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DEPARTMENT OF ENVIRONMENTAL SCIENCE

AN INVESTIGATION INTO THE PREVALENCE OF WORK-RELATED MUSCULOSKELETAL DISORDERS AMONG JACKHAMMER OPERATORS: A CASE OF CHIFEN QUARRY MINING COMPANY IN ZIMBABWE.

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JUNE 2022

DECLARATION

I Omega Chihure, do hereby declare that this research project is my own work and additional sources have been properly and fully acknowledged by means of references. This dissertation has not been submitted before for any degree or examination in any other university, I am responsible for this research and its articulation alone. In no ways do any of the mentioned persons in the acknowledgement bear any direct responsibility for this work.

Student Signature ………………………………………. **Date: …………………………….**

APPROVAL FORM

This undergraduate dissertation entitled “Investigation into the prevalence of Work-Related Musculoskeletal Disorders among jackhammer operators. A case of Chifen Quarry Mine: Masvingo”, prepared and submitted by OMEGA CHIHURE in partial fulfilment of the BSc (Hons) Safety Health and Environmental Management, has been examined and recommended for acceptance by Bindura University of Science Education.

Student signature ……………………………………….. Date……………………..

Supervisor signature …………………………………... Date……………………….

DEDICATION

To my beautiful family, the Chihure family and fellow earth habitants, this is for you.

ACKNOWLEDGEMENTS

I thank God, for the free ancillary gift of ability and will to complete the project. I also thank my project supervisor Dr Loveness Mabhungu, for the above mediocrity supervision. I also extend my gratitude to my friends for their encouragement, as well as the management and staff at Chifen Quarry Mine, for their participation in this study.

ABSTRACT

The prevalence of musculoskeletal disorders, among Jackhammer operators who specialise in drilling granite rock boulders at Chifen Quarry Mine in Masvingo, was assessed. A descriptive cross-sectional study design was used to gather the data for the study. A total of 100 jackhammers participated in answering semi-structured questionnaires to determine the prevalence of Muscular Skeletal Disorders (MSDs) and three jackhammer operators were selected for postural analysis using the Rapid Entire Body Assessment (REBA). The REBA evaluated the risk posed by prominent postures in the routine work of jackhammer operators. Statistical Package for Social Sciences (SPSS) was used for Descriptive statistics and Binomial Regression. The prevalence of musculoskeletal disorders was high in the upper limb region (76%) and doubled that of the lower limb region (39%). Seventy-five percent of the jackhammer operators complained of MSDs in the lower back, 54% in the wrists/hands, 42% in the upper back and 30% in the neck. The prevalence of MSDs in the hips/thighs was 39%, 29% in the knees and 23% in the ankles. Binary regression showed that age ($p < 0.05$), work experience ($p < 0.05$) and height ($p < 0.05$), were significant risk factors in the development of musculoskeletal disorders. The REBA showed very high scores of 13 and 15 for the jackhammer alignment posture and drilling posture respectively. The study showed that the jackhammer operators' poor workplace design and high workload contributed to a high prevalence of MSDs whilst individual characteristics such as old age increased the severity of MSDs. It is therefore critical to implement ergonomic risk interventions at Chifen Quarry Mine.

Keywords: Prevalence, Work-Related Musculoskeletal Disorders, Rapid Entire Body Assessment, Risk Factors.

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List of Acronyms

WRMSDs = Work Related Musculoskeletal Disorders

LBD = Lower Back Disorders

UBD = Upper Back Disorders

CMDQ = Cornell Musculoskeletal Disorders Questionnaire

REBA = Rapid Entire Body Assessment

NSSA = National Social Security Act

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Work-related Musculoskeletal Disorders (WRMSDs) are severe maladies of muscles, bones, nerves, tendons and other soft tissue that are caused or aggravated by workplace activity (Hossain et al., 2018). There are a variety of physical conditions such as lifting weighty objects that might enhance physical loading in the musculoskeletal system, causing discomfort and pain (Matsie et al., 2020). Individual factors such as the age of the workforce, in addition to the physical demands of the job, contribute to the development of Work-related Musculoskeletal Disorders. Work-related Musculoskeletal Disorders, like many other occupational health issues, are challenging to categorize using established disease definitions. Furthermore, establishing a direct cause-and-effect relationship between occupational activities and musculoskeletal problems is not always achievable. Musculoskeletal diseases at work can result in discomfort, numbness, tingling, decreased productivity, time away from work, and temporary or permanent disability (McCauley, 2012). Adding to this, work-related musculoskeletal disorders have a large economic implication to businesses and healthcare systems. This is due to lost productivity, new worker training, and injury compensation expenditures. These expenses are felt globally, primarily as companies form multinational partnerships for manufacturing and service jobs. Musculoskeletal illnesses account for 37% of the disease burden (Vieira, 2010). In Australia, musculoskeletal disorders were responsible for 60% of illnesses from 2013 to 2014 (Johanning, 2000). In the years 2016 to 2017, musculoskeletal disorders accounted for at least 39% of all reported work-related illnesses in the United Kingdom (Hossain et al., 2018). A high incidence rate of 62% has been reported on the African continent (Vieira, 2010).

Jack hammer operators provide a critical service in the mining sector. Their task is to drill holes in hard rock for primary and secondary ground blasting in the process of mineral ore extraction. The nature of jackhammer operation makes operators susceptible to developing WRMDs. This is due to its awkward or unnatural postural demands, repetitive movements, jackhammer vibration and force targeting minor elements of the body like the hand/wrist and feet. Furthermore, jackhammer operations include housekeeping activities like bench dressing, loading and offloading of all drilling equipment (Yang et al., 2016). Musculoskeletal problems in jackhammer operation commonly involve strains to the cervical spine, back and slightly lower extremities (Okunribido, 2011). Adding to this, jackhammer operators are at high risk for developing low back pain due to prolonged awkward and static posture (Johanning, 2000).

Work-Related Musculoskeletal Disorders are a substantial public health problem affecting a significant number of jackhammers operators in developing and developed countries. Musculoskeletal Disorders account for roughly $1 out of every $3 in workers' compensation expenditures (Middlesworth, 2014). Eliminating ergonomic risks presents a substantial cost reduction opportunity, as indirect costs can be up to twenty times the direct cost of an injury (Middlesworth, 2014). Musculoskeletal Disorders can be avoided by proactively eliminating ergonomic risk factors since there is evidence of a link between job activities and musculoskeletal diseases (McCauley, 2012). Healthy people are the most important asset, and ergonomic assessment demonstrates a company's dedication to workers' safety and health as a core value. Creating and fostering a safety and health culture in a firm will result in improved human performance for that company. Furthermore, proper workplace ergonomics boost employee motivation. Employee turnover is reduced by 48% on average, and absenteeism is reduced by 58% on average, resulting in a 25% increase in productivity (Häkkänen et al., 2001).

The prevalence of MSDs peculiar to jackhammer operators in the mining industry in Zimbabwe is not known even though ergonomic risks are known as causes for most occupational diseases worldwide. This study seeks to address the gap in ergonomics hazards in the critical task of jackhammer operation by encompassing the prevalence of musculoskeletal disorders.

1.2 PROBLEM STATEMENT

Since Chifen quarry mine`s establishment, no ergonomic survey on Work-Related Musculoskeletal Disorders and their risk factors among jackhammer operators has been conducted. Even though there are existing data on MSDs complaints, various risk factors which aggravate ergonomic issues have not yet been documented at the quarry mining company. This prompted an investigation into the prevalence of WRMSDs among Jackhammer operators. The investigation will give recommendations to solve the escalating reports on work-related musculoskeletal disorders experienced by the company`s jackhammer operators.

