0	100.0	

Workers fatigue is a leading cause of injury especially in hazardous environment like construction sites. Workers in construction sites work for long hours in order to complete project but the fatigue results in employees who are less efficient and effective. Majority work sites did not have job rotation. This means that they work for extremely longer period daily (NIOSH, 2016). Breaks are a vital element in every work productivity. In this study, shows that workers value brakes and that its importance can be seen from their work performance. Contractors should endeavor to five their employees brakes and it minimizes fatigue and work stress and the same time prevents mistakes that can occur when working.

4.6.5 Training and induction

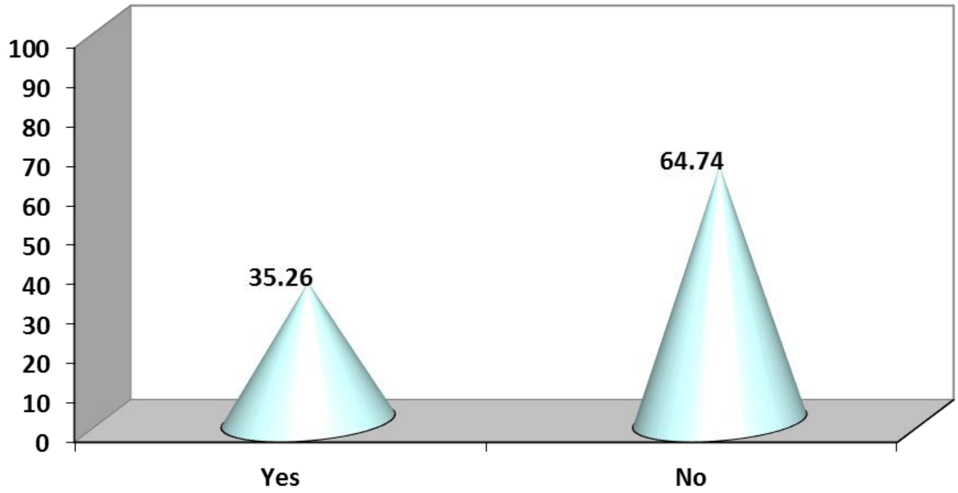


Figure 4.13 Number of workers trained on health & safety

It was important for the researcher to establish training and induction status from the respondents. From **Figure 4.13**, only 35.26% have been inducted/ trained in the years of experience in construction and the majority, 64.74% have never been inducted or trained. One of the most important aspects of construction site safety is training. This is because the construction work involves a lot of hazards. Having the best safety controls in place is pointless if workers aren't aware of the hazards that work in the building industry can present. Worker training, especially worker orientation training, has been recognized as vital to achieving good safety performance. As a result, it is common on large construction sites for orientation to be offered. The issue that is important to worker safety is that the induction before work must be provided to all workers and it must be formalized (standardized to ensure that every worker receives the same quality of orientation training).

Effective safety training reduces the number of construction site accidents (O'Toole, 2002). Training enables the workers to avoid ERFs during the task performance.

For the 143 respondents who stated that they have been trained and inducted, 13% have been trained in the past 2 years, 27% said between 2-4years and 60% above 4 years ago. Training and inductions in construction site workplace helps inculcate in employees a positive health and safety culture. Armstrong (2009), stated that health and safety training is key part of the preventive programme and should start as part of induction courses. Safety trainings hence spell out the rules and provide information on potential hazards and how to avoid them.

4.6.6 Records keeping for accidents and incidents in the construction sites

The study aimed to finding out whether accidents and incidents records are kept by the employer on site. This section was specific to the 8 foremen from the visited construction sites. The study found out that 78% of the construction sites had no incident/accident records. This is a worrying figure considering the importance that these records have in the management of health and safety matters. Recording incidents as soon as they occur is a crucial part of a proper incident investigation. Having a written record is the primary source of information about the people involved and the source of hazards. Recording incidents as soon as they occur is a crucial part of proper incident investigation and management. OSHA requires companies to have a written record of any work related incidents for a minimum of 3 years (OSHA, 2007). Keeping incidents records provide a broad-spectrum of information about the circumstances as well as help establish a better course of action for future accident prevention. It is important for all construction sites to keep accurate records as it acts as the holding, guarding, collection and preserving of information or data on a specific subject (Oloycdc, 2003). This study therefore, importance of record keeping cannot be ignored. In order to have a meaningful interpretation of the numbers of accidents recorded, it is essential to have statistics in construction industry where the volume and nature of work changes rapidly and the proportion of casual labor is significant. Records from accidents/incidents investigations provide information on the underlying causes to an accident. Keeping records is a requirement of OSHA regulation. Records of workers injury, death or diseases is vital to assist in finding the solution to the problem and also to highlight where fault occurred and what can be done to prevent that. It should be noted that many accidents occur because the real hazards were either not perceived or were not perceived to be less dangerous than they actually were.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The overall aim of this research was to study Ergonomic Risk Factors (ERFs) in relation to Musculoskeletal Disorders in selected occupations; Carpenters, Masons, Plasters, Steel fixers Roofers, Painters and Foremen in both commercial and residential buildings in Mombasa County. Specifically, the study sought to establish the Ergonomic risk factors in building construction, levels of musculoskeletal disorders in construction workers, establish awareness levels of ergonomic risk factors by the construction workers and also to establish the extent of which health and safety management system in building construction affects the occurrences of ergonomic injuries.

Descriptive and inferential study was used for the 1364 targeted. Stratified random sampling and simple random sampling was employed in the study to attain a representative sample size of 309 respondents. An assessment checklist was administered together with a standardized Nordic questionnaire to collect specific body part affected by the effects of ERFs.

The study found out that there is ERFs are the main cause of MSDs occurrences in construction workers. Majority of workers (87%) have experienced body pain from the ERFs. Backpain/waistpain and soreness of muscles at (MS >4.5), affected majority of workers. This is due to overexertion and manual handling of materials.

This study also established that ERFs awkward posture (68%), repetitive work (29.4%) and forceful exertion (15%) are the main contributing factors to MSDs. From the regression analysis conducted in this study, it was established that, ERFs are the statistically significant contributing factor to MSDs at $p=0.000$. Chi square test established that there is actually a significant relationship between ERFs and MSDs occurrences at 77.3%. Furthermore, the study confirmed that construction activities impact negatively on the construction worker as a result of various body actions and affects the physical nature of the workers. Thus design dictates most of the activities and however contributes to the onset of WMDs. Additionally, Ergonomic programs in construction workplace showed there were little ergonomic programs and induction of workers before work at 97% and 94% respectively. Therefore there should be a promoted awareness of ergonomics in the construction sector as there are needs to protect the construction workers in relation to the menace that impaired on the body systems during construction activities. However the construction process should be re- engineered and reviewed to improve the activity environment against ergonomic injuries.

5.2 Recommendations

From the study findings, it is recommended regular training of all the workers with regards to ergonomic risk factors, and Work Related Musculoskeletal Disorders (MSDs).This should be conducted regularly by qualified professionals who are licensed by DOSHS. The training should encompass all matters relating to construction safety and health.

The study further recommends:

i. The enforcement of both NCA 2011 and OSHA 2007 through adoption of a more proactive and comprehensive management mechanism to enforce the existing safety and health regulations in construction sites.
ii. The employers /owners of construction sites should play a key role in managing the safety and health programs in the construction sites.
iii. Construction companies need to allocate funding for health and safety and provide workers with the appropriate Personal Protective Equipment (PPE).

REFERENCES

Aaras, A., Westgaard, R., and Stranden, E. (1988). "Postural angles as an indicator of postural load and muscular injury in occupational work situations." *Ergonomics*, 31(6), 915-933.

Acharya, S.R. (2014). Utilization Pattern of Personal Protective Equipment among Industrial Workers of Nawalparasi, Nepal. *Health Prospect Journal of Public Health*. 13 (2), 1-5

Agumba J. and Haupt T. (2008) Perception of construction health and safety performance improvement enablers. *In: Proceedings of Association of Schools of construction in South Africa (ASOCSA) 3rd Built Environment Conference, 6-8 July*. Westin Grand, Cape Toen, Soth Africa pp 184-200

Ajayi O. and Thwala W.D. (2011*). Impact of Musculoskeletal disorders on Nigeria construction industry*. Proceedings of CIDB 2011-19, University of Pretoria. South Africa: 135-149

Al Swaity, A. and Enshassi, A. (2012) *Construction ergonomics related to safety*. Proceeding of the 4th International Engineering Conference-Towards engineering of 21st century. Retrieved from www.research.iugaza.edu.ps/files/2147.PDF

Annis, J. F., and McConville, J. (1996). Anthropometry. O*ccupational safety and health*-New York, *27*, 1-46.

Amstrong J.J., Lifshita Y. (1993). Evaluation and design of jibs for control of cumulative trauma disorders. *Ergonomic interventions to prevent musculosketal injuries in industry*. Chelsea, Lewis Publisher, Inc.

Armstrong J.J. (1997). *Evaluation and design of jobs for control of cumulative trauma disorders. Ergonomic interventions to prevent musculosketal injuries in industry.* Chelsea, Lewis Publisher, Inc.

Arndt, V., Rothenbacher, D., Daniel, U., Zschenderlein, B., Schuberth, S., & Brenner, H. (2005). Construction work and risk of occupational disability: a ten year follow up of 14 474 male workers. *Occupational and Environmental Medicine, 62*(8), 559–566. http://doi.org/10.1136/oem.2004.018135

Babbie E. (2007) Conducting qualitative field research. In: *The Practice of Social Research* (11th ed.,) USA. Thomson Wadsworth publishers

Bao S. Spielholtz P. Howard N. and Silvertein B. (2009) Force measurements in field ergonomics research and application. *International Journal on Industrial Ergonomics* 2009 26(39), 333-340

Becker P Winn G, Frederick L. (2000) *Adding construction to the academic safety curriculum.* Professional Safety 45, 16–8.

