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Assessment of Rapid Entire Body Assessment (reba) and Rapid Upper Limb Assessment (rula) applicability in ergonomics risk assessment. Case study ZPC Hwange expansion project Sherwood Block

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DECLARATION

I, Mugwagwa Tapiwa T, 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 at any other university. I am responsible for this research and its articulation alone. In no way do any of the individuals mentioned in the acknowledgement bear any direct responsibility for this work.

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

To be completed by the supervisor

This dissertation has been examined for conformance and is approved for submission to the faculty.

Supervisor Signature…………………………………. Date……………………

DEDICATION

To my beautiful family, the Mugwagwa and Nyanyiwa families, and fellow earth inhabitants, this is for you.

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ABSTRACT

Assessment of rapid entire body assessment (REBA) and rapid upper limb assessment (RULA) applicability in ergonomic risk assessment A fundamental understanding of ergonomic hazards at work is essential for preventing work-related musculoskeletal injuries. A descriptive cross-sectional study was used in this research. A sample consisting of 112 workers from Synohdro Company, from the 5 main departments: bricklaying, carpentry, concreting workers and scaffolding, participated in answering semi-structured questionnaires to determine the prevalence of muscular-skeletal disorders (MSDs) and were selected for postural analysis using the Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA) of the Statistical Package for Social Sciences (SPSS). The majority of the subjects—100 out of 112 (89.29%)—reported having aches, pains, or body discomfort in various parts of their body, indicating a high prevalence of work-related MSD symptoms. What follows is a summary of the survey that was made on site: back pain 65%, neck pain 25%, shoulder pain 55%, upper back 23%, wrist and hand 15%, knees 20%, and ankles and feet 8%. RULA and REBA tools were both easily and effectively applicable for postural risk assessment at Sherwood B, having the advantage of being more versatile and less expensive in terms of time. Both RULA and REBA allow for the calculation of a numeric index that represents the quantitative value of the risk to which the worker is exposed during the target work, as well as the determination of the priority level of interventions and actions required. The higher the congruence between the RULA and REBA evaluations, the more they confirmed similar results from other investigations in the industries.

Keywords: Prevalence, Work-Related Musculoskeletal Disorders, RULA, REBA, 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

MSDs =Musculoskeletal Disorders

HSE =Health Safety and Environment

CHAPTER 1

1.1 INTRODUCTION

The construction sector represents about 10% of global Gross domestic product 6-8% in industrialized nations and employs roughly 253 million people across the globe, and 7% of the global labour force. Kumar and Gopalakrishnan (2020. The production of the global construction industry was predicted to be approximately $ 13 billion in 2017. Gopalakrishnan, E., & Palinka, I. (2018). However, the construction industry is regularly ranked as one of the riskiest jobs that have a severe influence on health. (Boschman et al., 2012) Construction workers might be subjected to a variety of adverse outcomes and develop health issues as a consequence of their working situations or personal habits and lifestyles. Gopalakrishnan & Kumar (2020) Compared to other occupations; construction workers had 50% greater back injuries. Tal et al. (2013) One or more MSD-related symptoms were self-reported by roughly 46% of construction workers. With the continuous proliferation of construction projects, building employees appear to be consistently exposed to unfavourable ergonomic issues of their large variety of responsibilities. Van der Beek et al. (2020). Previous studies have indicated that in this area of work, back, shoulder, neck, arm, and hand discomfort are prevalent difficulties. (Chakravarthy et al., 2015) The latest literature shows that construction employees have nearly twice more work-related injuries and illnesses across all other industrial workers. Lee S., et al. (2015) However, practically all ergonomics-related accidents as well as ailments in the construction business are avoidable only if suitable evaluation tools are employed on the relevant job to adopt good, sound ergonomic measures, according to Proksch T. (2012).

To be sure, steps have been taken in identifying the causes of musculoskeletal disorder through adherence to these standards for individual, biomechanical, and psychological and social work parameters, and also the engagement of the institution and level of professional area or task design on accident possibility over the last two decades. Tal et al. (2013) There are several concepts and approaches based on field observation that may be used to evaluate construction activities among these are the Quick Exposure Check, Rapid Upper Limb Assessment, Rapid Whole-Body Assessment, Ergo Check (Inyang et al 2018), and OVAKO Work Posture Analysis System (Li et al 2018). It is crucial to pick the correct tools for each analysis. Utilizing the proper tools for the job can help identify workplace risks and a worker's musculoskeletal load, which will increase the likelihood that musculoskeletal ailments will be prevented. Denice, E., & Palinka, I. (2018) There are numerous sorts of instruments that may be used to perform ergonomics assessments; hence, it is vital to pick the correct tools for each study. Some aspects, such as the tools' analyst competence, the job being analysed, the tools' features, and the data required from the analysis, need to be examined to pick the proper ergonomics analysis tools. Denice, E., & Palinka, I. (2018). These techniques might well be classified into personality, observational, and direct measurements

The above tools range in their stages of evaluation and also vary considerably in the body segment they measure as well as the sorts of labour activities users concentrate on (Hussain et al. 2016). Observation methods are susceptible to their typical constraints, and the drawback of these techniques is also that they merely categorize workload classifications and frequently do not properly depict the complex nature of working practices, particularly three-dimensional motions such as torsion and lateral bending of the spine and appropriate evaluation of the workload sequence and relaxation time. (Hussain et al. 2016) The ergonomic evaluation approaches were developed with a particular collection of risk observation criteria in mind. Each part of an activity may not contain all the exposure variables. Hence, a method may not be suited for the ergonomic evaluation of all labour factors. Stal et al. (2013). It's also crucial to understand and comprehend all of the assessment instruments prior to actually advancing to the assessment. Various kinds of equipment analyse different bodily parts. Some people evaluate the entire body, while others just evaluate the top half. Others separately inspect the back, upper, and lower limbs (Hussain et al. 2016). REBA, OWAS, and ROSA are common full-body ergonomics examinations, and all three are part of static load. (Chakravarthy et al., 2015) The static load may be described as employees sustaining the very same stance for a prolonged period throughout their job, and it seems to be one of the elements that contribute to raising the risk of developing musculoskeletal diseases. (Chiasson, 2012)

RULA is another piece of equipment utilized in measuring constant force, but it is more suited to upper-limb assessments. (2015) Chakravarthy et al. Each evaluation technique has its usefulness, and it will undoubtedly operate and accomplish its aim given that it has been applied in the appropriate manner. In order to achieve decent and more precise results for every work activity, the aspects of picking tools are highly significant and have to be examined each time before the onset of the assessment. Tal et al. (2013) As a result, a selection process for ergonomic assessment tools has been developed to assist one in selecting an appropriate tool for assessing purpose with ease. Using the proper instruments on the right job task will aid in identifying the job risk and a worker's biomechanical load, which will lead to the ability to minimize the incidence of musculoskeletal diseases (MSDs). Denice, E., & Palinka, I. (2018)

The implementation of ergonomic evaluation tools has already been done in a diversity of industries, and comparisons of the outcomes of every approach have been made. Stal et al (2013) Several techniques have been developed nowadays to anticipate and evaluate the threat variables influencing the incidence of musculoskeletal illnesses. 2016 (Hussain et al.) Each approach takes into account several variables, such as the various states of the body's departure from its natural posture, repetitive motions, pressure exertion, period, in addition to other environmental and personal variables. (Hussain et al. 2016) These techniques may typically be divided into three categories: self-report, observation, and direct measurements. Observational methods are among the most popular because they are easy to use, adaptable, and affordable to adopt. (Chiasson, 2012). The approaches indicated above are among the ones that are often employed in ergonomic evaluation. Additionally, no research has been done yet to determine the most accurate way to forecast the likelihood of musculoskeletal problems in the construction industry. (Hankook & Chemehuevi, 2013) Therefore, the current study sought to evaluate the applicability of REBA and RULA in ergonomic risk assessment in the construction industry.

1.2 PROBLEM STATEMENT

Musculoskeletal injuries continue to be a key origin of disability and higher absenteeism in the construction industries globally, with the prevalence rate varying from 15% to 69% (Feng B et al., 2014).Globally ergonomic issues are a major threat facing many industries at their workplaces (Hussain et al 2016) Leading research like Obi's (2015) has proven that construction workers in Africa are exposed to a relatively high degree of safety concerns, underscoring the unpopularity of ergonomic design and inputs in the workplace.

Since the time of the introduction of RULA and REBA, studies showed their value for postural assessments of jobs in several occupational settings, including construction, supermarket workers, clothing manufacturing, assembly, rubber and sugar industry, firefighters and emergency medical technicians, sawmills and hospitals. (Proksch, T. 2012) However very few studies have been done to test and prove the applicability of this tools in the construction industry particularly in Zimbabwe, therefore the study will focus on assessing the applicability of REBA and RULA in evaluating ergonomic effects. Although in principle, REBA and RULA are effective and efficient assessment tools, if not utilized with care and cognizance, the obtained results can be simply wrong, resulting in erroneous decision making, practically inapplicable. Buckle and Li (2018)

It is of concern to notice that over 70 percent of complaints reported during safety conversations from 2020–2021 September was connected to work-related diseases, which can be related to MSDs. The local clinic acknowledged that physical illnesses that may be connected to work were widespread. "They begin with very little pain in the initial stages." These signs go away after a brief break or at bedtime when you don’t work. However, the symptoms return the next day when you engage in the same activities (Mavis et al., 2014). This indicates that there is a shortfall in the system for implementing ergonomics. It is in this context that our study at Sherwood B tries to shed further light on ergonomics.