1.3 AIM

Investigate the prevalence of work-related musculoskeletal disorders among Jackhammer operators, at Chifen Quarry Mine.

1.4 OBJECTIVES

- To determine the prevalence of Work-related Musculoskeletal Disorders, on jackhammer operators at Chifen Quarry Mine.
- To determine the risk factors of developing MSDs among jackhammer operators, at Chifen Quarry Mine.
- To ascertain the working postures contributing to MSDs among jackhammer operators using Rapid Entire Body Assessment, at Chifen Quarry Mine.

1.5 JUSTIFICATION

The study will look into the prevalence and risk factors of Work-Related Musculoskeletal Disorders experienced by jackhammer operators at Chifen Quarry Mine. This will bring out the risks associated with each task and therefore determine measures to manage each risk factor. Measures to manage each risk factor will eliminate or lessen the risk of developing Work-Related Musculoskeletal Disorders among jackhammer operators locally and internationally. The study will raise awareness of the associated risks to jackhammer operators and prompt them to comply with safety rules. This will ensure that management of ergonomic risks is also done at the worker's level.

The study will provide local regulatory authorities such as National Social Security Act (NSSA), with epidemiological information on Work-Related Musculoskeletal Disorders among jackhammer operators. The epidemiological information will facilitate the formulation of occupational health and Safety policies which cater for the establishment of worker-friendly environments for jackhammer operators.

The research may perhaps help Chifen Quarry Mine, comply with the legal requirements such as the Labour Act (2006) Chapter 28:01. The Act emphasizes the working environment and worker relationship. Furthermore, this study will help the mining sector with a clear view of the criticality of issues buried under the generalization of WRMDs assessments in the mining sector. The research will minimise the research gap on mining ergonomic risks specific to jackhammer operation. Finally, this will call for adequate attention to ergonomic hazard control in jackhammer operation from mining companies’ top management, national policymakers and the manufacturers of drilling equipment abroad.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The chapter presents a review of the literature relevant to this research. It includes information on the aetiology and classification of work-related musculoskeletal disorders, as well as examples of work-related illnesses and symptoms. To reduce work-related musculoskeletal problems, the chapter also includes risk management actions connected to ergonomic risks in jackhammer operation. Different scholars have been reviewed to have a thorough grasp of how jackhammer activities contribute to the development of musculoskeletal illnesses.

2.2 THE ESSENCE OF ERGONOMICS

Ergonomics is a scientific study of employees in their working environment, taking into account what they are capable of as well as their limitations. It also involves the workplace design and job demands to ensure compatibility with the employees' quality (Johanning, 2000). One of the explicit goals of the 2030 Agenda for Sustainable Development is to promote safe and secure working environments for all workers, making ergonomics a critical aspect. Motivations are based not just on protecting personnel's health and safety, but also on financial considerations. Such financial considerations include medical expenditures associated with physical and psychological harm, as well as potential absenteeism (OSHA, 2000). More so, professional and experienced personnel are replaced by inexperienced alternatives as a result of absence, which may affect production (Resource, 2007). Ergonomics improves workplace productivity, reduces muscle fatigue, and reduces the likelihood and severity of work-related MSDs. As a result, ergonomics has become an integral aspect of labour-intensive businesses or businesses where humans play a critical role (Häkkänen et al., 2001). Ergonomics can improve individual well-being and overall safety and health management system performance by addressing physical, psychological, and social elements of work-related issues (McCauley, 2012).

2.3 CAUSES OF WORK-RELATED MUSCULOSKELETAL DISORDERS

Musculoskeletal disorders (MSDs) are a collection of inflammatory and degenerative diseases. The affected body organs include muscles, tendons, ligaments, peripheral nerves, joints, cartilage, vertebral discs, bones, and/or blood vessels that support them. They are caused by heavy, repeated workloads and long shifts (Vieira, 2010). Working conditions can develop or exacerbate musculoskeletal diseases during work (McCauley, 2012). MSDs are not usually produced by one-time occurrences, but rather develop over time. Hand-arm vibration syndrome, for example, can be caused by prolonged vibration exposure to the hand and forearm (HAVS). Symptoms of HAVS include numbness, tingling, and pain in the hands and arms (HSE, 2012). According to previous research, jackhammer operators are expected to perform demanding physical activities, such as loading and unloading jackhammers (weighing 90lb) as part of housekeeping (Neugebauer et al., 2010). The jackhammer operator is at risk of developing Work-Related Musculoskeletal Disorders due to a variety of factors, including vibration and poor postural requirements (HSE, 2012)..

2.4 CLASSIFICATION OF WORK-RELATED MUSCULOSKELETAL DISORDERS

Work-Related Musculoskeletal Disorders (WRMSDs), are classified by the affected body region. Work-Related Musculoskeletal Disorders must be classified to be managed effectively (Pereira et al., 2021). They are classified as, Work Related Upper Limb Disorders (WRULDs), Work-Related Lower Limb Disorders (WRLLDS) and Work-Related Back Disorders, (WRBDs).

2.4.1 WORK-RELATED UPPER LIMB DISORDERS

Work-Related Upper Limb Disorders (WRULD) are a group of disorders that affect the soft tissues and nerves of the hand, wrist, arm, elbow, shoulder, and neck. Repetitive actions or extended monotonous posture cause WRULDs (Hutson, 2014). Pain, oedema, decreased ability to move the affected limb, stiffness, and cramping are some of the symptoms. Mild symptoms normally go away with rest, but some might develop into permanent disability if not treated, especially in people who already have musculoskeletal problems (Health and Safety Executive, 2013).

2.4.2 WORK-RELATED LOWER LIMB DISORDERS

Work-Related Lower Limb Disorders (WRLLDs) are conditions that affect the pelvis and legs. A common risk factor is prolonged monotonous posture, such as standing for more than 2 hours without a break. Osteoarthritis of the pelvis and knees, as well as injured varicose veins of the legs, are examples of work-related lower limb illnesses (Matsie et al., 2020). Previous research has revealed that there are a few work-related illnesses affecting the lower appendage.

2.4.3 WORK-RELATED BACK DISORDERS

Work-related diseases of the back are common in a variety of occupations, ranging from heavy to light industrial employment (Pilling, 1997). Poor ergonomic factors hasten the progression of existing lower back ailments such as hernias and spondylolisthesis, both of which are disorders of spinal discs

(Pilling, 1997). Occupational physicians spend a significant amount of time treating back diseases in the workplace. In addition to the natural ageing process, epidemiological studies show that poor workplace ergonomics contribute to lower back issues in otherwise healthy individuals.

2.5 WORK-RELATED MUSCULOSKELETAL DISORDERS RISK FACTORS

Work-Related Musculoskeletal Disorders risk factors, are the activities, postures, workspace design, and personal qualities that may cause musculoskeletal problems to develop. The effects of risk factors on the development of MSDs depend on the length and intensity of exposure. Risk factors might have temporary or lasting effects (McCauley, 2012). Risk factors for the development of musculoskeletal disorders include, vibration, static postures, force, repetitive motion, anthropometrics, age and experience.