Blanchard, P. N., and Thacker, J. W. (1999). *Effective training: Strategies, systems, and practices.*

Bohr PC. (2000). Efficacy of office ergonomics education. *Journal of Occupational Rehabilitation,* 4*(*10), 243-55.

Brenner, H. and Ahern, W. (2000). Sickness absence and early retirement on health grounds in the construction industry in Ireland. *Journal of Occupational Environmental Medicine* 2000 (57),615-620

Buckle, P. and Li, G. (1998). "*A practical method for the assessment of work-related musculoskeletal risks* -Quick Exposure Check (QEC)." *Proceedings. The Human Factors and Ergonomics Society, 42nd Annual Meeting,* Chicago, IL, USA, Oct. 5-9. (1998).

Bongers, P. M., Kremer, A. M. & Laak, J. T. (2002). Are psychosocial factors, risk factors for symptoms and signs of the shoulder, elbow, or hand/wrist: A review of the epidemiological literature. *American Journal of Industrial Medicine*, 37(41), 315-342.

Bosch, T., Mathiassen, S. E., Visser, B., De Looze, M. D. & Van Dieën, J. V. (2011). The effect of work pace on workload, motor variability and fatigue during simulated light assembly work. *Ergonomics*, 6 (54), 154-168

Buchholz B. (2003) Task content and physical risk factors in construction ironwork. *International Journal of industrial ergonomics* Vol.34

Bureau of Labor Statistics (BLS) (2002). *"National Census of Fatal Occupational Injuries in 2002*." U.S. Department of Labor, Bureau of Labor Statistics. Retrieved from http://www.bls.gov/iif/oshcfoil.htm

Bureau of Labor Statistics. (2009). *"Incidence rate for nonfatal occupational injuries and illnesses.*" Retrieved from http://www.bls.gov/iif/oshwc/osh/case/ostb2454.pdf.

Canadian Center for Occupational Safety and Health (CCOHS) (2009) Retrieved from http://www.ccohs.ca/oshanswers/phys_agents/vibration/vibration

Centers for Disease Control and Prevention. (2012). *Workplace Safety and Health Topics, Women's Safety and Health Issues at Work.*

CCOHS (2009). "Hazard and Risk." *Canadian Centre for Occupational Health and Safety*. Retrieved from http://www.ccohs.ca/oshanswers/hsprograms/hazard_risk.html

Calderwood, M., & Crone, J. (2015*). Hajj will go ahead in Mecca, despite 107 deaths in crane disaster. Mail Online.* Retrieved from http://www.dailymail.co.uk/news/article-3231117/At-62-people-dead-crane-collapses-Grand-Mosque-Mecca.html

Chung, M. K., & Kee, D. (2000). Evaluation of lifting tasks frequently performed during fire brick manufacturing processes using NIOSH lifting equations. *International Journal of Industrial Ergonomics,* 25 (4), 423-433.

Canas, J. Di Stasi, L. L., Renner, R., Staehr, P., Helmert, J. R., Velichkovsky, B. M., & Pannasch, S. (2010). Saccadic peak velocity sensitivity to variations in mental workload. *Aviation, Space, and Environmental Medicine*, 81 (4), 413-417.

Chen, J., Jung, H., and Peacock, B. (1994). *"A fuzzy sets modeling approach for ergonomic workload stress analysis." International Journal of Industrial Ergonomics,* 13(3), 189-216.

Chau N., Bhattacherjee A. and Kunar B.M. (2009) *Relationship between job, lifestyle, age and occupational injuries.* Occup.Med(Lond) 59(2),114-9. Retrieved from http://occmed.oxfordjournals.org/content/59/2/114.fullpdf+html

Choobineh A., Hamidreza S., Tozihian M., & Ghadami F. (2007) *Musculoskeletal problems among workers of an Iranian Communication Company*. Retrieved from http://www.ijoem.com/text.asp?

Choudhry, R. M., Fang, D. & Hinze, J, (2008) 'Investigating safety and productivity on construction sites', *Proceedings of CIB W99 International Conference 14th Rinker International Conference*, Gainesville, Florida. 9 - 11 March 2008, 103-115

Choi, S.D. and Rajendran, S. (2014). Construction workers perception on stretch and flex program effectiveness in preventing work-related musculoskeletal disorders. *Proceedings of the XXVI Occupational Ergonomics and Safety Conference*

Claudon, L. and Cnockaert, J. (1994). "Biomecanique des tissus mous: modeles biomechaniques d'analyse des constraints au poste de travail dans le context des troubles musculosquelettiques." *Le Medecin du Travail,* (58), 140-148.

Colombini, D., Occhipinti, E., Molteni, G., & Grieco, A. (2000). Evaluation of work chairs. *International Encyclopedia of Ergonomics and Human Factors, 3,* 921.

Cooper, A. G. and Schindler, B. M. (2000). *Sampling Techniques* (Third Ed). Wiley. ISBN 0-471-16200-X

Cook, T.M. Rosecrance, J.C. & Zimmerman, C.L (1996). Work-related Musculoskeletal Disorders in Bricklaying: a Symptom and Job factors Survey and Guidelines for Improvement. *Applied Occupational Environment Hygiene,* (11), 1335-1339.

David G.C. (2005) Ergonomic methods for assessing exposure to risk factors for work-related musculoskeletal disorders. *Occup Med(Lond)* 55(3),190-9. Retrieved from http://occmed.oxfordjournals.org/content/55/3/190.long

Directorate of Occupational Health and Safety Services DOHSS 2014. Kenya annual report for 2014

Directorate of Occupational Health and Safety Services DOHSS 2011. Kenya annual report for 2011

Directorate of Occupational Health and Safety Services DOHSS 2009. Kenya annual report for 2009

Dionne CE, Von Korff M, Koepsell TD, Deyo RA, Barlow WE, Checkoway H. (2001) Formal education and back pain: a review. *Journal of Epidemiology & Community Health* 2001 (55), 455-68.

Dubois A. and Gadde Lais-Erik (2002) Systematic combining: An abductive approach to case research. *In Journal of Business Research* 55(7), 553-560

Everett J.G. and Peter B. F. (1996) *C*osts of accidents and injuries to the construction industry. *J. Constr. Eng. Manag.* 122 (2), 158-164

Entzel, P., Albers, J., and Welch, L. (2007). "Best practices for preventing musculoskeletal disorders in masonry: Stakeholder perspectives." *Applied Ergonomics,* 38(8), 557-566.

Faucett, J., Meyers, J., 2007. Rest break interventions in stoop labor tasks. *Applied Ergonomics.* 2007 March; 38(2), 219-226.

Fernandez, lE. and Marley, R.M.(1998) *Applied Occupational Ergonomics:* A Textbook, Kendall-Hunt Publishing, 1998.

Feyen R., Liu, Y., Chaffin, D., Jimmerson, G., and Joseph, B. (2000). "*Computer-aided ergonomics: A case study of incorporating ergonomics analyses into workplace design*." Applied Ergonomics, 31(3), 291-300.

Fitzgerald MD, Tanaka H, Tran ZV , *et al*. (1997) Age-related declines in maximal aerobic capacity in regularly exercising vs. sedentary women: a meta-analysis, *J Appl Physiol* 1997, 83(1),160-165

Government of Kenya (2007). *The Constitution of Kenya, 2010*. Government Printer, Nairobi

Government of Kenya (2007) Kenya Gazette supplement number 111 (Acts No. 15). *The Occupational Safety and Health Act (OSHA),* Government Printer, Nairobi.

Government of Kenya (2007) Kenya Gazette Supplement. *The Work Injury Benefit Act (WIBA),* Government Printer, Nairobi

Grant, R. M. (1996). Prospering in dynamically-competitive environments: Organizational capability as knowledge integration. *Organization science*, *7* (4), 375-387.

Hagberg M., Silverstein B., Wells R., Smith M., Hendrich H., and Carayon P. (1999) *Work-related musculoskeletal disorders (WRMSDs). A reference book for prevention.* London, England; Taylor and Francis

Haupt T. C., Smallwood, J., (2005), Rethinking and Revitalizing Construction Safety, health, Environment and Quality. cm W99 Working Commission. *'The Proceedings of the W99 Triennial International Council for Research and Innovation in Building and Construction'* (Cm). CREATE, Port Elizabeth. 2005. ISBN 0-620-33919-5.

Health and Safety Executive (HSE) (2007). *Managing Health and Safety*: Five Steps to Success. London: Health and Safety Executive.

Hecker, S.F., Gambatese, J.A. and Weinstein, M. 2006. “Designing for construction safety in the US: Progress, needs, and future directions.” *In Proceedings of the 16th Triennial Congress of the International Ergonomics Association, Maastricht*, The Netherlands, 10-14 July 2006

Heinrich, H. (1983). Accidents costs in the construction industry. *National Safety Council Transactions* 6: 374 -377.

Hess JA, Hecker S, Weinstein M, Lunger M (2004). A participatory ergonomics intervention to reduce risk factors for low-back disorders in concrete laborers. *Applied Ergonomics* 35(5), 427-441.

Hess, J., Kincl, L., Amasay T., and Wolfe, P. (2010). “Ergonomic evaluation of masons laying concrete masonry units and autoclaved aerated concrete.” *Applied Ergonomics*, 41(3), 477-483.