1.3 OBJECTIVES

- To determine if reports of or complaints about ergonomic illnesses are related to the type of job being done or exposure to risk factors.
- To assess REBA and RULA’s applicability in ergonomic risk assessment at Sherwood B

1.4 RESEARCH QUESTIONS

- Which duties need one to work in an awkward position??
- How common are musculoskeletal illnesses among Sherwood B employees??
- Are there strategies to lessen musculoskeletal disorders??

1.5 JUSTIFICATION

Working in the construction industry exposes workers to a variety of ergonomic risk factors, including awkward postures, static force, vibration, repeated, environmental risk, and contact stress (Proksch, T. 2012). These factors all increase the likelihood that workers will experience musculoskeletal disorders. (Inyang et al 2018) In different businesses, ergonomic risks, effects, and risk factors have been evaluated, assessed, and identified using a variety of ergonomic techniques. Denice, E., & Palinka, I. (2018) This study will measure the applicability of RULA and REBA in the construction industry. The applicability will be measured by the ability of the tools to identify all ergonomic risk factors and their impacts about MSDs. In addition, this research will allow for measuring the ergonomic risk factor detection level of these tools according to the data that has been gathered by other researchers on similar grounds. (Chakravarthy et al., 2015) This study will aid with site-based solutions to ergonomic challenges appearing in the construction industry, mostly in developing regions. This research will present a fundamental review of ergonomic risk factors, aim to establish control strategies for preventing accidents that are probable to happen in the future, and provide complete monitoring to reduce and avoid such risk factors. Denice, E., & Palinka, I. (2018) The research might highlight training needs with respect to the system. The research is relevant to ZPC management, as it will assist in analysing and enhancing the SHEQ management systems, as well as those of its sub-contractors, and might potentially contribute to proposed plans to improve ergonomic assessment in the organization as well as in other companies.

CHAPTER TWO: LITERATURE REVIEW

2.1 ERGONOMIC RISK FACTORS INVOLVED IN CONSTRUCTION INDUSTRY

Ergonomics awareness is critical in ensuring the least risky and safest workplace for workers; however, ergonomics is still a non-issue across many building projects Hankookb & Charehzehi, 2013). It could, however, be different given that the fundamental goal of ergonomics is to improve working environments and working conditions in a manner that "humanizes" working life by eliminating drudgery, decreasing physical and mental stress, and promoting initiative, creativity, self-esteem, and a sense of reward for effort. (Scott et al. 2013). Previous research has demonstrated that using ergonomic principles improves the standard of labour. The main benefit of ergonomics is that it makes work environments better for employees and encourages productivity and high-quality output. This has also been explored by Ismaila (2014), who argues that ergonomics determines the human features, limits, capacities, and wants that are required for work design, boosting human efficiency and workers' safety. Physical and environmental aspects are included in the field of ergonomics. The task, environment, and design of the job must all take the employee's skills and requirements into consideration. (Shruti 2012) According to past research, poor ergonomics has been connected to occupational musculoskeletal illnesses. Any harm to the human support system—including the joints, tissues, muscles, ligaments, tendons, blood vessels, and nerves—due to exposure to hazards at work is referred to as WMSDs (Asante 2012).

The typical demands of construction work include adopting unnatural positions, lifting heavy objects, manually moving heavy objects of varying sizes, frequently bending and twisting the abdomen, working above shoulder height, working below knee level, remaining still for extended periods of time, climbing and descending, and pushing and pulling loads. Risk factors listed by Ajayi O et al. (2015) include awkward postures, lifting heavy objects, handling heavy and irregular-sized loads by hand, frequently bending and twisting the body, working above shoulder height, working below knee level, remaining still for an extended period of time, climbing and descending, and pushing and pulling loads. Ajayi O et al. (2015) describe risk factors as "activities or situations that raise the potential for damage to the musculoskeletal system." It is unclear how risk factor exposures affect the likelihood of suffering a musculoskeletal injury. Physical risk factors are important first-line risk factors, but there are other likely components, such as organizational and behavioural factors, that might result in a disease or subtly change the impact of physical risk factors. In addition, no two individuals who are exposed to the same combination of risk factors to the exact magnitude will react to them in the same way.

Several studies suggest that ergonomic risk factors are a significant source of musculoskeletal issues in the workplace. Repetition, high pressure, as well as inappropriate postures, are frequently viewed as the most significant ergonomic risk factors in the workplace. A complete examination of the literature, however, suggests that there are no criteria for repetition, force, or posture for ergonomic job analysis. Francis, J. R., & Deepan, G. (2019). Ergonomic risk factors can come from workstations, tools, equipment, work processes, work environments, worker personal characteristics, metabolic needs, physical stress, and emotional stress. Francis, J. R., & Deepan, G. (2019). Because there is evidence that these risk variables are directly associated with lower back and upper extremity musculoskeletal problems, recognizing ergonomic risk factors is essential. The risk elements were divided into administrative risk elements, environmental risk elements, health-related risk elements, and other risk elements. S. Baskar et al. 2018

2.2 REPETITION

Repetition rate, as defined by N. Jaffar et al. (2014), is the average number of motions or exertions carried out by a joint or a body link inside a period of time, or doing identical motions with the same body part with minimal rest or recovery. Repetition can also be described as excessively conducting the same movement or collection of gestures or exertions performed by a joint or a body link within a unit of time or performing comparable motions with the same part of the body with little rest or recuperation. Repetition is also classified as excessively conducting the same movements or collection of motions. A large number of existing studies support the idea that repetition entails completing an activity that engages the same muscles again and again with little time for rest or recovery. Lan der Beek, et al (2020) The survey published in Iran classified repeating tasks as the workers' execution of the same task or activity repeatedly throughout a period without sufficient breaks. M. and A.J. van der Beek (2020), They said that repetitive employment is the main risk factor for MSD, which results in 14% of chronic impairments among construction workers worldwide each year. However, 65% of the time, repeated motions cause discomfort and tiredness of the muscles, ligaments, and tendons. Iavicoli, S. et al. (2018) In a similar line, research has shown that repetition involves repeatedly carrying out tasks or activities with only a specific type of muscle, with little time for rest or recovery. L. M. and A. J. van der Beek (2020)

Due to inadequate staffing, job demands, and a lack of strictly implemented regulations, repeated injuries still affect a variety of construction workers throughout Africa. Peytremann-Bridevaux (2016) As a result of muscular exhaustion, repetitive motion leads to increased accidents at construction sites across the world, including falling incidents. A recent study by Ayaka J et al. (2012) concluded that in poor countries, construction workers are rewarded as per the bricks they place, that results in workers working all through break hours to meet their daily salary objective. Peytremann-Bridevaux, I. (2016). While other risk factors like an awkward posture or heavy force) are prevalent, repetition puts workers at a higher chance of being injured. Repetitive or cumulative injuries, such as tendinitis, are common in jobs that require a lot of repetition (Asante, K. 2012).

2.3 FORCE

A recent study by Lee S. et al. (2015) referred to "force" as the physical or mechanical effort to perform provided activity. Force is the amount of physical effort required to complete a task (like lifting) or to maintain control of tools or equipment. Exerting force on a person or item may overload our muscles and tendons. Lee S., et al. (2015) The force may be applied by pulling, pushing, lifting, or gripping. Furthermore, this same effort that a worker puts into an item is a significant risk. The tendons and muscles could be stressed once you exert a significant force on an item. Iavicoli, S., et al. (2018) A series of recent studies have implied that there are three kinds of activities that demand force, such as the force needed in loading, lowering, or holding, the force implicated in pressing or pulling, and grip force. (Luttmann et al., 2016). Another definition of force is the degree of physical effort required for someone to finish a task or maintain control over tools or equipment. The tendons in the wrist are stressed 3–5 times more by a pinch grasp than by a full-handed hold. Iavicoli, S. et al. (2018): Excessive force causes the muscles to contract much more forcefully than usual, which might put stress on the tendons, muscles, and joints. (Luttmann et al. 2016) Usually, the bigger the force, the higher the extent of the danger. A higher risk of damage to the elbow, neck, low back, arm, wrist, and hand has been linked to the high force. It is important to remember that other labor-related factors, such as posture, acceleration/velocity, repetition, and length, affect the relationship between force and degree of injury risk. Lee S., et al. (2015)

2.4 VIBRATION

As reported by Scott et al. (2013), work-related- related vibration exposure happens when the body is subjected to periodicity, shaking, or muscle spasms usually produced by a vibrating object such as a power hand tool. Vibration is sometimes referred to as a "vector quantity," which denotes that the vibratory oscillation has a detrimental impact in and of itself as well as an aspect of magnitude or intensity. There are two types of vibration exposure: whole-body vibration and hand-arm vibration. (Luttmann et al. 2016) These two kinds of vibration come from distinct places, influence various parts of the body, and manifest as various symptoms. A vibrating hand tool or workpiece that transmits the movement is often what causes hand-arm vibration. (Luttmann et al. 2016). Hand-arm vibration is frequently related to using power tools, according to Goldswain CC et al. (2015). When the hand and arm get vibrations from the tool, exposure occurs. Whole-body vibration is usually associated with standing or sitting on a vibrating object. While vibrations are transferred, often through the feet when standing or the legs and hips when seated. WBV can have an impact on internal organs as well as the overall body. There is considerable evidence that exposing the entire body to vibration might cause harm (often through the legs or hips when riding in a car). Luttmann et al. (2016)