2.5.1 VIBRATION

Vibration exposure is when a vibrating object, such as a machine, tool, or surface, sends vibration energy to a person's body (Neugebauer et al., 2010). "Segmental vibration" exposure and "whole-body vibration" exposure are the two types of vibration exposure that are of interest. Vibration exposure that is primarily conveyed to and focused on a single region of the body, such as the hand, arm, or leg, is known as segmental vibration exposure. Work-Related Musculoskeletal Disorders, such as Hand-Arm Vibration Syndrome, are caused by segmental vibration. Whole-body vibration causes a variety of short- and long-term symptoms, including disruptions in circadian cycles, elevated heart rate, and spinal, digestive, neurological, and reproductive system issues (Neugebauer et al., 2010).

2.5.2 STATIC POSTURES

Any position in which the load on the musculoskeletal system is maintained for more than 4 seconds is considered a static position (Suszyński et al., 2017). A measure called the percentage of Maximum Holding Time (MHT) is used to assess static postures. Maximum Holding Time is calculated experimentally by calculating the amount of time it takes for a research participant to be unable to hold a specific static position after a certain amount of time has passed (Vieira, 2010). The use of a jackhammer is linked to a static position for long periods (Pope et al., 2002). Muscle exhaustion, tingling, soreness, nerve damage, and cramping are all symptoms of static postures, which restrict the normal flow of blood (Suszyński et al., 2017).

2.5.3 FORCE

Forced is the amount of physical effort required by a person to complete a task or maintain control of tools or equipment. The amount of force required is determined by the weight of the object, the grip used, and the duration of the task (*Force, Motion and Machines*, n.d.). The key risk factor is the amount of force used by a worker when pushing, dragging, or lifting an object (Cao et al., 2017). Drilling activity includes strenuous movements, such as supporting and pressing down on the jackhammer throughout the drilling process. Retrieving and storing jackhammers and other drilling equipment are also physically demanding activities (Cao et al., 2017).

2.5.4 REPETITIVE MOTION

Doing the same motion over and over again at certain positions or grips can cause pain and organ inflammation (Syndrome, n.d.). Repetitive motion exposes employees to a higher risk of having injuries, especially in a situation when other risk factors are also present such as an awkward posture or heavy force. Continuous exposure to a task causes a collection of muscular complaints referred to as repetitive motion disorders (Syndrome, n.d.). The repetitive disorders include tendinitis, which is inflammation of the tendons and Tenosynovitis, which can be a condition in which both the tendon and its covering become inflamed (McCauley, 2012).

2.5.5 AGE AND EXPERIENCE

Age, on its own, is not a risk factor for work-related MSD. An exception to this is diseases that affect the muscles and bones, such as arthritis, which are generally age-related and may be aggravated by certain occupations. Besides worsening existing diseases occupational activities can also increase the likelihood of their early onset (Vieira, 2010). Over 40-year-old jackhammer operators have been found to have a high rate of musculoskeletal problems. Musculoskeletal disorders identified vary from mild to severe aches, discomfort and tingling sensations in the different regions of the body (Krajewski et al., 2009).

2.5.6 ANTHROPOMETRIES

Anthropometrics is a set of non-invasive, quantifiable body measurements that are used to evaluate growth, development, and health (Torma-Krajewski et al., 2009). Because anthropometrics is such a subjective topic, engineering controls are required to meet the needs of each operator. Appropriate jackhammer hand grip area proportions, as well as altering jackhammer weight, are predicted to mitigate the mismatch in palm-size and strength (Torma-Krajewski et al., 2009).

2.6 ERGONOMIC RISK MANAGEMENT ACTIVITIES

The goal of ergonomic risk management is to protect the human resource value. The International Standard Organisation 3100 of 2018 for Risk Management provides guidelines for effective ergonomic risk management. The ISO 31000 guide outlines the hazard control hierarchy, which includes, but is not limited to, the following controls:

Engineering controls - Technical ergonomics methods such as changing operational procedures, resources utilised, and machinery, and even changing the end product to eliminate risks (Cantino et al., 2016). Administrative controls - Modifications to how duties are carried out. In a workplace, these procedures or decisions are normally taken by the respective management (Cantino et al., 2016).

2.7 SUMMARY

This chapter gave a survey of the literature connected to this topic, including ergonomic studies by various scholars on work-related musculoskeletal disorders hazards, causes, common diseases, symptoms, and common discomfort regions. Risk management activities for ergonomic risks in jackhammer operation were also covered.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 DESCRIPTION OF STUDY AREA

The research was conducted at Chifen quarry mine. Chifen Quarry Mine is situated in Glyntor 4, 10 kilometres from Masvingo City`s Central Business District, along Harare road. Chifen quarry mine is located in the Northern part of Masvingo with coordinates 20. 0200° S, 30. 4734° E. Granite quarry stones are extracted from a doom shaped granite-mountain which stretches for a kilometre in length and is approximately 105 meters in depth from the mountain bench. Chifen Quarry Mine is open 24 hours a day to meet the growing demand for quarry stones as a modern-day construction material countrywide. The majority of manual labourers including jackhammer operators are from the closest residential areas namely, Zimre Park and Cooden farm. Figure 3.1 below shows the location Chifen Quarry Mine in Masvingo, Zimbabwe.

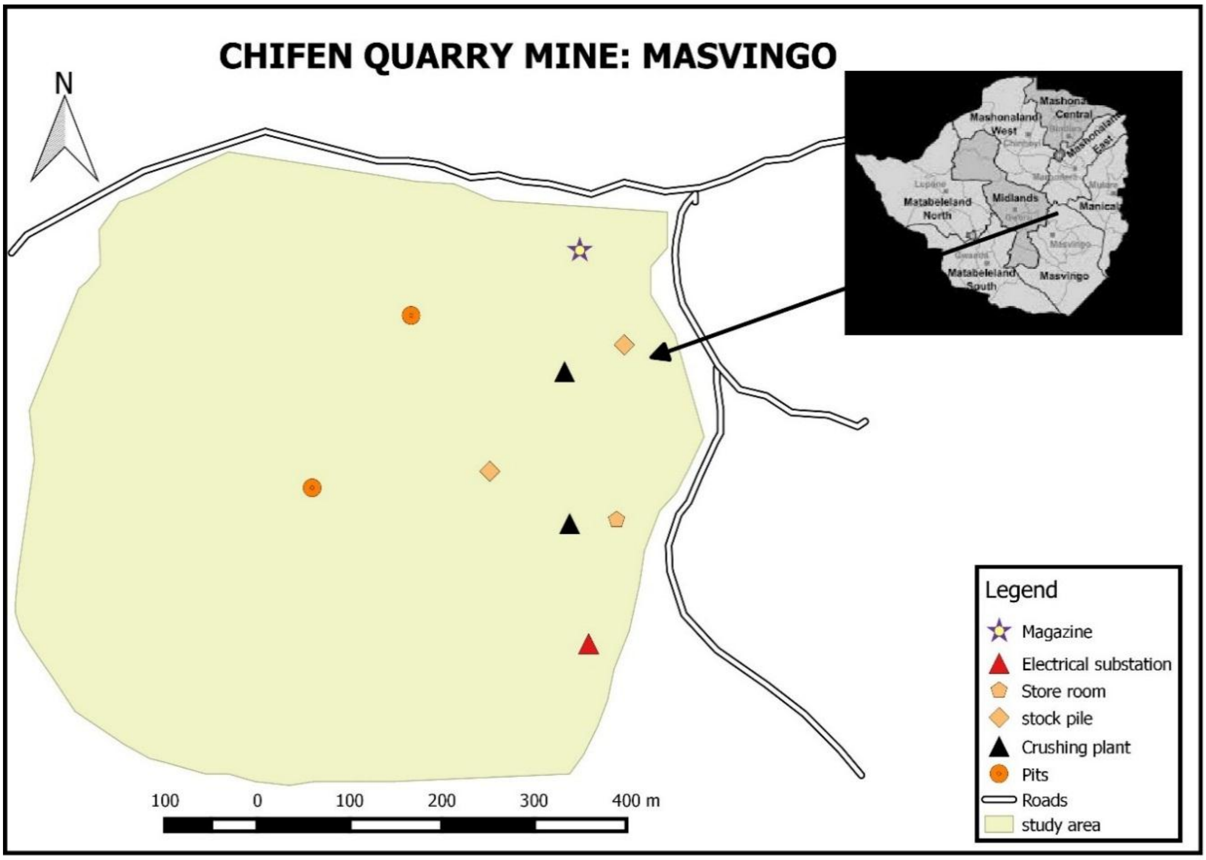

Figure 3.1. Chifen Quarry Mine: Masvingo.