Hinze, J. (2005). A Paradigm Shift: Leading to Safety; *Conference Proceeding CIB W99 on Rethinking and Revitalization of Construction Safety, Health Environment and Quality*; Port Elizabeth South Africa 17-20 May 2005

Hignett, S. & Mcatamney, L. 2000. *Rapid Entire Body Assessment (REBA).* Applied Ergonomics, 31: 201-205.

Hinze J.W. (1997) *Construction safety*. New Jersey: Prentice Hall, Inc.

Holmstrom E, Engholm G (2003). Musculoskeletal disorders in relation to age and occupation in Swedish construction workers. *Am J Ind Med* 2003, (44),377–384

Hughes P. and Ferrette E. (2011) *Introduction to Health and Safety in construction*. 4th Ed.Oxon: Routledge pp 44-54

Huysmans, M., Hoozemans, M., Van der Beek, A., Looze, M., and van Dieen, J. (2008). "Fatigue effects on tracking performance and muscle activity." *Journal of Electromyography and Kinesiology,* 18(3), 410-419

IEBC (2011) Retrieved from www.iebc.or.k/physicallocationofconstiuencies.

Ilmarinen J & Tuomi K. (2004) Past, *Present and Future of Work Ability*. In: Ilmarinen J & Lehtinen S. Past, Present and Future of Work Ability. People and Work –Research Reports 65, Finnish Institute of Occupational Health, 2004; ISBN 951-802-581-9 [English]

International Labour Organization (2013). *Facts on Safety at Work*. Geneva: International Labor Office, pp.1-2.

International Labour Organization (ILO) (2005). *Global estimates of fatal work related diseases and occupational accidents,* World Bank Regions. International Labour Organisation, Geneva.

International Labor Office, ILO (2005). *A Global Strategy. Promoting health and safety at work.* The ILO report for world Day for Safety and Health at work. International Labor Organisation, Geneva, Switzerland. Retrieved from http://www.ilo.org.pk/information files/ prevention% 20A20 Global%20 strategy.pdf

International Labor Organization (ILO) (2002). *Bureau of Labor Statistics, U.S. Department of Labor,* Occupational Outlook Handbook, 2001-02 Edition.

International Labor Organization (ILO) (2011). ILO *Introductory report: global trends and challenges on occupational safety and health, in XIX World Congress on Safety and Health at Work*: Instabul, Turkey, 2011no. September pp 11-15

Jonsson, P., Johnson, P. W., Hagberg, M. & Forsman, M. 2011leigh. Thumb joint movement and muscular activity during mobile phone texting – A methodological study. *Journal of Electromyography and Kinesiology,* (21), 363-370

Jannadi, MO and Al-Sudairi, A (1995), '*Safety management in the construction industry in Saudi Arabia'*, Building Research and Information, 23(1), 60-63

Jeanne M.S., (2007) *Encyclopedia of Occupational Health and Safety,* (3rd ed.). Geneva: ILO

Kamalamma N., Parimalam P., & K. Ganguli (2007) Knowledge, attitude and practices related to occupational health problems among garment workers in Tamil Nadu, India; *Journal of Occupational Health;* Vol. (49), 528 534.

Kaminskas K.A. and Antanaitis J.A. (2010) Cross sectional survey of construction workers: an ergonomic approach. In: *The 10th International Conference on Modern Building Materials, structures and Techniques. Vilnius, Lithuania;*

Vilnius Gediminas Technical University; 2010, 1246-1252. Retrieved from http://dspace.vgtu.lt/btstream/1/495/1/1246-125

Karhu, O., Kansi, P., and Kuorinka, I. (1997). “Correcting working postures in industry: a practical method for analysis.” *Applied Ergonomics*, 8(4), 199-201.

Karwowski, W. and Marras, W. (2003). “*Occupational ergonomics: principles of work design*.” Florida: Construction Research Congress.

Keyserling, W., Stetson, D., Silverstein, B., and Brouwer, M. (1992). “A checklist for evaluating ergonomic risk factors associated with upper extremity cumulative trauma disorders.” *Ergonomics*, 36(7), 807-831.

Khairuzzaman M D., FatemaMoni Chowdhury, SharminZaman, Arafat Al Mamun and MD.Latiful Bar (2014). Food Safety Challenges towards Safe, Healthy, and Nutritious Street Foods in Bangladesh: *International Journal of Food Science*, 20 (14) 9

Kimeto Solomon Kiprotich (2014). *Evaluation of occupational safety and health awareness and practices among workers at Kenya tea development agency factories in Kenya*; A thesis dissertation. Master of Science in Occupational safety and health in the Jomo Kenyatta University of Agriculture and Technology.

Kroemer K. (2009) *Fitting the human. Introduction to Ergonomics*, 6th edn. CRC Press, London

Kothari, C. R. (2004) *'Research methodology: Methods and techniques* ', 2nd revised Ed, New Delhi, New Age International Publishers

Kumar, S. (2001). “Theories of musculoskeletal injury causation.” Ergonomics, 44(1), 17-47.

Latza, U. Kamaus, W. Sturner, T. Steiner, M. and Neth M. (2000) Cohort study of occupational risk factors of low back pain in construction workers. *Journal of Occupational Environment Medicine*. (57), 28-34

Legislation, Regulations, and Guidelines (2010). "*Musculoskeletal Disorder (MSD) prevention*." Centre of Research Expertise for the Prevention of Musculoskeletal Disorders. University of Waterloo, ON, Canada Retrieved from http://cre-msd.uwaterloo.ca/Legislation__Regulations.aspx

Lehtola M.M., Van der Molen F.F. Lappalainen J., Hoonakker P.L., Hsiao H., Haslam R.A. Hale A.R. and Veerberk JH (2008). *The effectiveness of interventions for preventing injuries in the construction industry: a systematic review.* AM J PrevMED 2008 Jul; 35(1), 75-85

Leigh J. (2011) *Economic burden of occupational injury and illness in the United States*. Milbank Q., 89(4) 728-772.

Lemasters G, Lockey J, Levin L, McKay R, Rice C, Horvath E, Papes D, Lu J,Feldman D. (1998) "An industry -wide pulmonary study of men and women manufacturing refractory ceramic fibers." *Am J Epidemiol* 13 (148), 910-919

Pompeii LA, Lipscomb HJ, Dement JM (2008). Surveillance of musculoskeletal injuries and disorders in a diverse cohort of workers at a tertiary care medical center. *Am J Ind Med*. 2008; 51(5), 344–56.

Ling, F. Y., Liu, M. & Woo Y. W (2009). Construction fatalities in Singapore. *International journal of Project Management* (27),717-726.

Lingard, H and Rowlinson, S M. (2005). *Occupational Health and Safety in construction project management*; UK Taylor & Francis.

Lopez, A. D. & Project, D. C. P. (2006*). Global Burden of Disease and Risk Factors,* Oxford University Press.

Luopajarvi, T. (1990). Ergonomic analysis of workplace and postural load. *Ergonomics: the physiotherapist in the workplace. Edinburgh, London, Melbourne and New York*, 51-78.

Malchaire, J. B. (2001). "Associations between hand-wrist musculoskeletal and sensorineural complaints and biomechanical and vibration work constraints." *The Annals of Occupational Hygiene*, 45(6), 479-91.

Manager's Handbook, Canada Labour Code, Part II (2010). "Section 125(1)(t) and (u)." Retrieved from http://www.tbssct.gc.ca/pubs_pol/hrpubs/tbm_119/clc-cct-PR-eng.asp?printable=True

Marras W.S., Lavender S.A., Leurgan S.E., Rajulu S.L., Allread W.G., Fathallah F.A., Ferguson S.A. (1993) The role of dynamics three dimensional trunk motion in occupational-related low-back disorders: The effects of work place factors trunk position & trunk motion characteristics on risk of injury, spine, *Ergonomic journal* 18(5),617-628

Manuele, F. A. (2008). Prevention through design: Addressing occupational risks in the design and redesign processes. *Professional Safety Journal of the American Society of Safety Engineers*, 53(10), 28-40.

McAtamney, L. and Corlett, E. (1993). "*RULA: A survey method for investigation of work-related upper limb disorders."* Applied Ergonomics, 24(2), 91-99.

Mohamed, S. (2003). *Safety Culture, Climate and Performance Measurement, Construction Safety Management System* Ed. Rowlison,S Taylor and Francis, New York.

Mojtaba V.S. Azin S.B. and Amin R. (2013) Ergonomics principles and utilizing it as a remedy for probable work related injuries in construction projects: *International Journal on Advance in Engineering and Technology* 6(1), 232-245

Mombeki F (2006) Roles of stakeholders, partnering in enhancing health and safety in construction sites. Tanzania experience and way forward. *Conference proceeding CIB W99, Global unity for safety and health in construction* 28-30 June 2006, Beijing

Manoharan, P. K., Jha, S. K., & Singh, B. K. (2012). Modeling the risk factors in ergonomic processes in Brick kilns workers using Fuzzy Logic. *International Journal of Applied Science and Engineering Research,* 1 (1), 92-97.

Mitulla, W. V. and Wachira, I. N. (2003). Sectoral activities Programme Working Paper (WP.204) -Informal labor in Construction Industry in Kenya-A Case Study of Nairobi Retrieved from: http:/www.ilo.org/public/English/dialogue/sector/paper/construction/wp204.pdf

Moore, A. and Wells, R. (2005). "*Effect of cycle time and duty cycle on psychophysically determined acceptable levels in a highly repetitive task.*" Ergonomics, 48(7),859-873.