Prior research suggests that vibration severely limits the blood flow to the fingers and hands, which, depending on the vibration prolonged (Luttmann et al. 2016). According to international standards (ISO 2631-1, 2016), vibration causes impacts including harm to different organs as a consequence of their being assailed by high vibration thresholds at relatively low frequencies and failure of body cells due either to sustained resonance or their uptake of high energy vibration. Vibration can cause damage to body organs, which can lead to nerve injuries and ruptured blood vessels that cause internal bleeding (Goldswain CC et al., 2015). Grinders, sanders, and jigsaws are examples of machinery that vibrates mildly. Impact wrenches, carpet extractors, floor polishers, chainsaws, percussive tools, jackhammers, and chipping hammers are examples of machinery that generates a lot of vibration. (Luttmann et al., 2016)

2.5 AWKWARD POSTURE

When doing work-related activities, awkward posture is defined as a substantial departure from the neutral position of the body. According to Scott et al. (2013), a number of research indicate that uncomfortable posture involves reaching, stretching, bending, kneeling, crouching, working with your hands or arms up high, or maintaining fixed positions. A neutral posture is one that is relaxed, with the shoulders down and on the same plane, the arms at the sides, and the upper arm and shoulder regions. Operating while the arms are extended, shoulders drooping, and abducted away from the body restricts the range of motion of these joints naturally, needs greater muscular force, and considerably raises the risk of injury. Scott and others (2013) Strained sitting postures, such as leaning side to side, contorting the skeletal system, bending forward, or sagging, begin as reactions to accommodate for particular job connections but may become routines with time. (Luttmann et al., 2016A higher risk of musculoskeletal issues is associated with posture profile characteristics such as torsos o twist, tilted shoulders, head tilt or rotation, raised elbows, and working with hands close to the face. According to a study by Trevelyan and Haslam (2018), awkward posture is associated with a higher risk of injury. It is a common perception that a joint's risk of harm increases the more it deviates from its neutral position.

2.6 AGE

Previous studies have emphasized that each worker’s capacity to adapt to the external demands of a job is diverse and unique. Everyone is unique, and work has to be created to meet each employee’s strengths. The only way to actually know what staff can accomplish is to examine and assess them based on the underlying criteria. Peytremann-Bridevaux, I., (2016). Age, independent of many other considerations, has been demonstrated to alter humans’ power to work. People's mental and physical well-being deteriorate as they age, resulting in a mismatch between occupational needs and individuals' work capabilities. Luttmann et al. (2016): This mismatch could have serious implications, including higher chances for impairment, occupational injury, ergonomic problems, and poor performance. Peytremann-Bridevaux, I., (2016) According to Luttmann et al. (2016), the occurrence of ergonomic injuries rises as individuals reach their productive years. Most people first encounter back pain by the time they are 35 years old. Once in their working years, the predominance is generally steady. Musculoskeletal impairments constitute one of the most widespread and symptomatic health conditions in middle-aged and elderly people (Luttmann et al. 2016). Aging is associated with a decline in mental and physical well-being. In this line, there is a significant decline in muscle endurance, bone strength, and aerobic capacity, which causes a sharp decline in functional capacity, particularly at the age of 60 and beyond, depending on an individual's lifestyle, body weight, and heredity. Garg et al. (2014)

2.7 ERGONOMIC EXPOSURE ASSESMENT AND ASSESMENT TOOLS

Many techniques have been designed to obtain exposure-risk-associated parameters. Particular strategies were designed to handle some specialized key industries, such as agriculture or the forestry industry. A few of them are generic and can be utilized in almost any industrial area. According to Garg et al. (2014), methodologies were created for measuring vulnerability to ergonomic hazards for practically the full body, including the upper areas of the body such as the back, chin, arms, and forearms. Methods for detecting risk factors and assessing the extent to which ergonomics pose a risk in the environment are critical. The possible hazard of ergonomics could be identified by going through a suitable ergonomics evaluation with various kinds of methodologies or instruments. Deepan, G. (2019). There are numerous sorts of instruments that may be used to perform ergonomic evaluations; hence, it is vital to pick the correct equipment for every study. Several aspects, including the tools' strategist competence, the job being analyzed, the instruments' features, and the required data from the evaluation, must be examined throughout to pick the proper ergonomics evaluation tools. These approaches may be divided into three categories: direct measurements, participant observation, and self-reports (Chakravarthy et al., 2015). These tools differ in their phases of evaluation, the body parts they evaluate, and the kinds of labor duties they concentrate on. Therefore, it is essential to be aware of the instrument before to the evaluation. G. Deepan (2019).

The strategies employ combos of exposure-risk variables their evaluation. A few methods, including the REBA, RULA, and the Ovako, use standardized tables in which the combination of the head, back, arms, and legs positions yields a postural score and denotes the degree of risk associated with the task (Chakravarthy et al., 2015). Approaches used in research papers and the advantages and disadvantages revealed, every single evaluation tool is beneficial in any intervention, but just one evaluation method does not deliver the intended answer; a combination of several techniques should be employed to achieve the ideal outcome. M.N. Cecchini (2013) The combination of RULA and REBA always produces distinct results since both evaluation methodologies differ from each other. M.N. Cecchini (2013)

2.8 REBA

The REBA technique (Hignett et al, 2000) offers an overall scoring rate that incorporates all the parts, such as the trunk, legs, neck, shoulders, arms, and wrists. The point total includes the same additional variables as RULA, plus the quality of the hand coupling. Body postures are watched, and a score is ascertained on the basis of deviations of body parts. REBA has been produced and, for the most part, utilized as a part of medicinal services, and different commercial enterprises (Petriková & Petrik, 2015) have introduced REBA and expressed its utilization to evaluate stances about the dangers of business-related MSD clutters (WRMSDs). REBA is a device that determines MSD dangers by assigning bodies to parts (both upper and lower body parts). Some authors have also suggested that, by defining neutral postures as poses with certain ranges of angle variances of the linked joints as well as categorizing leg stances into four categories, REBA conforms to hugely diverse workstations better than RULA. This can be linked to the fact that RULA was developed in a particular research environment, which renders it inaccurate when used in another context. Petrik and Petriková (2015) According to Iavicoli, S et al. (2018), on the evaluation of hazards at the level of analysis, there is a chance of an assessment mistake as well as misunderstanding. This might be the result of poor knowledge of the task being assessed, a biased judgment, measurement errors, or arithmetic errors. According to the study by D. K. Kushwaha (2015), Rapid Entire Body Assessment offers a quick method for evaluating a variety of operating poses for the possibility of ergonomic issues, that splits the body into various parts. D. K. Kushwaha (2015) also noted REBA's shortcomings, including that it should only be used with the assistance of experts or practitioners. It can occasionally be biased because an analyst chooses which component to take into account.

2.9 RULA

RULA is a research technique applied to be used in the ergonomics evaluation of worksites in which occupational related upper limb abnormalities are reported (Lynn McAnncy et al 2013). This tool was created specifically to assess an individual's upper-limb risk level. This technique computes the final result using 3-score tables and body position diagrams. After the evaluation is complete, the final score will be divided into 4 levels of ergonomic risk severity, with scores 1-2 denoting acceptable posture, scores 3–4 denoting additional research and a potential need for change, scores 5–6 denoting additional research and a potential need for change soon, and scores 7 denoting additional research and the implementation of change (Petriková et al 2015).

According to the study by D. K. Kushwaha (2015), because RULA places a lot of emphasis on posture, it might alternatively be referred to as the "Posture Analysis Technique." RULA is quick and observant, so even someone with no prior understanding of the subject may do this exercise. Additionally, D. K. Kushwaha (2015) was able to pinpoint RULA's limitations, or instances in which it does not apply throughout the complete body. Furthermore, RULA only works well for severe postures that last a short time; in other situations, such as professions involving pressures, recurrence, and extended periods, RULA may overestimate the danger.