3.2 RESEARCH DESIGN

The research was done using a descriptive cross-sectional study design. Descriptive cross-sectional study designs are generally quick, and easy whilst capturing multiple variables simultaneously (Sileyew, 2020). Modified Nordic Musculoskeletal questionnaires were used to get data on the prevalence of MSDs and the risk factors of developing MSDs among jackhammer operators, at Chifen Quarry Mine. The Rapid Upper Entire Body Assessment (REBA) was used to ascertain the working postures contributing to MSDs among jackhammer operators at Chifen Quarry mine.

3.3 SAMPLE SIZE AND SAMPLING TECHNIQUE

Jackhammer operators at Chifen Quarry mine, fall under the drilling and blasting department and there were a total of 3 shifts a day, at Chifen Quarry Mine. The entire population for 3 shifts was 120 male jackhammer operators, their ages ranging from 19-40 years and with different years in service. Using the Slovin Formula (Appendix 1) to determine the sample size, 100 jackhammer operators were selected to be the questionnaire respondents. Simple random sampling a type of probability sampling in which the researcher randomly selects a subset of participants from a population was used to select the respondents. The names of all 120 jackhammer operators were written on separate pieces of paper and put in a container where 100 names were selected blindly. Three operators were selected for REBA, 1 from each shift, using the simple random technique described above, to eliminate bias.

3.4 DATA COLLECTION

Data was gathered to assess the prevalence of Work-Related Musculoskeletal Disorders, among jackhammer operators at Chifen Quarry Mine. Semi-structured questionnaires were distributed to jackhammer operators to determine the prevalence and risk factors for WRMSDs. Data on vibration frequency produced from pneumatic jackhammers were also acquired from Chifen Quarry Mine's HSE Department records. The Rapid Entire Body Assessment was used to ascertain working postures contributing to the development of WRMSDs. The workers` body movements and postures were observed during the drilling activity throughout the shift.

3.5 MODIFIED CORNEL MUSCULOSKELETAL DISORDER QUESTIONNAIRE

Data on the prevalence of WRMSDs among respondents was obtained using the Modified Cornel Musculoskeletal Disorder Questionnaire (CMDQ) (Gounder, 2012). Personal and organisational aspects which lead to the development of WRMSDs were included in the questionnaire.

The questionnaire (appendix 2), consisted of both closed and open-ended questions. The questionnaire was divided into the following sections. First section: Gathered demographic data, which is age, height, weight, educational level, and marital status. Respondents were equipped with a measuring tape to determine their height. Second section: Gathered data on personal and organisational aspects that may contribute to the development of musculoskeletal problems. This includes job experience, daily and weekly working hours, and perceived speed of continuous work without a break. Third part: The third part of the questionnaire gathered data on WRMSDs experienced for the last 12 months and 7 days to aid the assessment of WRMSDs prevalence. A body map that indicated ten symptom sites: neck, shoulders, upper back, upper arm, lower back, lower back, forearm, wrist, hips/buttocks, thigh, knees, and lower legs aided completion (Crawford et al, 2007).

3.6 RAPID ENTIRE BODY ASSESSMENT

The Rapid Entire Body Assessment (REBA) is a precise interaction to assess the entire body's postural MSD and risk linked to job activities. A solitary page worksheet is utilised to assess required or chosen body movements, forceful tasks, postures, and coupling. The REBA is quick and easy, so various positions and tasks undertaken during the work cycle can be assessed without a critical time/exertion cost. While utilising REBA, just the right or left side is evaluated at a time. After talking to and noticing the specialist the evaluator can decide whether only one arm ought to be assessed, or then again on the off chance that an appraisal is required for the two sides (Middlesworth, 2021).

Utilising the REBA worksheet, (Appendix 3), a score was relegated for every one of the accompanying body locales: wrists, lower arms, elbows, shoulders, neck, trunk, back, legs, and knees.

3.7 STATISTICAL ANALYSIS

Statistical Package for Social Scientists (SPSS), was used for descriptive statistics to determine the distribution of the demographic variables of jackhammer operators. Binary regression tests were done to determine the relationship between age, weight, height education, marital status and experience with the development of musculoskeletal disorders (MSDs), in each body region. The REBA scores were used for postural analysis on a low, medium and high-risk scale.

3.8 RELIABILITY VALIDITY AND ETHICS

For research findings to answer the research questions, the research instruments must be valid, and reliable and ethics must be observed for credibility (Hendee, 2009).

3.8.1 RELIABILITY

Consistency and repeatability throughout time are indicators of reliability. Furthermore, reliability is defined as the degree to which a test is devoid of measurement errors, the higher the number of measurement errors, the less trustworthy the test becomes (Resnik, 2014).

3.8.2 VALIDITY

Validity is foremost in the mind of those developing measures and that actual scientific measurement is foremost in the minds of those who seek good outcomes from assessment (Showkat, 2017). Therefore, validity can be seen as the core of any form of accurate and trustworthy assessment. External validity was enhanced through a set of recommendations established to ensure that problems experienced by the quarry mining company are addressed and meet the objectives of the research study.

3.8.3 ETHICS

The fundamental ethical principles were applied to the planning and in conducting and publishing of research findings since a credible research study entails observance of ethics. Participation in this research was by voluntary consent and participants have the right to withdraw their participation at any time for any reason of their own and do not need to explain their withdrawal. However, although participation is entirely voluntary, responding to the questions ate into some of the participant's valuable time and disrupted their schedule. However, the duration of participation is not expected to be more than 50 minutes. Withdrawal of one's voluntary participation did not result in any penalty nor affect your future relationships with the researcher and Chifen. In terms of benefits and compensation, participation is purely voluntary, unfortunately, there were no benefits such as monetary payments for those who participated in this study.

3.8.4 VALUES

Values are incorporated mental designs that guide decisions by bringing out a feeling of fundamental standards of good and bad (for instance., virtues), a feeling of needs (for instance., individual accomplishment versus bunch great), and make an eagerness to make significance and see designs (for instance., trust versus doubt) (Resnik, 2014). The researcher has own values namely integrity, transparency, responsibility and respect. These values enabled acceptance of the researcher by the company under study and promised total cooperation. The researcher observed research values to get informed consent and emphasis on the respondent’s right to withdraw at any time.

3.8.5 BELIEFS

Beliefs such as trust, confidence, truth and actuality during data collection were recognised as essential. The study was introduced to the company in a way to boost respondents' confidence in the benefit of their occupational health, by solving recurrent MSDS complaints. The study created a triple-win situation between the researcher, respondents and the company under study.