Mugenda O. M. and Mugenda A.G. (2003), *Research methods: Quantitative and qualitative approaches.* (Revised Ed) Nairobi, Acts press

Mroszczyk, J. W. Gambatese, J. A., (2006). Designing for Construction Worker Safety. American Society of Safety Engineers

Nabila H.A. and Aziruddin R. (2014) *Ergonomic awareness on construction*. Retrieved on from International Ergonomics Association

http://www.civilutm.my/content/uploads/pdf

NCA, (2011). National Construction Authority Act. Act No 41 of 2011. An Act of parliament of the government of Kenya

Ng, S.T., Cheng, K.P. and Skitmore R.M. (2005) *A framework for evaluating the safety performance of construction constructors*. Building and Environment 40: 1347-1355

NIOSH. (2016). *NIOSH program portfolio: Musculoskeletal disorders*. Retrieved from www.cdc.gov/niosh/programs/msd/default.html

Nkpa N. (1997). *Education Research for Modern Scholars*. Fourth Dimension publishing Co. Ltd: Enugu.

Nussbaum, M., Shewchuk, J., Kim, S., Seol, H., and Guo, C. (2009). *"Development of a decision support system for residential construction using panellised walls: Approach and preliminary results." Ergonomics*, 52(1), 87-103.

Nyakang`o J. (2007) *Status of Occupational Health and Safety in Kenya*. Retrieved from http://www.iupac.org/fileadmin/user_upload/projects/05-Nyakango.pdf

Odunjo O. Ajay O. Joseph O. and Okanlawon S. (2015) Assessment of the impact of MSDs on Nigerian Construction Workers. *Int. Journal of civil Engineering, construction and estate management.* 3(3) 66-84

Ofori G. (2010) *Challenges of construction industries in developing countries*. Lessons from various countries.

Oh, J.I.H. and Sol, V.M. (2008). *The policy program improving occupational safety in the Netherlands: An innovative view on occupational safety*. Safety Science, 46(2), 155-163

Oliver S., Harden A., Garcia J., Brunton G. (2004). Applying systematic review methods to studies of people's views: an example from public health research. *Journal of Epidemiology and Community Health 37* (58) 794-800

Olson, D. L. (1999). An onsite Ergonomic Program: a model for Industry.

O'Leary P. et al.(2012) “Workplace injuries and the take-up of Social Security disability benefits,” *Social security bulletin*, 72, (3) 1–17

O’Toole, M., (2002). The relationship between Employees’ perceptions of Safety Organizational culture. *Journal of safety research* 33 (2002) 231-243.

Oude K.M., Blatter B. Geuskens G.A and Koppes L.L. (2011). *F*actors associated with the ability and willingness to continue working until the age of 65 in construction workers. *International Journal of Occupational and Environmental Health 85*(7), 783-90

Palmer K. and Goodson N. (2015) Ageing musculoskeletal health and work. *Best practice and research. Clinical Rheumatology,* 29(3), 391-404

Pamela L., Lutgen-Sandvik, Tracy, S. J., & Alberts, J. K. (2007). Burned by bullying in the American workplace: Prevalence, perception, degree and impact. *Journal of Management Studies,* 44(6), 837-862

Palliser C.R., Firth H.M., Feyer A.M. and Paulin S.M. (2005) Musculoskeletal Discomfort and work related stress in New Zealand Dentist. *Work & Stress* 19(4), 351-359

Pandey, K., & Vats, A. (2013). Ergonomic hazard identification of workers engaged in brick making factories. *Journal of Applied and Natural Science*, *5* (2), 297-301.

Patkin, R. A. (1987). Arbitration of Extraterritorial Discovery Disputes between the Securities and Exchange Commission and a Foreign Broker-Dealer*: A New Approach to the Restatement Balancing Test. BU Int'l LJ, 5:* 413.

Phoya, S., Eliufoo H., Pietrzyk, K., & Nyström, M. (2011). Assessment of Health and Safety Risk Perception of Site Managers, Supervisors and Workers in Tanzania Urban Construction Sites; *Conference Proceeding; Prevention:*

Means to the End of Safety and Health Incidents and Illnesses; 24th -26th August 2011. Washington, DC.

Pransky G., Burlon W.N., Chen C.Y., Conti D.J. and Schultz A.B. (2005). The association of health risks with on the job productivity. *Journal of OccupEnviron Med*. 2005 Aug; 47(8),769-77

Proulx, G., (2013). Playing with fire: Understanding human behavior in burning Buildings. *American Society of Heating, Refrigerating, and Air -Conditioning Engineers (ASHRAE) Journal*, 45 (7), 33- 35.

Rahman ZA, Atiya AS (2009). Prevalence of work-related upper limbs symptoms (WRULS) among office workers. *Asia Pac J Public Health*. 2009; 21 (3), 252–8.

Remana KR and Satyanarayana KN (2005). Occupational Safety and Health of Indian Construction Workers Engaged in Manual Material Handling. *Proceedings of the 4th Triennial International Conference Rethinking and Revitalising Construction Safety Health Environment and Quality*. 461-469, Port Elizabeth, South Africa, 17-20 May.

Reese, C. D. & Eidson, J. V. (2006) *Handbook of OSHA Construction Safety and Health,* Second edition. CRC Press, Taylor & Francis Group, Boca Raton, FL, USA.

Roger W (2004) *Do long working hours lead to more workplace injuries? Evidence from Australian industry-level panel data.* Melbourne institute of applied economic and social research. The university of Melbourne:3-5 https://www.dtl.unimelb.edu

Rowlinson, S (2004) 'Health and safety Training and Education: A Case of Neglect?' In: *Construction Safety Management Systems*, edited by Rowlinson, S, Spon Press, London, pg. 293-296.

Rowlinson, S. (1997) *Hong Kong Construction-Site safety management*, Sweet & Maxell Asia

Rwamamara, R. (2007). "Risk assessment and analysis of workload in an industrialized construction process." *Construction Information Quarterly*. 9(2), 80-85.

Rwamamara R, Lagerqvist O, Olofsson T, Johansson B (2007) Best Practices For the Prevention of Work- related Musculoskeletal Disorders in The Construction Industry. *J Const Manag Eng ASCE* 56:1-21.

Samuels WM, Haupt TC and Shakantu WM (2006). The Silent Ergonomics of the South African Construction Industry: Observations in the Western Cape. *Proceedings of the CIB W99 International Conference Global Unity for Safety and Health in Construction*. 619-626, Beijing, PRC, 28-30 June.

Schneider, S. and Susi, P. (1994). "Ergonomics and Construction. Review of Potential Hazards in New Construction." *American Industrial Hygiene Association Journal*, 55 (7), 635-649.

Schneider SP (2001). Musculoskeletal injuries in construction: A review of the literature. *Appl Occup Environ Hyg* 16: 1056-1064.

Sean. (2010). Construction site safety checklist. Retrieved from http://www.ehow.com/constructio.health-and-safety/dated 18/3/2011

Shameem, S., Z. Taha, I. Nazaruddin, R.A. Ghazilla and N. Yusof, (2001). Perception and attitude of Malaysian industrial workers towards their workplace. *Proceedings of the Malaysian Ergonomics 2001: Safe and Healthy Workplaces for Better Productivity and Efficiency*, Apr. 17-18, Intel Technology Sdn. Bhd., Penang

Sett, M. and Sahu, S. (2008) Ergonomics study on female workers in manual brick manufacturing units in West Bengal, India. *Asian-Pacific Newsletter* on Occupational Health and safety, 15(3), 59-60.

Smallwood JJ (1997). Ergonomics in construction. *Ergonomics SA*, 9 (1), 6-23.

Smallwood J., Haupt T. & Shakantu. (2008). *Construction health and safety in South Africa:* Status and recommendations. CIDB report

Smallwood, J.J. (2008). The Role and Influence of Clients and Designers in Construction Health and Safety. *First European Conference on Construction Health and Safety Coordination in the Construction Industry*, Barcelona, 21-22 February.

Smallwood, J.J. 2002. "Construction Ergonomics: General Contractor (GC) *Perceptions." Ergonomics SA* 14(1), 8-18.

Sobeih, T., Salem, O., Genaidy, A., Abdelhamid, T. & Shell, R. (2009) Psychosocial Factors and Musculoskeletal Disorders in the Construction Industry. *Journal of Construction Engineering and Management* 135(4), 267-277.

Spielholz, P., Davis, G. & Griffith, J. (2006) Physical Risk Factors and Controls for Musculoskeletal Disorders in Construction Trades. *Journal of Construction Engineering and Management* 132 (10), 1059-1068.

Stal, M., Pinzke, S., and Hansson, G. (2003). "Highly repetitive work operations in a modern milking system: A case study of wrist positions and movements in a rotary system." *Annals of Agricultural and Environmental Medicine,* 10(1), 67-72.

Stattin, M. & Järvholm, B. (2005). Occupation, work environment, and disability pension: a prospective study of construction workers. *Scandinavian Journal of Public Health* 2005 (33), 84-90

Straker, L., Pollock, C., and Mangharam, J. (1997). "The effect of shoulder posture on performance, discomfort and muscle fatigue while working on a visual display unit." *International Journal of Industrial Ergonomics,* 20(1), 1-10.

Stromme, M. H. (2004). Workplace hazards: A threat to workers' senses. *Occupational Health and Safety,* 73(3), 40-44.

Steve R. and Gregory Z. (2013) Safety and Reliability analysis methods based on systemic-structural activity theory. *Journal of Risk and Reliability* 227:5, 2013

Tam, C.M., Zeng S.X. and Deng Z.M. (2004) *Identifying elements of poor construction safety management in China.* Safety Science 42:569-586

Tayyari F and Smith J.L (1997). *Occupational Ergonomics Principle and Applications*. London; Macmillan.