2.10 QUICK EXPOSURES CHECK

QEC is a body position approach that integrates the observer's assessment with the employee's replies to closed-ended questions. Q allows for the examination of risk factors for musculoskeletal problems in the back, shoulders, neck, and upper limbs at a job. This method provides a risk index for every targeted site as well as a total score for the entire body. In addition to psychological risk factors and vibration exposure, the examination considers stance motion frequency, exertion, and shift duration. (Chiasson, 2012) It is indeed a new approach that was created for professionals to quantify exposure to the risks of Work-related-related musculoskeletal disorders. This method is demonstrated to be effective for detecting the difference in the exposure both before and following an ergonomic adjustment based on test results. D. K. Kushwaha (2015)

According to research by Chiasson (2012), there are a few benefits to QEC, including the ability to analyze the worker's back, wrist, neck, and shoulder with regard to repetitions. More specifically, risk factors or exposures are determined using a scoring sheet, and the total score is determined by adding up the results of the two high-level exposures and the two low-level exposures, correspondingly. This approach merely serves as a foundation for the consequences of alterations before and after an adjustment, and the outcome may be subjective or wrong. It is insufficient to describe the risk variables. K. Kushwaha (2015)

2.11 NORDIC QUESTIONNAIRE

The NMQ is an objective instrument that is frequently adopted alone or in conjunction with other techniques for assessing MSD and its associated psychosocial and occupational issues. This simple, comprehensive questionnaire, which is widely accepted and verified, detects issues with the head, spine, hips, and limbs (Kahraman et al 2014) It offers 28 questions, some of which are grouped into two distinct parts. The first section referred to as the general section, deals with symptoms that have occurred during the last seven days or 12 months in nine different body parts: the throat, wrists, elbows, arms, upper limbs, lower back, hips/thighs, and knees. The second component, which is unique, refers to symptoms that the individual had seven days earlier in the neck, shoulders, and lower back. In both cases, further details on the employees' qualitative traits, such as their gender, age, nationality, etc., might be advantageous but not necessary for a more accurate evaluation. (Genc, A.; Kahraman 2014). Standardization of the questions, universal recognition, the capability to assess oneself, the ability to recognize symptoms reasonably rapidly, and the possibility to be utilized with enormous populations are all advantages of the NMQ. The instrument is widely used simultaneously with other assessment techniques such as RULA, REBA and OWAS The drawbacks of NMQ include Obligatory responses to the questionnaire, the complexity of assessing the truthfulness of replies, and the difficulty of use in regions that do not use English for errors in interpretation, and recognition. (Petriková & Petrik, 2015) Petriková & Petrik, (2015)

CHAPTER THREE

3.1 STUDY AREA

The research was conducted at Sherwood B substation which is located 15 km off the Harare –Bulawayo Road at 183 km peg. It is located 31kilometers from Kwekwe in Midlands province. It is located at a height of 1169.00m/3835.30 feet, in latitude 18.74° S and longitude 29.78°E. The substation will receive 600MW with another substation such as Insukamini and Marvel.

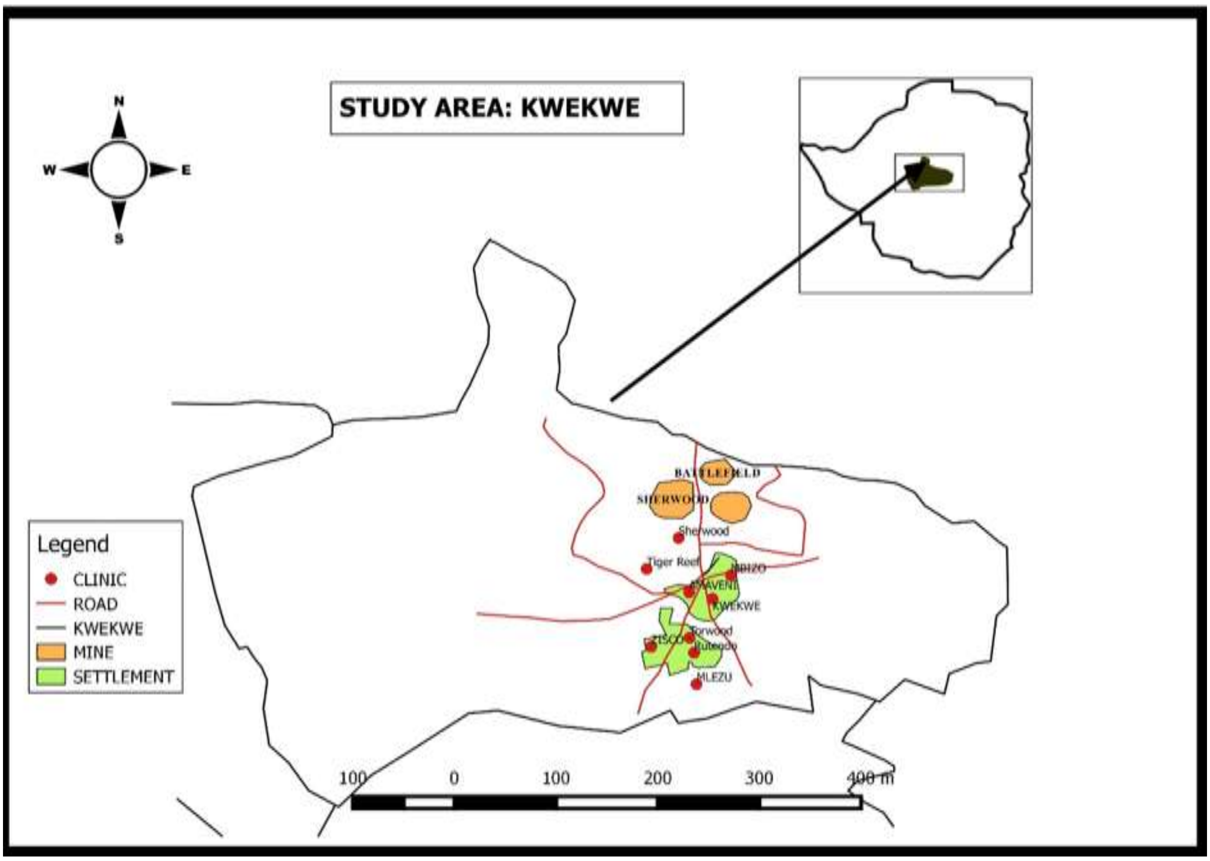

Figure 3.1 Research Area

3.2 RESEARCH DESIGN

A case study design was used for this research. Observational research was carried out. A Nordic standardized questionnaire as well as REBA and RULA assessment sheets were used by the researcher to collect data. Qualitative techniques were used on this research to gather data; the research was carried out based on the primary and secondary data.

3.3 SAMPLE SIZE AND SANPLING PROCEDURE

A sample consisting of 112 workers from Synohdro Company workers from 5 main activities brick laying, carpentry, concreting, scaffolding and welding. A sample of people between the ages of 18 and 60 was chosen for this survey. The population from the purposive sampling frame was then selected using a straightforward random selection procedure, which minimizes the sampling bias that may render the study inadmissible.

3.4 DATA COLLECTION METHODS AND TECHINIQUES

A Nordic Standardized Questionnaire was used in this research. Body posture evaluation by using both RULA and REBA for different workers while performing different tasks.

3.5 NORDIC STANDARDZIED QUESTINNAIRE

The questionnaire asked for demographic information, personal information, employment history, whether or not the respondent had had musculoskeletal pain in the previous 12 months, the afflicted body areas, and the level of discomfort. The researcher used it in the screening of musculoskeletal disorders, which are most prevalent at Sherwood B. A body map that highlights nine symptom sites—the shoulder, neck, upper limbs, elbows, low back, forearm, thighs, knees, and ankles—helps with completion.

3.6 RULA

The researcher observed and awarded the RULA scores to participants while they were doing their daily jobs. This tool was created specifically to assess an individual's upper-limb risk level; it includes wrist, arm, legs, trunk, and neck analysis

There are three steps to the RULA use approach. which is stage 1- 1st stage is related to selection and observation of posture which are to be evaluated, stage 2- 2nd stage is to score and record the selected stance and stage 3- 3rd stage is to determine the action to be taken.
Final Score:

Scoring:

1 and 2 indicate tolerable posture.

3 or 4 indicate that more research or a change may be required.

5 or 6 Implies further research, shortly to alter

7 = Examine and bring about change

3.7 REBA

The researcher observed and awarded the REBA scores to participants while they were doing their daily jobs. This instrument was particularly created to evaluate the individual's entire body's risk level.

REBA employs a six-stage technique.
1st stage is to watch task performed by the worker. 2nd stage is to select the postures which are deemed to be at risk ,3rd stage is to score the postures as per the REBA sheet, 4th stage is to evaluate the scores, 5th stage is to build up score. The final stage is to select the action plan as per the scores.
Finding Score:

1 indicates negligible danger

2 or 3 = minimal risk, alteration may be required4 to 7 Indicates medium danger; additional research; modification to be done

8 to 10 indicate considerable danger; conduct research and make changes.

11+ = extremely high risk; bring about change

3.8 RELIABILTY AND VALIDITY OF VALIDITY OF RESEARCH

The researcher pre-tested the questions before running the real data in order to assess whether they were acceptable to the respondents and to make sure that only relevant information was included in the questionnaire. This improved the reliability and validity of the data obtained. To increase validity, randomizing families was also used. The symmetric validity of RULA was developed with the referenced premise (REBA). REBA was anticipated to be used for straightforward applications without the need for an enhanced extent in ergonomics or costly rigging. After accumulating and assessing the data for each site, the evaluator assigned a score for each of the going-with-body districts: wrists, lower arms, elbows, shoulders, neck, trunk, back, legs, and knees. The danger factor is then evaluated using tables on the structure, yielding a single score that accounts for the MSD level. REBA and RULA are assumed reliable and valid since they are international recognised.

3.9 ETHICAL CONSIDERATION

Permission was obtained from the Synchro worker's committee and ZPC HEP to carry out the study. Neither titles nor any identifying details were enclosed in the questionnaire. Answering the questionnaire was deemed as an agreement to take part in the study, which was voluntary.

3.10 DATA PRESENTATION AND STATISTICAL ANALYSIS

Excel 2007 was used to create the initial database entry. SPSS 22.0 Software was used for the statistical analysis (SPSS, IBM Inc.). Age-related descriptive statistics were computed, encompassing percentages, means, medians, and standard deviations. Chi-square tests were used to analyze the prevalence differences at a statistical significance threshold of 0. 05. For a better understanding of the study subject, the data were categorized and displayed in graphs and tables after collection. Panneerselvan (2014).