CHAPTER 4: RESULTS

4.1 DEMOGRAPHIC INFORMATION AND STUDY PARTICIPANTS

Out of the 100 respondents in the study, 82% were married and 18% were single. The highest number of respondents fell into the 20-25 years age group whilst the 30-35 years age group had the least number of respondents. Ninety-four percent of the respondents reached a secondary educational level and the remaining 6% reached a primary level as their highest level of education, (Figure 4.1).

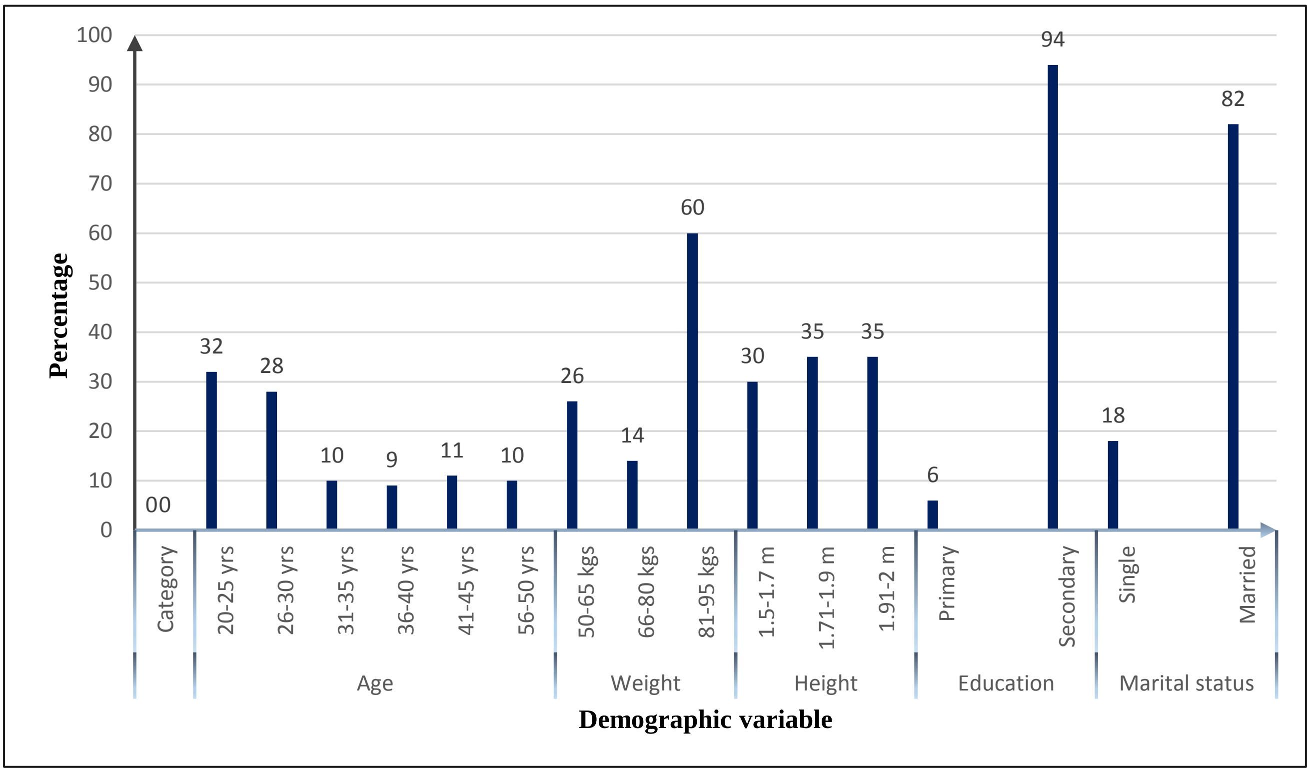

Figure 4.1 **Demographic information on jackhammer operators at Chifen Quarry Mine.**

Every respondent reported that they work overtime per shift resulting in 9 and 36 daily and weekly working hours on average.

4.2 PREVALENCE OF MUSKULOSKELETAL DISORDERS AMONG JACKHAMMER OPERATORS

The prevalence of musculoskeletal disorders was high in the upper limb region and doubled that of the lower limb region. On average, 50% of MSDs experienced caused interference with normal work and the average percentage medical visits for all musculoskeletal disorders experienced was 16%. (Figure 4.2).

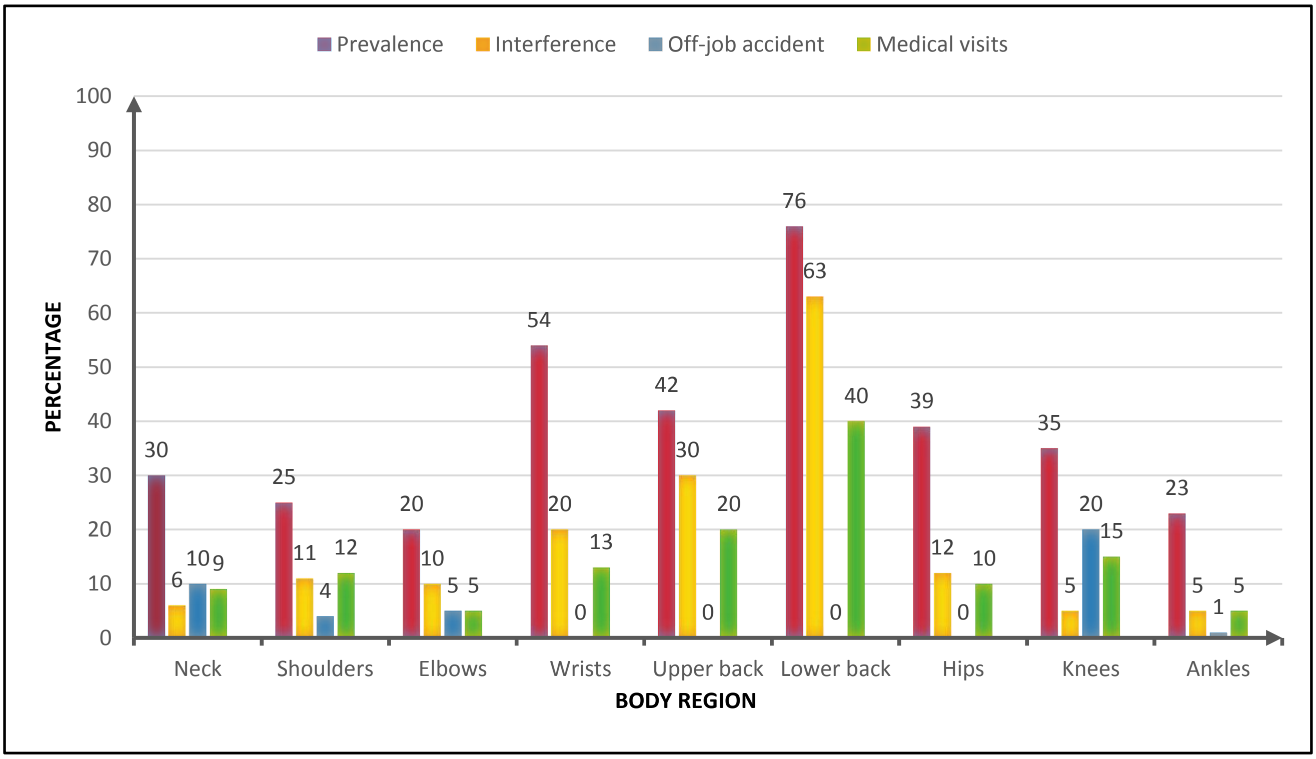

Figure 4.2 **MSDs prevalence among jackhammer operators at Chifen Quarry Mine.**

4.3 ASSOCIATION OF RISK FACTORS OF DEVELOPING MUSCULOSKELETAL DISORDERS WITH PREVALENCE AMONG JACKHAMMER OPERATORS

Binary regression tests were carried out to determine the relationship between age, weight, height, education and marital status with the development of musculoskeletal disorders (MSDs), in each body region. A P-value less than 0.05, showed a statistically significant result depicting a significant association between age, weight, height education, marital status (independent variables) and the development of MSDs, (dependant variable).