Teo. E.A and Ling F.Y.Y (2006) Developing a model to measure the effectiveness of safety management systems of construction sites. *Journal of Building and Environment* 41:1584-1592

The Eastman Kodak Company (2004) *Kodak's ergonomic design for people at work,* 2nd Ed., John Wiley & Sons, Inc., New Jersey.

Thomas D.R. (2010) Sarcopenia *Clin Geriatr Med* 2010, vol. 26 2 (pp. 331-346)

Trevelyan, F. C., & Haslam, R. A. (2001). Musculoskeletal disorders in a handmade brick manufacturing plant. *International Journal of Industrial Ergonomics, 27* (1), 43-55.

University of Michigan (2003). *"3D Static Strength Prediction Program Version 4.3.6."* The University of Michigan Center for Ergonomics, Technology Management Office, Ann Arbor, MI, USA.

UNESCO (2005). *Education for all: The quality imperative*. Retrieved from www.unesdoc.unesco.org/image/pdf

U.S Bureau of Labor Statistics, Occupational *Outlook Handbook, 2010-11 Edition Structural and Reinforcing Iron and Metal Workers*, Retrieved from http://www.bls.gov/oco/ocos215.htm

Van der Molen H.F., Sluiter J.K. and Frings-Dresen M.H. (2009). The use of ergonomic measures and musculoskeletal complaints among carpenters and pavers in a 5 years follow-up study. *American journal of industrial medicine.* 52:954-963

Wang W.C., Lui J.J. and Chou S.C. (2006). Simulation-based safety evaluation model intergrated with network schedule. *National Chiao Tung University Institutional Repository 15(3) 341-354*

Wachira, I. N. (2003). Informal Labour In The Construction Industry In Kenya: A Case Study Of Nairobi, Sectoral Activities Programme Working Paper 204, *International Labour Organisation, Geneva*

Welch, Laura. (2009). Improving work ability in construction workers - Let's get to work. *Scandinavian journal of work, environment & health*. 35 (321)10-52

William J.,Wiehagen and FredC.T.,(2004) E*rgonomics assessment of Muscoskeletal risk factors art Four Mines States, Underground Coal, Surface Copper, Surface phosphate and underground limestone* SA

William, S. and Marras , W.K. (2011) *Ergonomic working for cement and concrete construction laborers*. Occupational and Industrial Orthopedic Centre (OIOC) 2011

Whiting H., Clarke, Martin & Seng, Dyna & Rosalind. (2011). Intellectual capital and firm performance in Australia. *Journal of Intellectual Capital*. 12: 505-530.

WorkSafeBC (2008). Worksafe Retrieved from

http://www.worksafebc.com/Portals/Construction/Statistics.asp

Yamane T. (1967) *Statistics: An introductory analysis*, 2nd Edition, New York: Harper and Row

Yranheikki E. and Savolainen H, (2000), Occupational safety and health in Finland, *Journal of Safety Research* 31(4), 177-183

Zimmerman CL, Cook TM and Rosecrance JC (1997). Trade specific trends in self – reported musculoskeletal symptoms and job factor perceptions among unionized construction workers. *Proceedings of the 13th Triennial Congress of the International Ergonomics Association Experience to Innovation.* 214-216, Tampere, Finland, 29 June–4th July 1997.

Zhou, Q.,Fang,D., and Wang, X, (2008). A method to identify strategies for the improvement of human safety behavior by considering safety climate and personal experience. *Safety Science,* (46), 1406-1419

APPENDICES

Appendix 1: Survey Questionnaire

- ✓ Kindly tick against your preferred choice
- ✓ Fill in where there are spaces provided

A. Personal information of the respondent

1. What is your gender?

a) Male b) Female

2. What is your age (in years)?

a) 19-29 b) 30-39 c) 40- 49 d) 50-59 e) 60 and above

3. What is your education level?

a) Never attended school b) Primary c) Secondary d) College/University/Tertiary institution

4. What is your job description?

a) Unskilled casual worker

b) Skilled casual worker (specify specialized area)

c) Others

5. How many years have you worked in the building construction industry?

a) 3-8 years b) 9-14 years C) 15-20 d) 21 years and above

6. What is/are your daily work?

a) Carpentry b) Masonry c) Plastering d) Roofing e) Painting f) Steel fixing g) Foremen h) Others

7. Do you find your daily work activities strenuous? If yes, why?

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

8. How many hours do you work in a day?

9. Do you take breaks during your working hours?

a) Yes   b) No

10. If Yes in question 9 above, for how long?

…………………………………………………………………………………………
……………………………………………………………………….

…………………………………………………………………………………………
………………………………………………………………………

B. Awareness of Ergonomic Risk Factors

11. Do you know what ergonomic risk factors are?

a) Yes   b) No

12. If YES in question 11 above, do you encounter any of these listed ergonomic risk factors during your daily work activities?

a) Repetition

b) Manual handling of materials

c) Forceful exertion

d) Awkward posture

e) Vibration

13. On a scale of 1-5 where 1 is least affected and 5 most affected, how well can you rate these risk factors?

S/No.	Ergonomic Risk Factor	Rate
1	Repetition	
2	Manual handling of materials	
3	Forceful exertion	
4	Awkward posture	
5	Vibration	

14. Are you provided with personal protective equipment (PPE)?

a) Yes b) No

15. What are the PPE provided?

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………..

…………………………………………………………………………………………
…………………………………………………………………………..

15. Are PPE necessary during work performance?

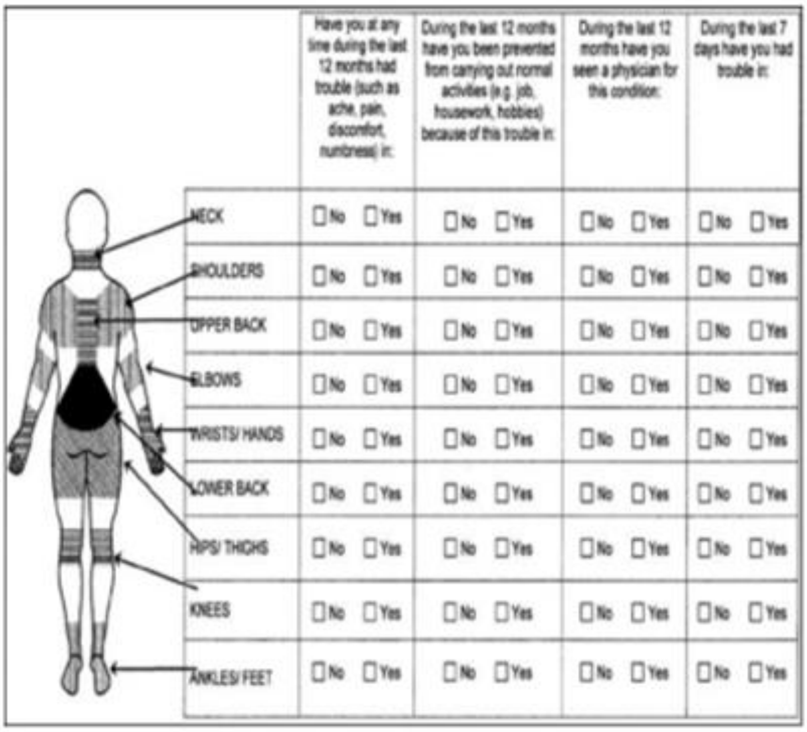
a) Yes b) No

C. Effects of Ergonomic Risk Factors

14. Have you experienced body pains in the last 6 months?

a) Yes b) No

15. If YES in question 14 above, use the diagram below to indicate the most affected body parts.



	Have you at any time during the last 12 months had trouble (such as ache, pain, discomfort, numbness) in:	During the last 12 months have you been prevented from carrying out normal activities (e.g. job, housework, hobbies) because of this trouble in:	During the last 12 months have you seen a physician for this condition:	During the last 7 days have you had trouble in:
NECK	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
SHOULDERS	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
UPPER BACK	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
ELBOWS	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
WRISTS/ HANDS	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
LOWER BACK	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
HIPS/ THIGHS	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
KNEES	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
ANKLES/ FEET	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes

16. How often do you experience the above body pain?

a) Daily   b) Once a week c) Occasionally d) Never

D. Health and Safety Management

17. Do you know what Occupational Safety & Health Act 2007 is?

a) Yes   b) No

17. Was there an induction/brief/training when you started work at construction sites?

a) Yes   b) No

18. Do you think workers need to be inducted or trained?

a) Yes   b) No

19. Are accidents and incidents reported in work sites?

a) Yes   b) No

20. If YES in question 19 above, to whom do you report it to?

a) Foreman   b) Doctor/Nurse at clinic c) DOSHS office d) Workmate

21. Do you think employers MUST put in place safety and health measures in work site?

a) Yes   b) No

Do you think your employer has put measures to prevent accidents/incidents at your work site?

a) Yes   b) No

21. If YES in question 21 above, what are these measures?

…………………………………………………………………………………………
……………………………………………………..

…………………………………………………………………………………………
………………………………………………………

22. Is there anything that can be done to make your workplace safe? If YES, please explain

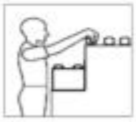
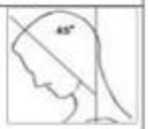
…………………………………………………………………………………………
……………………………………………………

…………………………………………………………………………………………
…………………………………………………….