CHAPTER 4: RESULTS

4.1 AGE DISTRIBUTION OF THE WORKERS TO THE NORDIC QUESTIONNAIRE

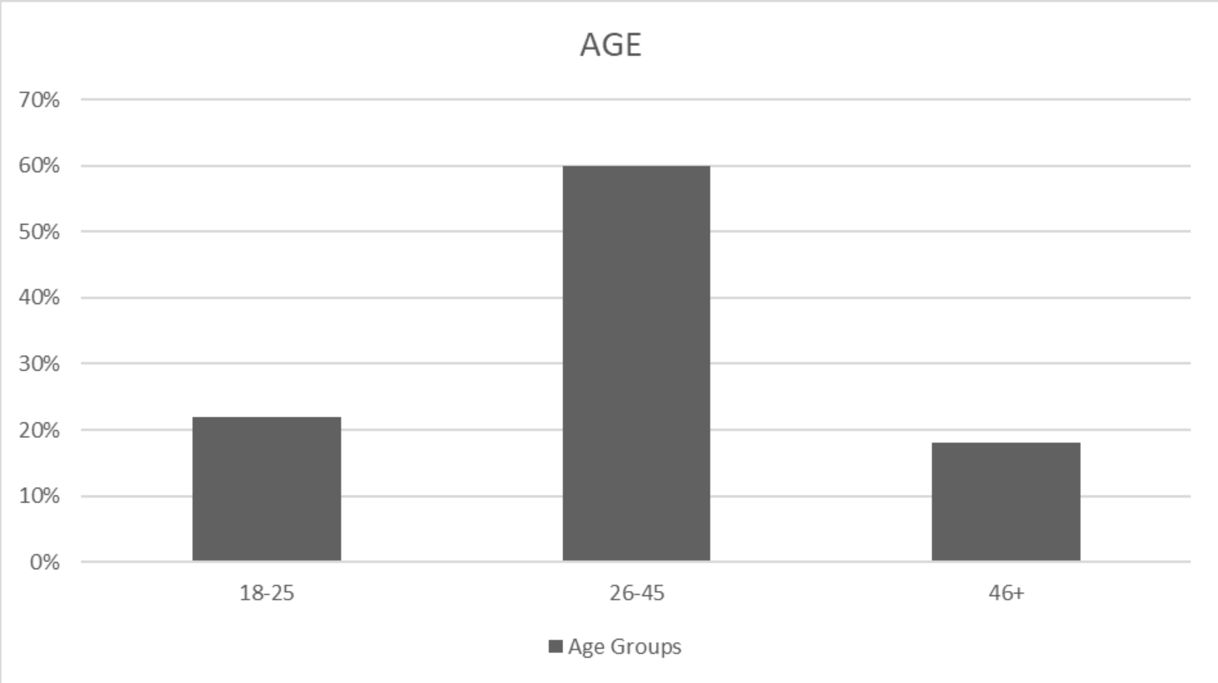

Figure4.1 Age Distribution Of the respondents to the Nordic Questionnaire

Figure 4.1 shows that (22%) of the workers are of age (18-25 years), 60% were 26 and 45 years and above, and lastly (18%) were aged (40) and above. The average age of the responders was 48.16; the youngest was just 22 years old and the oldest was 62.

4.2 PREVALANCE OF MSDS IN THE LAST 12 MONTHS BASED ON THE TYPE OF OCCUPATIONAL TASK

ACTIVITY	Neck %	shoulder %	elbow %	wrist %	Back %	Waist %	Knee %	ankle %	Thigh %
brick masons	50	66.7	50	36.7	43.3	60	56.7	43.3	23.3

Carpenters	39	61	44.1	33.9	37.3	47.5	40.7	47.5	39
Concrete workers	65.3	79.2	45.6	33.8	55.5	65.4	36.4	39.8	48.3
Scaffolders	15.4	53.8	30.8	53.8	15.4	38.5	38.5	84.6	84.6
Welders	26.8	14.3	71.4	42.9	14.3	14.3	57.1	71.4	14.3

Figure 4.2 Prevalence of MSDs in the last 12 months based on the type of occupational task

From the statistical analysis done in the table above it can be noted that 33% had pain in the back, 39% of the workers reported that they once had a Neck,40% in the wrist, 41% in the thighs, 45% in the waist, 45% in the knees, 55% in the shoulder, 57% in the elbow and lastly 57% in the ankles in the last 12 months.

4.3 REBA AND RULA MEAN SCORES OBTAINED PER TASK

	N=108 N (%)	REBA SCORE	RULASCORE
bricklaying	**46.2**	**6.5**	**6.5**
Carpentry	**13.8**	**5**	**5.6**
Concreting	**18.5**	**5**	**6.5**
Scaffolding	**9.2**	**5.1**	**6.5**
Welding	**12**	**5**	**5.5**

Figure 4.3 RULA and REBA mean scores obtained per task

Overall, the results of the current investigation showed that the RULA identified high and very high-risk levels whereas the REBA projected moderate levels better. Because there are so few classifications for the angles of various body parts, the results specifically demonstrated that RULA did not classify any of the activities at a low-risk level. The larger the score, the more significant the impact of the pose on the musculoskeletal system.

4.4 CORRELATION VALUES BETWEEN THE RISK LEVELS PREDICTED BY RULA, AND REBA IN DISTINCT OCCUPATIONAL TASKS

	Correlation coefficient	
Activity	**RULA**	**REBA**
Bricklaying	**0.766**	**0.692**
Carpentry	**0.746**	**0.503**
Concreting	**0.711**	**0.649**
Scaffolding	**0.723**	**0.634**
Welding	**0.682**	**0.374**
P -value 0.001>		

Figure 4.4 Correlation values between the risk levels predicted by RULA, AND REBA in different occupational tasks

The findings indicate that between the two techniques, the RULA had the highest correlation with the level of MSDS. According to the p-value, there is a significant correlation between the results acquired by the two evaluation instruments.

4.5 AGREEMENT COEFFICIENTS IN DIFFERENT OCCUPATIONAL TASKS BETWEEN THE RISK LEVELS OBTAINED BY, RULA, AND REBA ASSMENT METHODS

TOOLS	Bricklaying	Carpentry	Concreting	Scaffolding	Welding	TOTAL
REBA and RULA	0.532*	0.542*	0.491*	0.514*	0.483*	0.532*
*P<0.05						

Figure 4.5 agreement coefficients in different occupational tasks between the risk levels obtained by, RULA, and REBA assessment methods

The result indicated that the two assessment tools can be used to predict ergonomic risks in construction sites by correlating the level of incidence rates of MSDS for each activity with predicted risk levels in both assessment tools. It can be seen that the score was closely related to falling in the same range and capturing the same risk factors. The results revealed that the highest correlation existed between the risk levels of the REBA and RULA, which was reported as 0.532.

4.6 COMMON ERGONOMIC RISK FACTORS AT SHERWOOD B

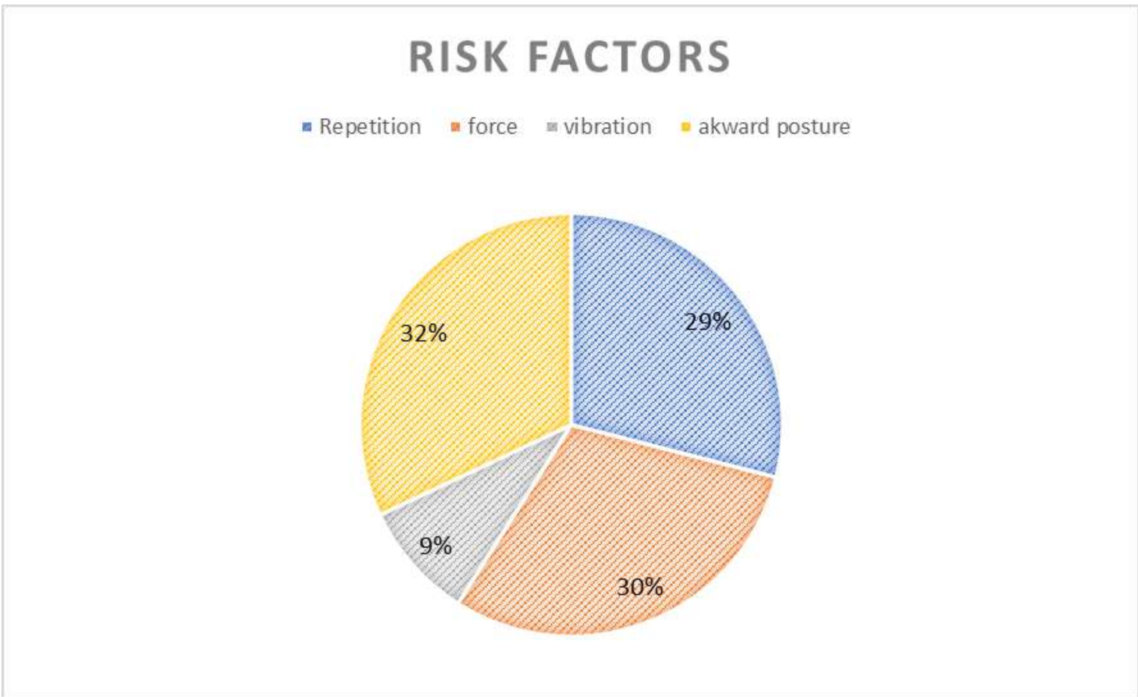

Figure 4.5.1 Ergonomic risk factors at Sherwood B

The research shows that the prevalent ergonomic risks at Sherwood B include (9%) vibration, (29%) repetition, (30%) forceful motions, and (32%) awkward postures, static positions, activities that are extremely paced, and job strain.