4.3.1 RELATIONSHIP BETWEEN RISK FACTORS AND PREVALENCE OF MUSCULSKELETAL DISORDERS IN THE WRISTS/HANDS

A binary regression test for the wrist/hands (Appendix 4), showed that age and work experience are significant risk factors ($p<0.05$) respectively. Education, marital status, weight and height, showed no significant relationship ($p>0.05$) respectively, with the development of MSDs in the wrists/hands.

4.3.2 RELATIONSHIP BETWEEN RISK FACTORS AND PREVALENCE OF MUSCULOSKELETAL DISORDERS IN THE UPPER BACK

A binary regression test for the upper back (Appendix 5), showed that age, work experience and height are significant risk factors ($p<0.05$) respectively. Education, marital status showed no relationship ($p>0.05$) respectively, with the development of MSDs in the upper back.

4.3.3 RELATIONSHIP BETWEEN RISK FACTORS AND PREVALENCE OF MUSCULOSKELETAL DISORDERS IN THE LOWER BACK

Binary regression test for the lower back (Appendix 6), showed that age, work experience and height are significant risk factors ($p<0.05$) respectively. Education, marital status and weight, showed no significant relationship ($p>0.05$) respectively, with the prevalence of MSDs in the lower back.

4.3.4 RISK FACTORS ARISING FROM JOB DESIGN AND WORKPLACE IN THE DEVELOPMENT OF MUSCULOSKELETAL DISORDERS AMONG JACKHAMMER OPERATORS

Ninety-three percent of the respondent's understudy confirmed that working overtime caused MSDs, 96% of the jackhammer operators agreed that drilling for over 1 month causes MSDs, and 89% verified that working in awkward postures, also causes MSDs. For housekeeping activities, 84 % and 82% of operators respectively agreed that bench dressing and offloading drilling equipment cause MSDs, (Table 4.2).

Table 4.2. **Job design and workplace risk factors for the development of MSDs**.

Risk factor question	**Participant response** ***(%)***	
	Agree	**Disagree**
Drilling for over 1 month cause MSDs	96	4
Awkward posture cause MSDs	89	11
Bench dressing cause MSDs	84	16
Offloading and loading drilling equipment cause MSDs	82	18
Working over-time cause MSDs	93	7

4.3 CONTRIBUTION OF WORKING POSTURES TO DEVELOPMENT OF MUSCULOSKELETAL DISORDERS AMONG JACKHAMMER OPERATORS

Posture for drill stick alignment, (fig 4.3) and posture for drilling, (fig 4.4), had high scores of thirteen and eleven respectively, (fig 4.5).

Figure 4.3: Drill stick alignment posture

Figure 4.4: Drilling posture

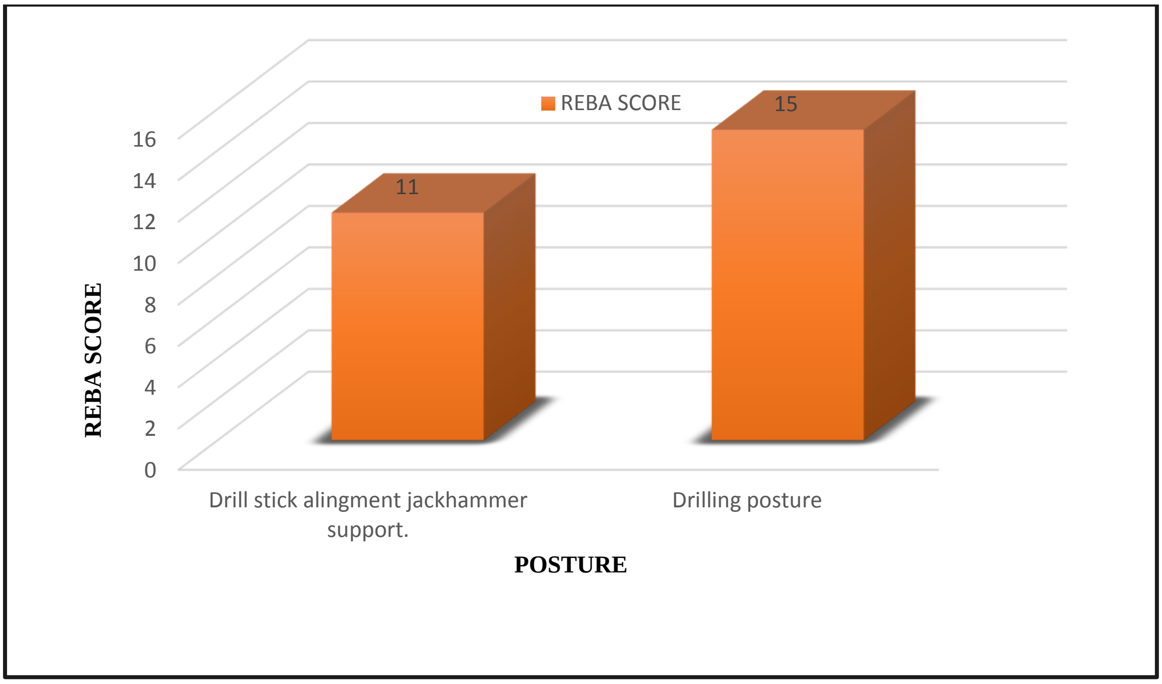

Fig 4.5 **REBA assessment for jackhammer operators at Chifen Quarry Mine.**

CHAPTER 5: DISCUSSION

5.1 INTRODUCTION

This chapter presents a discussion on the findings of the present study on the prevalence of MSDS, in relation to other studies in the same field of ergonomics, to help validate and support the findings of the study. In this chapter, prevalence of musculoskeletal disorders, risk factors of musculoskeletal disorders as well as working postures leading to the development of musculoskeletal disorders are discussed.

5.2 PREVALENCE OF MSDs AMONG JACKHAMMER OPERATORS

The prevalence of musculoskeletal disorders was high in the upper limb region (76%), than in the lower limb region (39%). The high prevalence of musculoskeletal disorders in the upper limb region is in line with the findings by Häkkänen et al (2001), which showed a high prevalence in the upper limb than in the lower limb, due to high workload and awkward postures. High work load and awkward posture cause lower and upper back pain due to muscle straining in the trunk region as stated by Singh et al (2011). The wrists had the second highest prevalence in the upper limb region, as a result of operating the jackhammer without hand gloves. These results are similar to that of a study by Singh et al (2011) where wrist illnesses were more prevalent in jackhammers without hand gloves, than in jackhammer operators who wore hand gloves. In a study by Häkkänen et al (2001), wrists were the most affected body region due to continuous exposure to vibration and high grip pressure caused by handling heavy jackhammers (90 lb). The lower limb region had the least prevalence of 39%, 35% and 23% MSDs complaints about the hips, knees and ankles respectively. These results are in line with the findings by Pilling (1997), where it was attributed to working on unstable ground and prolonged static postures, which mostly affected the lower limb.