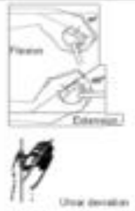
THANK YOU

Appendix II: Ergonomics Task Analysis Worksheets

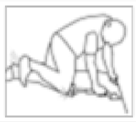
Task Analysis Checklist

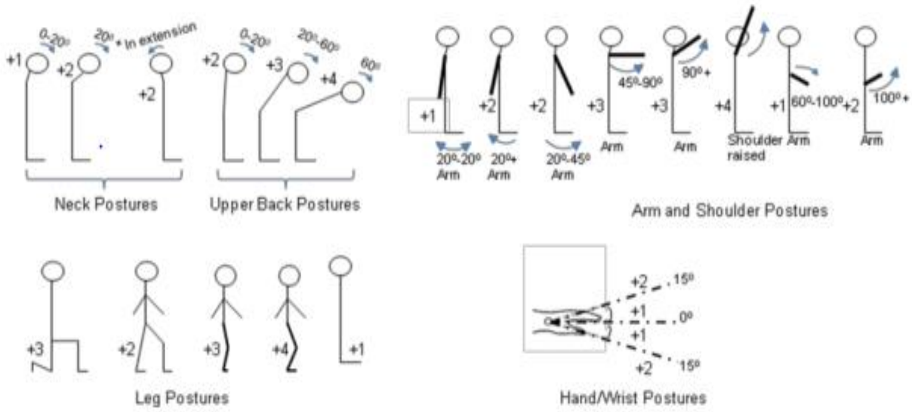
Awkward Posture				
Body Part	**Physical Risk Factor**	**Duration**	**Visual Aid**	Check (✓) here if this is a WMSD hazard
Shoulders	Working with the hand(s) above the head or the elbow(s) above the shoulder(s)	More than 4 hours total per day		
	Repetitively raising the hand(s) above the head or the elbow(s) above the shoulder(s) more than once per minute	More than 4 hours total per day		❑ ❑
Neck	Working with the neck bent more than 45° (without support or the ability to vary posture)	More than 4 hours total per day		❑
Back	Working with the back bent forward more than 30° (without support, or the ability to vary posture)	More than 4 hours total per day		❑
	Working with the back bent forward more than 45° (without support or the ability to vary posture)	More than 2 hours total per day		❑
Knees	Squatting	More than 4 hours total per day		❑
	Kneeling	More than 4 hours total per day		❑ ❑

High Hand Force

Body Part	Physical Risk Factor	Combined with	Duration	Visual Aid	Check (✓) here if this is a WMSD hazard
Arms, wrists, hands	Pinching an unsupported object(s) weighing 2 or more pounds per hand, or pinching with a force of 4 or more pounds per hand (comparable to pinching half a ream of paper)	Highly repetitive motion	More than 3 hours total per day		❑
		Wrists bent in flexion 30° or more, or in extension 45° or more, or in ulnar deviation 30° or more	More than 3 hours total per day		❑
		No other risk factors	More than 4 hours total per day		❑
Arms, wrists, hands	Gripping an unsupported object(s) weighing 10 or more pounds per hand, or gripping with a force of 10 pounds or more per hand (comparable to clamping light duty automotive jumper cables onto a battery)	Highly repetitive motion	More than 3 hours total per day		❑
		Wrists bent in flexion 30° or more, or in extension 45° or more, or in ulnar deviation 30° or more	More than 3 hours total per day		❑
		No other risk factors	More than 4 hours total per day		❑

Highly Repetitive Motion				Check (✓) here if this is a WMSD hazard
Body Part	**Physical Risk Factor**	**Combined with**	**Duration**	
Neck, shoulders, elbows, wrists, hands	Using the same motion with little or no variation every few seconds (excluding keying activities)	No other risk factors	More than 6 hours total per day	❑
	Using the same motion with little or no variation every few seconds (excluding keying activities)	Wrists bent in flexion 30° or more, or in extension 45° or more, or in ulnar deviation 30° or more **AND** High, forceful exertions with the hand(s)	More than 2 hours total per day	❑
	Intensive keying	Awkward posture, including wrists bent in flexion 30° or more, or in extension 45° or more, or in ulnar deviation 30° or more	More than 4 hours total per day	❑
		No other risk factors	More than 7 hours total per day	❑

Repeated Impact				Check (✓) here if this is a WMSD hazard
Body Part	**Physical Risk Factor**	**Duration**	**Visual Aid**	
Hands	Using the hand (heel/base of palm) as a hammer more than once per minute	More than 2 hours total per day		❑
Knees	Using the knee as a hammer more than once per minute	More than 2 hours total per day		❑



Body part analysis postures

Appendix III: Consent Form

This form provides important information about participating in the study. Please read it carefully before making decisions about taking part. You may discuss your decision with your family, friends and/or doctor. Feel free to ask any questions relating to this study. If you decide to participate in this research you will be required to sign this form.

Study Title: Ergonomic Risk Factors and Musculoskeletal Disorders in building construction sites in Mombasa County
Principal Investigator: Stellah Cherop Ndiwa P.O. Box 2162 G.P.O 80100 Mombasa, Kenya. Telephone: +254 722 532 981 E-mail addresses ndiwastellah@gmail.com
Supervisors: Professor Erastus Gatebe and Dr. Andrew Mwenga
Study Population: The study's target population will be the workers in building construction sites in Mombasa County.

Aim and Objectives of the Study

The purpose of this research is to:

1. **To identify the Ergonomics Risk Factors (ERFs) in building construction sites.**
2. **To establish the prevalence of musculoskeletal disorders in construction sites.**

3. **To establish the awareness levels of Ergonomic risk factors by the construction workers.**
4. **To establish the extent of which health and safety management system in building construction affects the occurrences of ergonomic injuries.**

Procedure

1. About 309 workers will take part in this research.
2. You will be provided with questionnaire with several questions relating to the topic that requires you to answer them to the best of your ability.
3. The researcher will also be carry observations on how the work is being performed and record hem appropriately.
4. The data collected will then be analysed and results generated.
5. The results will then be submitted to the relevant authorities to assist in policy making with regards to ergonomics and musculoskeletal disorders in construction industry.

Risk/Benefit

There will be no risk whatsoever during the collection of this data.

There are no direct benefits to you from your taking part in this research. Possible indirect benefits include the invaluable information obtained in this study that shall be used by policy makers to formulate better policies and treatment guidelines.

Assurance of confidentiality

Strict confidentiality relating to your information shall be observed.

Right to Refuse or Withdraw

Participation in this study is voluntary. You can choose whether or not to participate. If you choose to participate, you may change your mind and leave the study at any time. Refusal to participate or stopping your participation will involve no penalty or loss of treatment rights which you are otherwise entitled.

Contact Principal Investigator

The Principal Researcher in this study is Ms. Stellah Ndiwa. She can be reached between 8 am and 5p m for any questions, concerns or complaints about this study or to withdraw from the study.

Statement of Consent

I have read the information in this consent form including risks and possible benefits. All my questions about the research have been answered to my satisfaction. I understand that I am free to withdraw at any time without penalty or loss of benefits to which I am otherwise entitled.

I consent to participate in the study.

SIGNATURE

Your signature below indicates your permission to take part in this research

____

Name of participant

____________________________________ __________________

Signature of participant Date

____________________________________ __________________

Name of Investigator Date

____

Signature of Investigator

Appendix IV: Certificate of Ethical Approval

NACOSTI ACCREDITED

ERC/MSc/007/2016

Pwani UNIVERSITY

ETHICS REVIEW COMMITTEE

ACCREDITTED BY THE NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION (NACOSTI, KENYA)

CERTIFICATE OF ETHICAL APPROVAL

THIS IS TO CERTIFY THAT THE PROPOSAL SUBMITTED BY:

NDIWA STELLAH CHEROP

REFERENCE NO:
ERC/MSc/007/2016

ENTITLED:
Ergonomic risk factors and musculoskeletal disorders in building construction sites in Mombasa County

TO BE UNDERTAKEN AT:
MOMBASA COUNTY

FOR THE PROPOSED PERIOD OF RESEARCH

HAS BEEN **APPROVED** BY THE ETHICS REVIEW COMMITTEE AT ITS SITTING HELD AT PWANI UNIVERSITY, KENYA

ON THE 21ST **DAY OF MARCH 2016**

CHAIRMAN SECRETARY LAY MEMBER

PTO

Appendix V: Publication

ISSN NO. 2320-5407

Journal Homepage: - www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/4587

DOI URL: http://dx.doi.org/10.21474/IJAR01/4587

ERGONOMIC RISK FACTORS IN BUILDING CONSTRUCTION SITES IN MOMBASA COUNTY, KENYA

Stellah Cherop Ndiwa[1], Erastus Gatebe[2] and Andrew Mwenga[1]

[1] Department of Occupational Safety and Health, Institute of Energy and Environment Technology, Jomo Kenyatta University of Agriculture and Technology, Kenya, P.O Box 62000-00200 Nairobi, Kenya
ndiwastellah@gmail.com mwenga@gmail.com,

[2]Kenya Industrial Research and Development Institute , P. O Box 30650-00100 Nairobi, Kenya
erastusgatebe@gmail.com,