4.7 ASSOCIATION BETWEEN REBA SCORES, RULA SCORES, S AND RISK FACTORS

Model	Unstandardised	Coefficients	Standardized coefficients	
	B	Std Error	Beta	*T*

					sig
	8.777	.713		12.317	.000
RULA	-1.077	.201	-.723	-5.360	
REBA	-0.52	.105	-.060	-.495	.000
RISK FACTOR	379	.105	324	3.610	
					.622
					.000

Figure 4.7 Association between REBA scores, RULA scores, and risk factors

P-value is 0.025. Thus, since the significance score of RULA and risk factors obtained (0.000) is less than the P-value (0.025), thus the correlation between the two variables is statistically significant. The REBA score is (0.622), above the P-value (0.025) it is statistically insignificant to other variables. However, as observed during data collection when the RULA score was high REBA score was also high showing a strong relationship between the two variables.

CHAPTER 5: DISCUSSION

5.1 PREVELENCE OF MUSCULOSKELETAL DISODERS (MSD)

The results of the study showed that the periodic incidence rates of musculoskeletal diseases in the participants were 32.3%, 34.1%, 38.7%, 39.5%, 43.4%, 44.5%, 52%, 56,4, and 64.3%, correspondingly, in the neck, shoulders, elbow, hand/wrist, back, waist, knee, leg/ankle, and hip/thigh. Ayaka J et al. (2012) found 2012' that 45 8% of the abovementioned illnesses were connected to the neck and upper limbs, which is consistent to the findings of the current study. These results highlighted the significance of paying attention to these professions by demonstrating that the majority of jobs in the repair and maintenance industries involve a high risk of developing musculoskeletal disorders.

The major effect of MSDs among workers was found to be back pain and upper back pain because of various physical duties. Gopalakrishnan & Kumar (2020) The main factors that increase the likelihood of this back pain are unequal lifting, bending, twisting, and reaching when lifting heavy objects, and long working hours while in awkward postures. (Ahankoob & Charehzehi, 2013). Bricklayers complained more about back pain as their task required them to twist and bend to pick bricks, setting brick and block above the comfort zone of their reaching hands. According to recent research by Ayaka J et al. (2012), bricklayers in developing countries are rewarded based on the number of blocks they lay, which forces workers to labour during break times in order to meet their daily wage goals. Scaffolders were the second group of occupations with a higher percentage of back problems. Due to the nature of their task, they tend to be sitting or hunched over in uncomfortable positions for most of their day. According to Ajayi O et al. (2015), lower back pain is more common in manual construction workers than in all other occupational groups. A similar situation has been noticed with Brazilian employees. The most commonly detected body regions were the shoulder (45%), neck (47%), and back (51%). D. Kebrit and S. Rani (2013)

The other most affected parts are the shoulders. Shoulder pain complaints reached 55%; this percentage was substantially higher for crafts such as scaffolding, carpentry, and bricklaying. The previous studies reveal that the main risk factor is prolonged, forceful overhead work. (Luttmann et al., 2016) The findings agree with the findings of Ahankoob and Charehzehi (2013) that the other risk factor for shoulder pain is poorly designed workplaces where workers will perform work in awkward postures and use vibration tools. Shoulder pain is common among workers who perform tasks with repetitive movements. Ajayi O. et al. (2015) report that a significant number of workers complained about neck problems, reaching 25%. Due to machinery constraints at Sherwood, workers spend more time lifting, loading, carrying, pulling, or pushing loads of materials, and activities at shoulder height are considered cumbersome due to the awkward posture of the neck. There were few complaints about wrist and ankle pain—about 15% and 8%, respectively. In previous studies by Scott et al. (2013), the pain resulted from heavy material handling, stooping, kneeling, crouching, crawling, and repetitive movements.

5.2 REBA AND RULA FINAL SCORES

The final REBA and RULA scores revealed that practically all of the personnel in various areas dealt with musculoskeletal diseases. The scores are dependent variables derived from the posture analysis of subjects. Petrik and Petrik (2015) The results of the current study also showed that the REBA technique outperformed the other approach in predicting a low-risk level of musculoskeletal issues. Additionally, the RULA suggested high and very high risk, but the REBA predicted intermediate levels better. The RULA accurately predicted 57% of the likelihood of musculoskeletal issues in work at low and high levels, according to research conducted in 2012 by Domingo et al. Chakravarthy et al. (2015) likewise determined that the RULA technique lacks predictive value for low-risk scenarios. The findings notably showed that none of the activities were classified as low risk by the RULA. REBA had a maximum correlation with the RULA. And both prementioned methods were able to identify both low and high risks.

The final scores from both REBA and RULA showed that almost all the workers in various departments worked with muscular disorders. The scores are dependent variables derived from the posture analysis of subjects. Petrik and Petrik (2015). Furthermore, the REBA anticipated moderate levels best, while RULA indicated extremely high risk. Research done in 2012 by Domingo et al found that RULA projected 57% of the prevalence of musculoskeletal disorders in employment at moderate rates.

The key risk factors for higher RULA scores include inappropriate work posture keeping the hands lifted just above the head as well as the body bent and twisted, and the haste to complete the task as soon as possible. S. Iavicoli and others (2018) According to Domingo et al (2012).'s study, construction workers' REBA scores vary from 5 to 11. According to the findings, employees frequently suffer weariness in their thighs, ankles, and feet. This requires further investigation and a change of posture to decrease the effects. According to the study done by Odongo OO (2015), different body parts were analyzed for different activities like concreting, bricklaying, scaffolding, and plastering, and it was discovered that 37% of employees were between 4 and 6, indicating that they are at a very high risk and that immediate changes in work postures are required. 63% of laborers scored higher than 6, suggesting a high danger and indicating immediate improvements are required.

The study's findings indicate that Sherwood B employees are at a medium risk overall and an extremely high risk for upper back discomfort and that enhancing employee health necessitates using suitable work postures. This is supported by the finding by Luttmann et al. (2016) that posture, posture profile, and awkward posture are related to an increased risk for injury. RULA and REBA tools were both easily and effectively applicable for postural risk assessment at Sherwood B, with the benefit of being both more adaptable and less costly in regards to time (Chakravarthy et al., 2015). Both RULA and REBA enable the computation of a numerical index that depicts the numerical value of the threat to which the employee is exposed while doing the target job, as well as the assessment of the importance degree of essential interventions and actions. The greater the agreement between the RULA and REBA assessments, the more they supported findings from related studies in the industries (Chakravarthy et al., 2015).

CHAPTER 6: CONCLUSION

6.1 CONCLUSION

The present research demonstrated that both ergonomic work exposure and individual factors have an essential impact on the likelihood of developing MSDs. In order to better these employees' working circumstances, the current study attempted to evaluate the incidence of musculoskeletal discomfort and pain among construction employees. Both RULA and REBA may be used to assess postural risk in the construction industry with ease and effectiveness. Finally, each evaluation technique has its own usability, and as long as it is applied correctly, it will work and achieve its goal.

6.2 RECOMMENDETION

- Communication

Supervisors should be assigned to each task to promote communication between higher-level employees and lower-level employees. This approach may prevent unintentional message misunderstandings and promote productive communication among employees

- Posture analysis

Working posture is significant in studying and adjusting ergonomics because of the probable stress factors for employers. Due to the static burden, sustained periods inevitably lead to musculoskeletal disorders and back and neck joint dislocations. The use of tools like shovels for track maintenance, the digging motions, and the erect posture of the upper shoulders during concrete vibration was all observed is necessary to provide psychological counseling in order to prevent mental stress brought on by this discomfort.

- Training and Education

Effective education and training are needed to increase worker knowledge of ergonomics. The problems that the workers experience, such as chronic posture problems and back discomfort, must be dealt with beforehand. When doing the task, both the top-level supervisors and the bottom-level employees need to be aware of the risks.

REFRENCES

Abinaya Ishwarya, G.K. and Rajkumar, D. (2020) 'Analysis of ergonomic risk factors in construction industry', *Materials Today: Proceedings*, 37(Part 2), pp. 2415–2418. Available at: https://doi.org/10.1016/j.matpr.2020.08.269.

Abinaya Ishwarya, G.K. *et al.* (2022) 'Analysis of Ergonomic Risk Factors in Relation to Musculoskeletal Disorder Symptoms in Office Workers', *Applied Ergonomics*, 4(1), pp. 1–7. Available at: https://doi.org/10.18502/kls.v4i5.2536.

Alghadir, A. and Anwer, S. (2015) 'Prevalence of Musculoskeletal Pain in Construction Workers in Saudi Arabia', 2015.

Alireza Ahankoob, A.A. (2013) 'Mitigating Ergonomic Injuries In Construction Industry', *IOSR Journal of Mechanical and Civil Engineering*, 6(2), pp. 36–42. Available at: https://doi.org/10.9790/1684-0623642.

Capodaglio, E.M. (2022) 'Participatory ergonomics for the reduction of musculoskeletal exposure of maintenance workers', *International Journal of Occupational Safety and Ergonomics*, 28(1), pp. 376–386. Available at: https://doi.org/10.1080/10803548.2020.1761670.