Prevalence of MSDs is not limited to one risk factor as shown in a study by Rik et al (2000), where prevalence of MSDs was due to a combination of different risk factors at play. Therefore the impact of risk factors vary with individual fitness, working environment and tasks. More detail on the varying impact of risk factors in the development of MSDs is discussed in the following section.

5.3 ERGONOMIC RISK FACTORS AMONG JACKHAMMER OPERATORS.

The highest prevalence of musculoskeletal disorders was in the lower back, upper back and wrists. Binary regression tests for the upper and lower back showed that age was a significant risk factor in the development of musculoskeletal disorders of the lower back, upper back and wrist/hands. Most MSDs complaints came from jackhammer operators within the age range of 50-60 years. These results are line with the findings by Richards (2012) which showed that older individuals (50-60 years) at a work place are at a higher risk of developing MSDS than younger workers (20-40 years). Susceptibility to MSDs as one ages, is due to the degeneration of articular joints as stated in a study by Richards (2012). Work experience was a significant risk factor for the development of musculoskeletal disorders in the lower back, upper back and wrist/hands. This can be attributed to prolonged exposure to vibration as stated by Viera (2009). The higher the period of exposure to vibration the greater the susceptibility of developing MSDs (Viera, 2009). The significant relationship between work experience and development of musculoskeletal is also supported by McCauley (2012), where results showed a high rate of sick leave on disorders of the upper limbs recorded more for experienced workers than new workers. Height was a significant risk factor for MSDs development. These results are in line with the findings by Vieira (2009) which showed a significant relationship between height and the development of MSDs in jackhammer operation. Educational level, marital status and weight had no significant relationship with the prevalence of MSDs in the lower back, upper back and wrists/hands respectively. These results differ from findings by Singh et al. (2011) where there was a significant relationship between educational level and the prevalence of MSDs, because of varying mental abilities to understand and apply ergonomic training principles during work. From the survey, it was reviewed that 93% of the understudy respondents confirmed that working overtime causes MSDs, 96% of the jackhammer operators agreed that drilling for 1 month causes MSDs and 89% verified that vibration and working in awkward postures cause MSDs. This is supported by Singh et al. (2011)where results showed an association between heavy physical work and the development of musculoskeletal disorders.

5.4 WORKING POSTURES OF JACKHAMMER OPERATORS

A Rapid Entire Body Assessment resulted in very high scores of 15 and 13 for the drilling posture and the drill stick alignment posture, respectively. According to the REBA worksheet, appendix 3. Both postures scored high because they were awkward postures sustained for long, in addition to that, drilling activity was done on the unstable ground due to vibration and overlapping boulder arrangement. These scores for both postures contributed to the development of musculoskeletal disorders mostly in the lower-limb region.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 SUMMARY

The present research aimed at investigating the prevalence of work-related musculoskeletal disorders and their risk factors among Jackhammer operators, at Chifen Quarry Mine. The objectives were to determine the prevalence of MSDs, the risk factors of developing MSDs and ascertaining the working postures contributing to MSDs development among jackhammer operators at Chifen Quarry Mine.

6.2 CONCLUSION

There was a higher prevalence of MSDs on the upper limb compared to the lower limb due to high workload resulting in upper and lower back MSDs. The high workload was a result of weighty jackhammers and working overtime. Prolonged exposure to hand-arm vibration caused a high prevalence of MSDs in the wrists/hands. In addition to posing the risk of developing chronic illnesses, MSDs experienced did not only cause absenteeism at work but also resulted in monetary expenses on medical visits. The association of risk factors with the development of musculoskeletal disorder showed that age and work experience were the highest demographic risk factors. On postural analysis, the jackhammer alignment and drilling postures scored high on the REBA worksheet due to the weight of the jackhammer and unstable ground and mostly that jackhammer operators worked in awkward postures.

Risk refers to the probability and severity of unwanted events happening and according to ISO 31000, effective risk management prioritise addressing factors that increase the probability rather than the severity of a risk. Therefore recommendations in the following section aim at lessening the probability of ergonomic risks on jackhammer operators at Chifen Quarry Mine, and the recommendations are in line with the hierarchy of hazard control.

6.3 RECOMMENDATIONS

In light of the research findings, the following recommendations were drawn:

- Install shock absorbers on jackhammers to minimise vibration intensity.
- Substitute hydraulic (90 lb) jackhammers with pneumatic jackhammers (60 lb).
- Recruit jackhammer operators within the range of 20-35 years of age for contracts not longer than 2 years, to minimise the severity of MSDs that comes with increased age and experience.
- Set production targets that can be met without the need to work overtime. This is to minimise workload and comply with the Labour Act provision for ensuring a safe working environment.
- Use an excavator to lay boulders in a non-overlapping manner, for a stable ground before drilling activity to reduce the high REBA score to medium.
- Update the risk register with the recommendations above as per ISO 45000 guidelines. Documentation allows evaluation of the recommendation to give room for continual improvement.
- Wear hand gloves to minimise the intensity of vibration transmitted to the hands and arms.

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Appendix 1: Slovin Formula For Determining Sample Size.

The Formula for sample size: n = $N/1 + N(e)^2$………………………………….. (1)

Where:

n= sample size to be studies

N= Population size

e=margin of error

Appendix 2: Research Questionnaire

I am Omega Chihure, a BSc Student in Safety Health and Environmental Management at Bindura University of Science Education. I am currently undertaking research on the prevalence of Work-Related Musculoskeletal Disorders (WRMSDs) among jackhammer operators. This questionnaire seeks to gather information concerning my research topic. Participation in this research is by voluntary consent and participants have the right to withdraw their participation at any time for any reason without the need to explain their withdrawal.

The information provided by the respondents is for academic purposes and will be used to assess the prevalence of WRMSDs in jackhammer operation. Participation is purely voluntary and the researcher is unable to provide any material benefits such as monetary payments for participating in this study. More so, your views shall remain confidential and anonymous. Kindly, assist by going through the questionnaire and providing responses. Thank you in advance for your co-operation.

SECTION A: DEMOGRAPHIC INFORMATION

i. Age in years ……………

ii. What is your weight in kilograms ……………

iii. What is your height in metres …………….

iv. What is your level of education?