Abstract

Safety is, without doubt, the most crucial investment we can make. And the question is not what it costs us, but what it saves. Building construction activities are predominantly physical in nature and are usually executed in an uncomfortable environment at a fast pace. Construction work is ergonomically hazardous, as it requires numerous awkward postures, heavy lifting and other forceful exertions. This workplaces have a varying amount of stress on the musculoskeletal system (muscle, tendons, and ligaments) of the workers and increase the potential risk of work-related musculoskeletal disorders (MSDs). The main objective of this research was to evaluate Ergonomic Risk Factors (ERFs) in selected occupations; Carpenters, Painters, Plasters, Mason, Roofers, Steel fixers and Foremen in buildings construction in Mombasa County, Kenya. The target population in this study was 1,364 building construction workers drawn from the construction sites that were registered with NCA by the time of data collection. This was a descriptive cross-sectional study design. A Self-Reported Ergonomic Hazard Assessment checklist method was used. Stratified random sampling was used to obtain a sample size of 309. All the respondent were above 18 years and had worked in building construction for over one year. A standardized Nordic questionnaire was administered to collect data on ERFs from the respondents. Additionally, observation checklist was used to record workers activities on site. Data collected was subjected to statistical analysis. SPSS Version 20.0 was used to analyze quantitative data. Regression analysis was applied to determine the strength of the relationship between ERFs and the prevalence of MSDs. It was established that the majority of workers 97.1% are exposed to awkward posture and 90.3% exposed to manually handled materials. Back pain/waist pain with a Mean Score (MS) of 4.48 is the most affected body part, followed by general body aches and sore muscles & joints and at 4.43 and 4.45 respectively. It was also established that inappropriate work methods (41.7%) and faulty equipment (34.3%) and the major contributors to ERFs experience in workers. Additionally, the study established that 95% of the construction sites had no ergonomic program in place and 87% of the construction sites had no weight lifting restriction. Regression analysis established that there is a close relationship between ERFs and the occurrences of MSDs at 0.622 (62.2%). An increase in ERFs subjection will lead to a 70.9% increase in the occurrence of MSDs. Additionally, the regression model R square showed that 80.1% of the variation was explained. A Chi value of 0.773 (p=0.000) was obtained showing a strong relationship between ERFs and MSDs. From the study, it is evident that building construction work is not an ergonomically safe workplace. Therefore it will be important to implement ergonomic intervention at construction sites. Additionally, the study recommends the adoption of a more proactive and comprehensive management mechanism to enforce the existing safety and health regulations in construction sites. This should be achieved through regular training of all the workers with regards to ergonomic risk factors, and Work-Related Musculoskeletal Disorders and enforcement of both NCA 2011 and OSHA 2007 by the enforcement agencies.

Keywords: Ergonomics, Ergonomic Risk Factors (ERFs), safety, Musculoskeletal Disorders (MSDs)

1. Introduction

Among the known construction types in the world, building construction is one of the fastest growing industries and it has endeavored to employs a considerably large number of workers accounting for 10% of the Gross Domestic Product (GDP), and providing 7% of global employment. (Nubi, 2008).

The Kenya construction industry is set to grow steadily for the next decade attributed to an increased number of projects being carried out in the country (KNBS 2017). Recently, Kenya's construction industry has experienced considerable growth in construction activities especially in Major cities; Nairobi and Mombasa. Official figures showed that construction industry, which comprises buildings, roads and railway, grew 9.2 per cent in 2014 compared to 13.9 in 2015 and 13.1 a year earlier (KNBS 2017). This is as a result of the increased demand for housing facilities with high demand for labor (Murie, 2007). Unfortunately as Murie, 2007 established, construction industry contribute greatly towards occupational accidents and work related ill health. The high rate of urbanization has heightened demand for residential and commercial consumers in these cities which in return has

Corresponding Author: Stellah Cherop Ndiwa.

Address: Department of Occupational Safety and Health, Institute of Energy and Environmental Technology, Jomo Kenyatta University of Agriculture and Technology, Kenya

Journal Homepage: - www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
ISSN NO. 2320-5407
Article DOI: 10.21474/IJAR01/4587
DOI URL: http://dx.doi.org/10.21474/IJAR01/4587

increased the number of construction activities. This has been reflected by immense increase in employment opportunities for laborers, both skilled and unskilled and the urban poor who do not have many job options. Construction work is not safe, the International Labour Organization (ILO, 2005) estimates at least 60,000 fatal accidents a year on construction sites around the world that is one in six of all fatal work related accidents. Compared to other labor intensive industries, construction industry has reported high rate of injuries and fatalities. In a study by Rwamamara et al., 2007, and Agumba et al 2008, these studies found out that construction workers experience two times more work-related injuries than other industry workers. Construction by its very nature is ergonomically hazardous, whose works typically require the adopting of awkward postures, lifting of heavy materials, frequent bending and twisting of body, working above shoulders height, manual handling of heavy and irregular-sized loads, working below the knee level, staying in one position for a long period and pushing and pulling of loads (Odunjo et al., 2015). In Kenya, data available from Directorate of Occupational Health and Safety Services (DOHSS Annual Report Kenya 2011) indicates that between 2005 and 2009, there were 7769 fatalities across all industry sectors. The same report indicated that construction industry accounted for 16% of fatal accidents and 7% of non-fatal cases (DOHSS Annual Report, 2011). Fatalities and deaths have become common place in Kenya and Kenyans seems to resign to this fate (Omukubi, 2012). But the corresponding information for most developing countries, Kenya being one of them is rare. This makes it difficult to quantify the problem and put necessary ergonomic intervention in workplaces to alleviate causes of work-related musculoskeletal disorders (Bao 1997)

In Kenya, non-compliance of appropriate work methods such as working with vibrating machines, manual handling of materials, and awkward posture among others has been found to be prominent in most construction sites (DOHS Annual Report 2014). In Mombasa in particular, due to high demand for housing, safety standards have been compromised and this has seen an upsurge of accidents in construction sites, thus the need for this study.

2. Statement of the Problem

Ergonomics is a science discipline which is concerned with understanding the relationship between humans and social-technical system element while ergonomic risk factors are characteristics of a job that contribute to the creation of ergonomic stress on the body (Colombini et al., 2000). Construction is a basic pillar for global competitiveness and foundational enabler to Kenya's Vision 2030. To some purpose it is said, the construction and their extent is economic indicator of all the country. It shows the level of development, also the state of the country. However, the big amount of works increases the number of accidents in construction sites. Occupational injuries continue to place tremendous burden on workers globally with an estimated 100 million occupational injuries occurring worldwide each year (Leigh 2011). Ergonomic risk factors that causes ergonomic injuries also referred to as musculoskeletal disorders remain prevalent and often result in a substantial burden of disability and high associated cost (Palmer 2015). In US for instance, Bureau of Labor Statistics (BLS) reported over 2.8 million cases of nonfatal occupational injury of which MSD accounted for 33%. ILO estimates that at least 60,000 fatal accidents happen in a year on construction sites around the world, despite there being set regulations on health and safety. Developing countries has also recorded very frequent injuries and risks associated with construction work. Jason 2008, stated that the risk is 3-6 times bigger. It should be noted that unemployment and poverty has driven majority of Mombasa County populace to working in construction sites despite having full knowledge of how risky the industry can be. Despite the steady growth in the construction sector, the industry is a very accident prone. Data available from Directorate of Occupational Health and Safety Services (DOHSS) indicates that in between 2005 and 2009, there were 7769 fatalities across all industry sectors. In 2011, construction industry accounted for 16% of fatal accidents (40 cases reported for hundred thousand (100,000) workers) and seven percent (7%) of non-fatal cases (DOHSS Annual Report, 2011).

Because of failed enforcement of risk management system and generally construction health and safety management, there are numerous accidents and incidences of fatalities in many construction sites (DOSHS, 2009). DOSHS states that most accidents in construction sites go unreported. In addition, most construction workers have no information and or training on matters of health and safety that is pegged to as their rights. Unfortunately in Kenya and Mombasa County in particular, there are no reliable data on accident cases in construction because most contractors do not report all the accidents (DOHSS Annual Report, 2011). Many workers have met their deaths in construction sites while others have become permanently crippled from construction related injuries. Further, laws on occupational safety and health are not strictly enforced. Safety rules in most construction sites do not exist and if they exist, the regulatory authority is weak in implementing each rule effectively. It is against this background that the study sought to evaluate ergonomic risk factors and musculoskeletal disorders in building constructions in Mombasa County through identification of the Ergonomic risk factors, establishing the prevalence of musculoskeletal disorders and establishing the status of health and safety management systems in construction sites.

Study Objective

To evaluate Ergonomics risk factors and musculoskeletal disorders in building construction sites in Mombasa County.

Justification

Construction industry plays an important role in improvement of countries' economic growth. Despite its immense contributions to economic growth, construction industry has always been blamed for the high rates of accidents and fatalities; this issue has placed the construction

Corresponding Author: Stellah Cherop Ndiwa.
Address: Department of Occupational Safety and Health, Institute of Energy and Environmental Technology, Jomo Kenyatta University of Agriculture and Technology, Kenya

Journal Homepage: - www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
Article DOI: 10.21474/IJAR01/4587
DOI URL: http://dx.doi.org/10.21474/IJAR01/4587
ISSN NO. 2320-5407

industry among the industries with unreasonable rates of accidents, permanent and non-permanent disabilities and even fatalities (Hughes & Ferrett, 2011). A study done by Charamba in 2006 established that majority of the accidents don't just happen, instead, people who perform unsafe acts and creates unsafe conditions cause accidents to happen and hence accidents. Since most of these workers in this industry are considered young and vibrant, the expectations from family and community at large are high. But due to poor health and safety standards in construction sites, these young generation are subjected to poor health and high cost of treatment when accidents occur. Consequently being bread winners, they end up losing their source of livelihood and support to their families. This study therefore has provided data that will help in stemming the tide of ergonomic risk factors that have led to MSDS in the construction industry among workers in Mombasa County and Kenya at large.

Methodology:

Research Design:-

The study used descriptive and cross-sectional design. Descriptive design attempts to gather quantifiable information that can be used to statistically analyze a target audience or particular subject (Benard, 2012). The research design hence focused on gaining an understanding of the ergonomic risk factors in construction industry and its relation to Musculoskeletal Disorders in Mombasa County.