Chiasson, M. eve et al. (2015) 'Influence of musculoskeletal pain on workers' ergonomic risk-factor assessments', Applied Ergonomics, 49, pp. 1–7. Available at: https://doi.org/10.1016/j.apergo.2014.12.011.

Damaj, O. et al. (2016) 'Implementing ergonomics in construction to improve work performance', IGLC 2016 - 24th Annual Conference of the International Group for Lean Construction, pp. 53–62.

Das, M., Raythata, H. and Chatterjee, S. (2017) 'Bacterial Transformation: What? Why? How? and When?', *Annual Research & Review in Biology*, 16(6), pp. 1–11. Available at: https://doi.org/10.9734/arrb/2017/35872.

Dinar, A. *et al.* (2018) 'Analysis of Ergonomic Risk Factors in Relation to Musculoskeletal Disorder Symptoms in Office Workers', *KnE Life Sciences*, p. 16. Available at: https://doi.org/10.18502/kls.v4i5.2536.

Dul, J. and Neumann, W.P. (2009) 'Ergonomics contributions to company strategies', Applied Ergonomics, 40(4), pp. 745–752. Available at: https://doi.org/10.1016/j.apergo.2008.07.001.

Genaidy, A.M., al-Shedi, A.A. and Shell, R.L. (1993) 'Ergonomic risk assessment: preliminary guidelines for analysis of repetition, force and posture.', *Journal of human ergology*, 22(1), pp. 45–55.

Hulshof, C.T.J. *et al.* (2021) 'The effect of occupational exposure to ergonomic risk factors on osteoarthritis of hip or knee and selected other musculoskeletal diseases: A systematic review and meta-analysis from the WHO/ILO Joint Estimates of the Work-related Burden of Disease and In', *Environment International*, 150, p. 106349. Available at: https://doi.org/10.1016/j.envint.2020.106349.

Hulshof, C.T.J. *et al.* (2021) ‘The prevalence of occupational exposure to ergonomic risk factors: A systematic review and meta-analysis from the WHO/ILO Joint Estimates of the Work-related Burden of Disease and Injury’, *Environment International*, 146, p. 106157. Available at: https://doi.org/10.1016/j.envint.2020.106157.

Inyang, N. *et al.* (2012) ‘Ergonomic Analysis and the Need for Its Integration for Planning and Assessing Construction Tasks’, *Journal of Construction Engineering and Management*, 138(12), pp. 1370–1376. Available at: https://doi.org/10.1061/(asce)co.1943-7862.0000556.

Joshi, M. and Deshpande, V. (2019) ‘A systematic review of comparative studies on ergonomic assessment techniques’, International Journal of Industrial Ergonomics, 74(August), p. 102865. Available at: https://doi.org/10.1016/j.ergon.2019.102865.

Kim, I.J. (2017) ‘The Role of Ergonomics for Construction Industry Safety and Health Improvements’, *Journal of Ergonomics*, 7(2). Available at: https://doi.org/10.4172/2165-7556.1000e166.

Kolgiri, S., Hiremath, R. and Bansode, S. (2015) ‘Literature Review on Ergonomics Risk Aspects Association to the Power Loom Industry’, *Journal of Mechanical and Civil Engineering*, 13(1), pp. 56–64. Available at: https://doi.org/10.9790/1684-13135664.

López-Aragón, L. *et al.* (2017) ‘Applications of the standardized nordic questionnaire: A Review’, *Sustainability (Switzerland)*, 9(9), pp. 1–42. Available at: https://doi.org/10.3390/su9091514.

Muktar, M.Z. *et al.* (2017) ‘Assessment of ergonomic risk level and working performance of pre-cast construction workers in Sabah’, *Malaysian Journal of Public Health Medicine*, 17(2), pp. 151–158.

Mustapha, Z., Akomah, B.B. and Baiden, J. (2022) ‘Impact of Work-Related Musculoskeletal Disorders Among Construction Workers in Ghana’, *Baltic Journal of Real Estate Economics and Construction Management*, 10(1), pp. 129–139. Available at: https://doi.org/10.2478/bjreecm-2022-0009.

Nygaard, N.P.B. *et al.* (2022) ‘Ergonomic and individual risk factors for musculoskeletal pain in the ageing workforce’, *BMC Public Health*, 22(1), pp. 1–12. Available at: https://doi.org/10.1186/s12889-022-14386-0.

Pandya, M. (2019) ‘Systematic Review on Various Risk Assessment Techniques of Musculoskeletal Disorder’, *Industrial Engineering Journal*, 12(6), pp. 1–7. Available at: https://doi.org/10.26488/iej.12.6.1182.

Ranganathan, B.A. (2016) ‘Safety Performance in Construction Industries’, *International Research Journal of Engineering and Technology (IRJET)*, 3(6), pp. 2643–2646.

Rathore, B., Pundir, A.K. and Iqbal, R. (2020) ‘Ergonomic risk factors in glass artware industries and prevalence of musculoskeletal disorder’, *International Journal of Industrial Ergonomics*, 80(September), p. 103043. Available at: https://doi.org/10.1016/j.ergon.2020.103043.

Shang, L.T. (2020) ‘A Systematic Approach Of Ergonomics Assessment Tool Selection’, pp. 708–718. Available at: https://doi.org/10.15405/epsbs.2020.12.05.77.

Stelea, M.P., Moraru, R.I. and Băbuţ, G.B. (2021) 'Assessment tools analysis of work-related musculoskeletal disorders : strengths and limitations', 1009.

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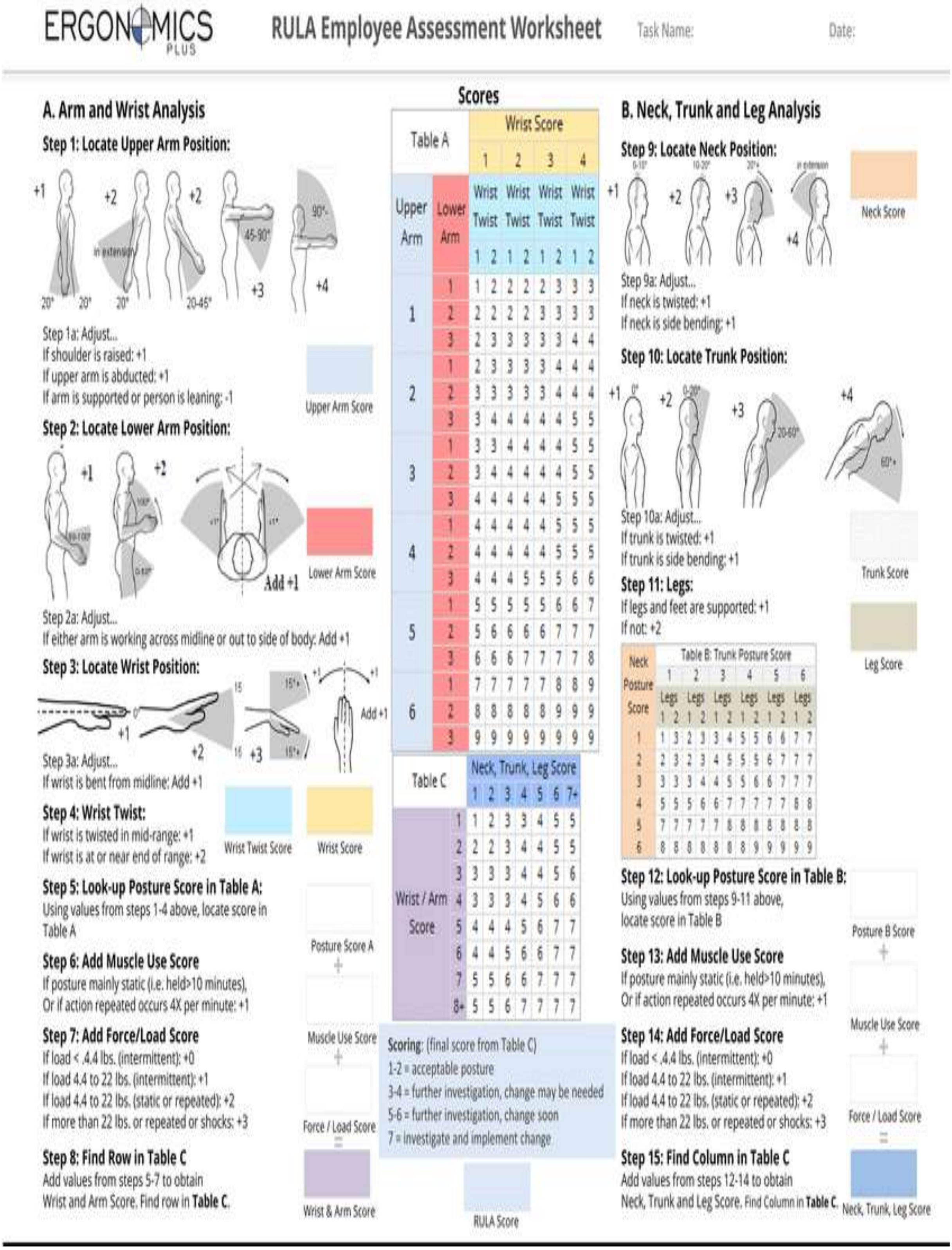
APPENDICES