☐ Primary

☐ Secondary

☐ Tertiary

v. What is your marital status ☐ Single ☐ Married

SECTION 2: CAUSAL FACTORS

i. What is your job experience in years …………………
ii. What are your daily working hours ………………….
iii. What are your weekly working hours …………………
iv. How many hours do you work without a break …………………
v. How many breaks do you take during your shift …………………
vi. How long do you break ...……………….
vii. Do you usually work overtime (Yes/No) …………………

If your answer on (vii) is YES,

how often do you work overtime ……………………..

viii. How would you rate your workload

☐ Low

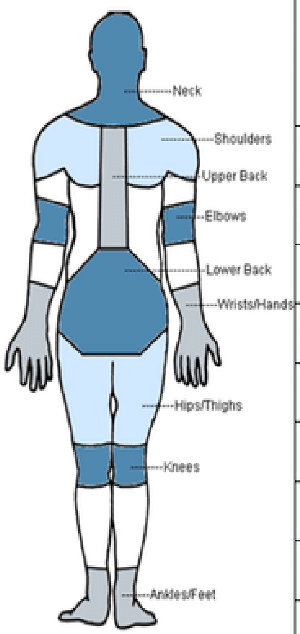
☐ Average

☐ High

ix. Please Tick Where Applicable

Dynamics	Agree	Disagree
Drilling for over 1 month cause MSDs		
Awkward posture cause MSDs		
Bench dressing cause MSDs		
Offloading and loading drilling equipment cause MSDs		
Working overtime cause MSDs		
Lack of hand gloves intensifies vibration transmission to your body		

SECTION C: WRMSDs EXPERIENCE



Have you at any time during the last **12 months** had trouble in:			Have you at any time during the **last 12 months been prevented from doing your normal work** because of the trouble?		Have you had trouble at any time during the **last 7 days?**		Have you ever hurt your body part in an **accident**?		What is the **total length of time** that you have had trouble during the last 12 months?				Have you been **seen by a doctor** because of trouble during the last 12 months?	
									1-7 days	**8-30 days**	**More than 30 days**	**Everyday**		
Neck	YES	NO	YES	NO	YES	NO	YES	NO					YES	NO
Shoulders	YES	NO	YES	NO	YES	NO	YES	NO					YES	NO
Elbows	YES	NO	YES	NO	YES	NO	YES	NO					YES	NO
Wrists/Hands	YES	NO	YES	NO	YES	NO	YES	NO					YES	NO
Upper back	YES	NO	YES	NO	YES	NO	YES	NO					YES	NO
Low back	YES	NO	YES	NO	YES	NO	YES	NO					YES	NO
Hips/Thighs	YES	NO	YES	NO	YES	NO	YES	NO					YES	NO
Knees	YES	NO	YES	NO	YES	NO	YES	NO					YES	NO
Ankles/Feet	YES	NO	YES	NO	YES	NO	YES	NO					YES	NO

Appendix 3: Postural Analysis Tool: Rapid Entire Assessment Worksheet.

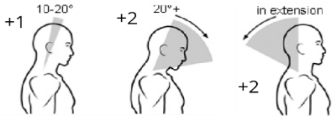
ERGONOMICS PLUS

REBA Employee Assessment Worksheet

Task Name: Date:

A. Neck, Trunk and Leg Analysis

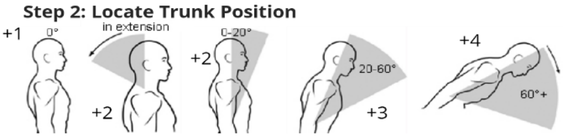
Step 1: Locate Neck Position



Neck Score

Step 1a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

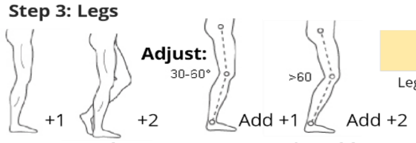
Step 2: Locate Trunk Position



Step 2a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

Trunk Score

Step 3: Legs



Leg Score

Step 4: Look-up Posture Score in Table A
Using values from steps 1-3 above,
Locate score in Table A

Posture Score A

+

Step 5: Add Force/Load Score
If load < 11 lbs. : +0
If load 11 to 22 lbs. : +1
If load > 22 lbs.: +2
Adjust: If shock or rapid build up of force: add +1

Force / Load Score

=

Step 6: Score A, Find Row in Table C
Add values from steps 4 & 5 to obtain Score A.
Find Row in **Table C**.

Score A

Scoring
1 = Negligible Risk
2-3 = Low Risk. Change may be needed.
4-7 = Medium Risk. Further Investigate. Change Soon.
8-10 = High Risk. Investigate and Implement Change
11+ = Very High Risk. Implement Change

Scores

Table A	Neck	1				2				3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk Posture Score	1	1	2	3	4	1	2	3	4	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

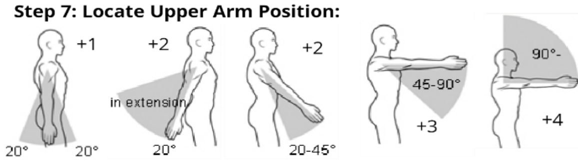
Table B	Lower Arm	1			2		
	Wrist	1	2	3	1	2	3
Upper Arm Score	1	1	2	2	1	2	3
	2	1	2	3	2	3	4
	3	3	4	5	4	5	5
	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
	6	7	8	8	8	9	9

Score A	Table C: Score B 1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

Table C Score + Activity Score = REBA Score

B. Arm and Wrist Analysis

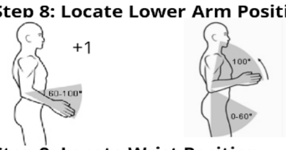
Step 7: Locate Upper Arm Position:



Step 7a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

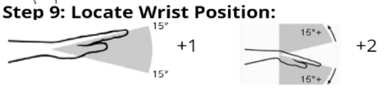
Upper Arm Score

Step 8: Locate Lower Arm Position:



Lower Arm Score

Step 9: Locate Wrist Position:



Wrist Score

Step 9a: Adjust...
If wrist is bent from midline or twisted : Add +1

Step 10: Look-up Posture Score in Table B
Using values from steps 7-9 above, locate score in Table B

Posture Score B

+

Step 11: Add Coupling Score
Well fitting Handle and mid rang power grip, ***good: +0***
Acceptable but not ideal hand hold or coupling acceptable with another body part, ***fair: +1***
Hand hold not acceptable but possible, ***poor: +2***
No handles, awkward, unsafe with any body part, ***Unacceptable: +3***

Coupling Score

=

Step 12: Score B, Find Column in Table C
Add values from steps 10 &11 to obtain Score B. Find column in **Table C** and match with Score A in row from step 6 to obtain Table C Score.

Score B

Step 13: Activity Score
+1 1 or more body parts are held for longer than 1 minute (static)
+1 Repeated small range actions (more than 4x per minute)
+1 Action causes rapid large range changes in postures or unstable base

Original Worksheet Developed by Dr. Alan Hedge. Based on Technical note: Rapid Entire Body Assessment (REBA), Hignett, McAtamney, Applied Ergonomics 31 (2000) 201-

Appendix 4: Binary Regression test for the wrists/hands.

Binary Regression Test

Variables in the Equation

		S.E.	df	Sig.
Step 1[a]	Age	.347	1	.001
	Weight	.468	1	.348
	Height	.913	1	.002
	Education(1)	.843	1	.999
	Marital(1)	.948	1	.276
	Experience	.527	1	.010
	Constant	1.464	1	.186

Appendix 5: Binary Regression Test for the Upper Back

<u>Binary Regression Test</u>

Variables in the Equation

		S.E.	df	Sig.
Step 1[a]	Age	.304	1	.001
	Weight	.480	1	.291
	Height	.826	1	.003
	Education(1)	.843	1	.999
	Marital(1)	.902	1	.438
	Experience	.835	1	.001
	Constant	1.639	1	.030

a. Variable(s) entered on step 1: Age, Weight, Height, Education, Marital, Experience.

Appendix 6: Binary Regression Test for the Lower Back

Binary Regression Test

Variables in the Equation

		S.E.	df	Sig.
Step 1[a]	Age	.347	1	.001
	Weight	.468	1	.348
	Height	.913	1	.002
	Education(1)	.843	1	.999
	Marital(1)	.948	1	.276
	Experience	.527	1	.010
	Constant	1.464	1	.186

a. Variable(s) entered on step 1: Age, Weight, Height, Education, Marital, Experience.