Population

The study targeted a population of 1364 workers that comprised of construction workers from selected trades; carpenters, roofer, masons, ironworkers and site managers drawn from registered construction sites by National Construction Authority in the four sub-counties in Mombasa. (**Table 1**)

Table 1: Population per sub-county

Sub-County	Number of Registered Building Construction sites	Total numbers of workers
Kisauni	27	916
Changamwe	12	298
Nyali	5	78
Jomvu	7	72
Total	**51**	**1364**

Sample and Sampling Frame

Sampling frame as defined by Cooper and Schinder (2000) is a list of all the elements from which a sample is drawn and is clearly related to the frame. In this study, stratified random sampling and simple random sampling was used with specification on job categories and level of construction. According to Cooper and Schinder (2000), a stratified random sample is a population sample that requires the population to be divided into smaller groups, called "strata". Random samples was taken from each stratum, or group.

From the selected sub-counties, 1364 workers from the registered building construction were divided into 5 strata based on the job cadre/task performed. They included: carpenters, roofers, mason, steel fixers and site managers. These group formed both the skilled and unskilled workers. Then random sampling was used in each stratum. Yamane (1967:886) provides a simplified formula to calculate sample sizes. This formula was used to calculate the sample sizes.

A 95% confidence level and P=.5 are assumed for **Equation 1**

$$n = \frac{1364}{1 + 1364(0.05)2}$$

$n = 309$

Results and Discussion

Response rate

309 (100%) questionnaires were distributed to the targeted group. The questionnaires were distributed to the workers on convenient basis in each site. The different sample from different construction sites in this study was a representative of the population of workers in each particular construction site. The respondents were randomly picked from each group based on specific tasks they performed. They include: site managers, carpenters, masons, roofers and iron workers.

Out of the 309 (100%) questionnaires distributed, 220 (71.2%) copies were returned and had the questions responded to correctly. Eighty nine (89) responses were invalid owing to inconsistency in the responses and were discarded. The remaining two hundred and twenty (220) responses were included in the analysis and provided useful information for the survey. Babbie (2007) suggests that in research a response rate of at least 50 per cent is considered adequate for analysis and reporting and a response of 70 per cent is very good. Hence the research 71 per cent was appropriate for data analysis.

Majority of the respondents were male [208(94.5%)] while female were very few [12(5.5%)]. This is because most construction work is strenuous and requires strength that's why it attracts more males than females as seen in this study. (Bernard, 2010). This explains the low rate of women employment in the housing construction industry. This can also be explained by the culture in community's stereotyping men as being superior than women and hence preferring construction work to male rather than female (Bhagwat et al., 2009). The study established the following information based on each of the ergonomic hazard classes:

i. Awkward postures

Except for the foremen, all respondents checked off high daily exposure to postures involving bending the neck > 45o for > 4 hours total. Hand over head or elbow was recorded high in painters, plasters and mason. Additionally, Steel fixers, carpenters, plasters and painters indicated considerably high levels of repeated raising hand over head for more than 4 hours. Plasters, painters and masons recorded checked high levels of neck bent above 450. Postures requiring the back to be bent >30o in 4 hours daily was checked by all the workers though minimum in foremen, (Figure 4.5). Daily ergonomic hazards affecting the back and knee was checked off by all carpenters, masons, plasters, roofers, painters, foremen and steel fixers. Foremen and painters recorded minimum effects from knees kneeling for > 4hours

ii. Manual handling of materials

Corresponding Author: Stellah Cherop Ndiwa.
Address: Department of Occupational Safety and Health, Institute of Energy and Environmental Technology, Jomo Kenyatta University of Agriculture and Technology, Kenya

Journal Homepage: - www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
Article DOI: 10.21474/IJAR01/4587
DOI URL: http://dx.doi.org/10.21474/IJAR01/4587
ISSN NO. 2320-5407

iii. Repetitive motion

All worker category except foremen checked off. They also checked high rate of lifting objects for every 20 minutes.

Based on the results from the checklist administered to the workers, the majority of workers graded their job tasks within the hazard zone for ergonomic risk. A correlation between the results from the assessment of perceived hazard exposure and the results from onsite observation, confirms that the majority of the participants are working within the hazardous range for WRMSDs.

iv. Forceful exertion

Steel fixers, roofers and carpenters are exposed to forceful exertion through hand, wrist, and arm tasks involving gripping of objects for more than 4 hours per day. These workers category checked off daily tasks requiring that the wrist be bent in flexion > 30° for more than 3 hours total.

Plate 4.1 Workers in awkward posture and without PPE.

Relationship between ERFs and MSDs

Table 2 ERFs association to MSDs

Model		Unstandardized Coefficients		Std Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.622	.142		5.369	.000
	Ergonomic Risk Factors that causes MSDs	.709	.036	.798	18.569	.000

From the Table 4.2, the equation Y=β0+β1X1+ε will be interpreted as:

Y=0.622+0.709X1+ε where

=0.622+0.709X1+0.05

Where:

Y=Occurrence of MSDs

β0= Constant

β1=performance

X1=independent variable (Ergonomic Risk Factors that causes MSDs)

E= error of estimate at 95% confidence level

The regression equation 0.622+0.709X1+0.05 established that that with a constant variable of MSDs occurrences, Ergonomic risk factors that result in MSDs in workers will be at 0.622. With the constant exposure of workers to ergonomically unfriendly work conditions, the risk factors that workers are exposed to will result to a 0.709 raise of the occurrences of MSDs This indicated that a unit change in ERFs subjection with result to MSDs irrespective of workers experience.

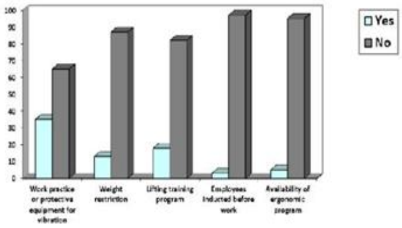


Figure 1 Ergonomics program in construction workplace

Figure 1 above gives the responses from the foremen on the availability of the ergonomic programme to their employees. It was noted that 95 % of the construction sites do not have an ergonomic programme in place, 18% ascertained that there is lifting programme in place for their workers. 87% does not have weight restriction while 35 % of the respondents have a work practices and protective equipment for vibrations. The research found that the respondents perceived that construction activity hampers the physical nature of construction workers. This findings clearly indicate that there is a need to reduce the onset of the WMDs among the construction workers.

Thus based on the findings and the fact that construction is a project based industry is an important contextual issue, when attempting to manage a dynamic changing work environment such as a construction site, it should be borne in mind that there is need to be in place of an appropriate safety structure to deal with the changing nature of the project.

Plate 2: Roofer working without appropriate PPE

Corresponding Author: Stellah Cherop Ndiwa.
Address: Department of Occupational Safety and Health, Institute of Energy and Environmental Technology, Jomo Kenyatta University of Agriculture and Technology, Kenya

ijar
ISSN NO. 2320-5407
Journal Homepage: - www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
Article DOI: 10.21474/IJAR01/4587
DOI URL: http://dx.doi.org/10.21474/IJAR01/4587

[16] Murie F. (2007) Building Safety-an International Perspective. Int. J. Occup. Environ. Health 2007 Jan-Mar; 13(1)5-11

[17] NCA, (2011). National Construction Authority Act. Act No 41 of 2011. An Act of parliament of the government of Kenya

[18] NIOSH 2004. Workers Health Chartbook. Available http://www.cdc.gov,niosh/docs/2004-146/pdfs/2004-146 Accessed on 2nd March 2018

[19] Nubi, O.T (2008): Affordable housing delivery in Nigeria. The South African Foundation International Conference and exhibition, Cape Town, Oct. 2008. Pp1-18

[20] Odunjo O. Ajay O. Joseph O. and Okanlawon S. (2015) Assessment of the impact of MSDs on Nigerian Construction Workers. Int. Journal of civil Engineering, construction and estate management. Vol3, No.3 pp66-84

[21] Omukubi, N., (2012) Collapsing buildings a major killer in Kenya: Jamhuri magazine.

[22] OSHA, (2007). Occupational Safety and Health Act No 15 of 2007. An Act of parliament of the government of Kenya

[23] O'Toole, M., (2002). The relationship between Employees' perceptions of Safety Organizational culture. Journal of safety research 33 (2002) 231-243.

[24] Palmer K. and Goodson N. (2015) Ageing musculoskeletal health and work. Best practice and research. *Clinical Rheumatology*, 29(3), 391-404

[25] Roger W (2004) Do long working hours lead to more workplace injuries? Evidence from Australian industry-level panel data. Melbourne institute of applied economic and social research. The University of Melbourne: 3-5 https://www.dtl.unimelb.edu

[26] Rwamamara, R. (2007). "Risk assessment and analysis of workload in an industrialized construction process." Construction Information Quarterly. 9(2), 80-85.

[27] Sanders, M. J. (2004) Ergonomics and the Management of Musculoskeletal Disorders, Second Edition. USA: Elsevier (Butterworth Heinemann).

[28] Steve R. and Gregory Z. (2013) Safety and Reliability analysis methods based on systemic-structural activity theory. Journal of Risk and Reliability Vol.227, Issue 5, 2013

[29] Yamane T. (1967) Statistics: An introductory analysis, 2nd Edition, New York: Harper and Row


INTERNATIONAL JOURNAL OF SCIENCE & RESEARCH

www.ijsr.net IJSR ISSN (Online): 2319-7064

ISSN:2319-7064

Certificate of Publication

www.ijsr.net

This is to Certify that the paper ID: ART20181825 entitled

Ergonomic Risk Factors in Building Construction Sites in Mombasa County, Kenya

Authored

By

Stellah Cherop Ndiwa

has been published in Volume 7 Issue 4, April 2018

in

International Journal of Science and Research (IJSR)

The mentioned paper is measured upto the required standard.

Editor in Chief, International Journal of Science and Research, India