APPENDIX I: RULA SCORE SHEET USED IN THE STUDY



ERGONOMICS PLUS

RULA Employee Assessment Worksheet Task Name: Date:

A. Arm and Wrist Analysis

Step 1: Locate Upper Arm Position:

Step 1a: 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 2: Locate Lower Arm Position:

Step 2a: Adjust...
If either arm is working across midline or out to side of body: Add +1

Lower Arm Score

Step 3: Locate Wrist Position:

Step 3a: Adjust...
If wrist is bent from midline: Add +1

Step 4: Wrist Twist:
If wrist is twisted in mid-range: +1
If wrist is at or near end of range: +2

Wrist Twist Score

Wrist Score

Step 5: Look-up Posture Score in Table A:
Using values from steps 1-4 above, locate score in Table A

Posture Score A

Step 6: Add Muscle Use Score
If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

Muscle Use Score

Step 7: Add Force/Load Score
If load < 4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

Force / Load Score

Step 8: Find Row in Table C
Add values from steps 5-7 to obtain Wrist and Arm Score. Find row in **Table C.**

Wrist & Arm Score

Scores

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

Table C		Neck, Trunk, Leg Score 1	2	3	4	5	6	7+
Wrist / Arm Score	1	1	2	3	3	4	5	5
	2	2	2	3	4	4	5	5
	3	3	3	3	4	4	5	6
	4	3	3	3	4	5	6	6
	5	4	4	4	5	6	7	7
	6	4	4	5	6	6	7	7
	7	5	5	6	6	7	7	7
	8+	5	5	6	7	7	7	7

Scoring: (final score from Table C)
1-2 = acceptable posture
3-4 = further investigation, change may be needed
5-6 = further investigation, change soon
7 = investigate and implement change

RULA Score

B. Neck, Trunk and Leg Analysis

Step 9: Locate Neck Position:

Neck Score

Step 9a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

Step 10: Locate Trunk Position:

Step 10a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

Trunk Score

Step 11: Legs:
If legs and feet are supported: +1
If not: +2

Leg Score

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

Step 12: Look-up Posture Score in Table B:
Using values from steps 9-11 above, locate score in Table B

Posture B Score

Step 13: Add Muscle Use Score
If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

Muscle Use Score

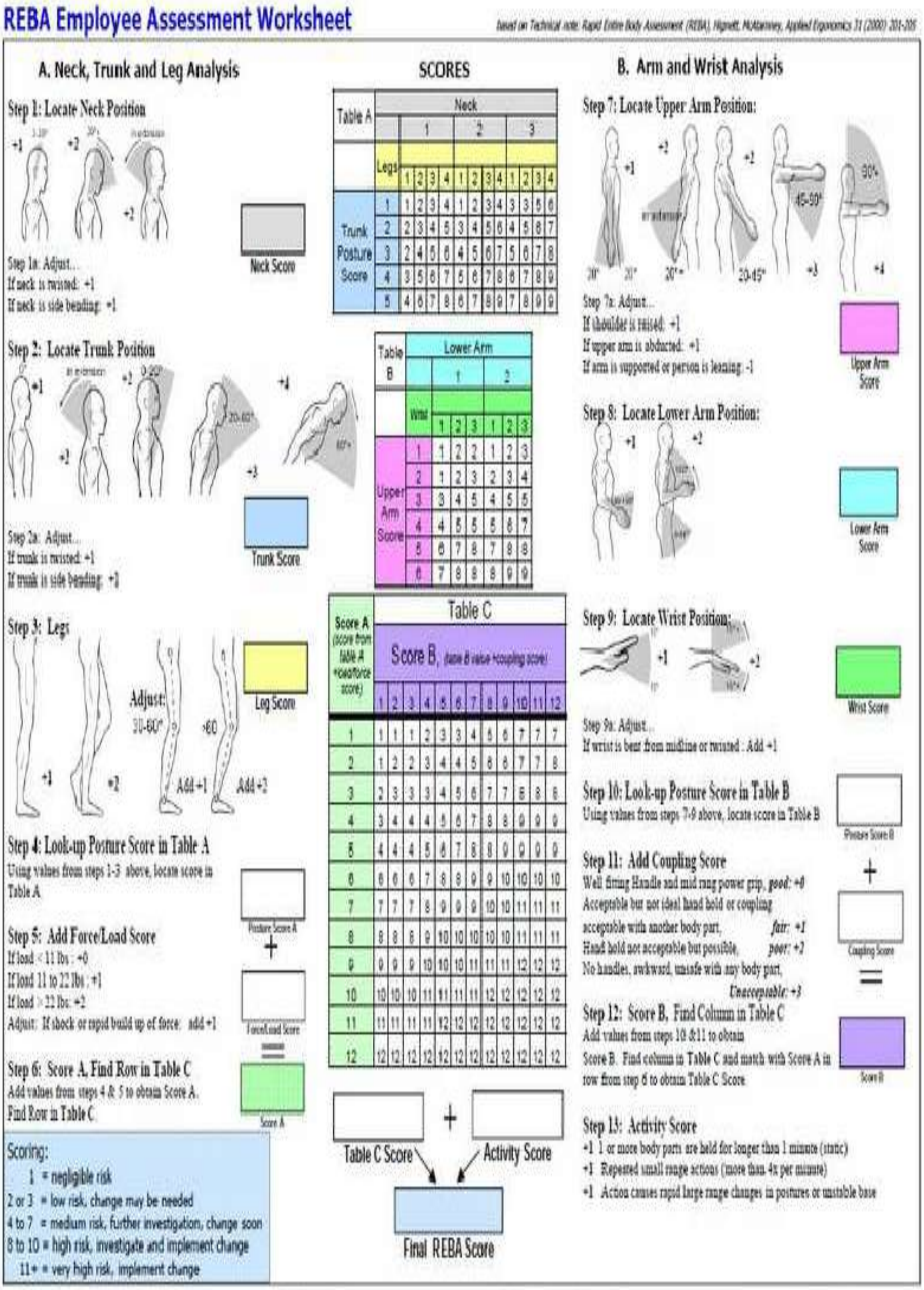
Step 14: Add Force/Load Score
If load < 4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

Force / Load Score

Step 15: Find Column in Table C
Add values from steps 12-14 to obtain Neck, Trunk and Leg Score. Find Column in **Table C.**

Neck, Trunk, Leg Score

APPENDIX 2: REBA SCORE SHEET USED IN THE STUDY



REBA Employee Assessment Worksheet

based on Technical note: Rapid Entire Body Assessment (REBA), Hignett, McAtamney, Applied Ergonomics 31 (2000) 201-205

A. Neck, Trunk and Leg Analysis

Step 1: Locate Neck Position

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

Neck Score

Step 2: Locate Trunk Position

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

Trunk Score

Step 3: Legs

Adjust: 30-60°: Add +1; >60: Add +2

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 or 3 = low risk, change may be needed
4 to 7 = medium risk, further investigation, change soon
8 to 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

Table C

Score A (score from table A +load/force score)	Score B, (table B value +coupling score) 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

Final 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:

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

Wrist Score

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

APPENDIX 3 QUESTIONNARE

QUESTIONNAIRE TOPIC: ASSESMENT OF ENTIRE BODY ASSESSMENT (REBA) AND RAPID UPPER LIMB ASSESSMENT (RULA) APPLICABILITY IN ERGONOMICS RISKASSESEMENT. CASE STUDY ZPC HWANGE EXPANSION PROJECT SHERWOOD B

My name is Tapiwa Mugwagwa, a student from Bindura University of Science Education. I
am currently studying towards degree of Bachelor of Environmental Sciences honours in
Safety, Health and Environmental Management. I am carrying out study to identify of ergonomic hazards at Sherwood B. I am therefore requesting your assistance to participate
in this survey as you associated with the work on a daily basis. I assure you of utmost confidentiality and a pledge that all the information gathered will be strictly used for academic purposes.

May you please tick and or where appropriate

QUESTIONNAIRE No…...…………

Date ……/……. /……

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. Do you perform highly repetitive tasks? (>100 reps/hour or 2000 per/day)

YES ☐ NO ☐

iv. Do you stand continuously for more than 30 minutes? YES ☐ NO☐

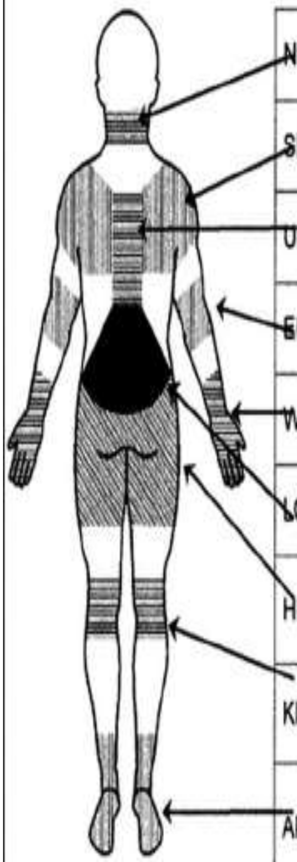
vi. Do you perform tasks while assuming awkward postures (e.g., hunching, bending, squatting? YES ☐ NO☐

vii. Do you routinely use high vibration tools? YES ☐ NO☐

viii. Do you lift, lower or carry large objects that cannot be held close to the body? YES ☐ NO☐

ix. How would you rate your workload? Low ☐ Average ☐ High☐

SECTION C: WRMSDs EXPERIENCE



	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