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Thesis Title: The Impact of Ergonomic Risk Factors on Musculoskeletal Disorders and Their Implication to Productivity Through Rapid Entire Body Assessment (REBA):

A Case Study at ALMED Textiles Plc.

Submitted to the School of Mechanical and Industrial Engineering in Partial Fulfillment of the requirement for the award Of MSc. In PISE

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This is to certify that this title entitled “The Impact of Ergonomic Risk Factors on Musculoskeletal Disorders and Their Implication to Productivity Through Rapid Entire Body Assessment (REBA)” A Case Study at ALMED Textiles Factory submitted for partial fulfillment of the requirement for the award of degree of MSc in Industrial Engineering (Production and Industrial System Engineering) Mekelle University through the School of Mechanical and Industrial Engineering done by Mr. Samuel Gebreigziabher under my full guidance. The work contained in this thesis has not been previously submitted for a degree at any other higher education institutes to the best of my knowledge and all the sources that I have used or quoted have been indicated and acknowledged by means of referencing.

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ABSTRACT

Musculoskeletal disorder (MSDs) is one of the most common occupational health conditions globally, especially in the labor-intensive sector like textile & garment manufacturing. This study examines the impact of ergonomic risk factors on the prevalence of MSDs & their implication for the operator's productivity at ALMEDA Textiles., a major garment manufacturer in Ethiopia. The study employs a cross-sectional design, combining observational method, REBA posture analysis tool along with a validated instruments such as CMSDQ & WPAI questionnaire to comprehensively assess ergonomic risk, & productivity loss. Data were collected from 295 operators across the garment department with a response rate of 93.35%. A key finding revealed that 75.8% of operators have reported symptoms of MSDs, specifically in the lower back, neck, shoulder wrist & knee. MSDs were prevalent, with 34.9% experiencing neck pain and 37.6% experiencing lower back pain daily. productivity losses averaged 43.87%, driven by absenteeism & presenteeism linked to MSDs. The finding also shows 90.8% (REBA score 8-10) of workstations posed high ergonomic risks, primarily due to awkward posture, repetitive motions & prolonged static loading. Regression analysis identified demographic risk factors (β=1.058, P=0.001), job-related risk factors (β=0.491, P=0.001), psychological risk factors (β=0.306, P=0.001), & physical risk factors (β=0.187, P=0.008) as significant predictors of MSDs. The study highlights critical gaps in ergonomic training & workstation design, with 95.6% of operators lacking ergonomic awareness. Recommendations include workstation redesign, mechanical aids & targeted training; such measures are vital for reducing MSD risks, improving operator well-being & enhancing productivity. This research contributes to the ergonomic literature in post-conflict industrial settings with a multidimensional view (utilizing a combination of REBA, CMDQ & WPAI) & offers actionable insights for improving worker health & productivity in Ethiopia's garment industry. For further investigation, researcher should explore the economic return of ergonomics investments analyzing how redesigns, training, & health focused initiatives translate into cost saving & efficiency for manufacturing firms. Relaying solely on self-reported data my introduce response bias due to underreporting or overreporting of symptoms. furthermore, Cross-sectional design capture data at a single point in time.

Keywords: Ergonomics, Musculoskeletal Disorder, Productivity, REBA, Textile & Garment firm.

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List of Abbreviations and Acronyms

CTS	Carpal Tunnel Syndrome
CMDQ	Cornell musculoskeletal discomfort questionnaire
HAVS	Hand-Arm Vibration Syndrome
IE	Industrial Engineering
JFQ	Job Factor Questionnaire
MSDs	Musculoskeletal disorders
NMQ	Nordic Musculoskeletal Disorder
OWAS	OVAKO Working Posture Analysis System.
QEC	Quick Exposure Check
REBA	Rapid Entire Body Assessment
RSIs	Repetitive Strain Injuries
RULA	Rapid Upper Limb Assessment
SI	Strain Index
SSMOs	Standing sewing machine operators
USD	united states dollar
WMSDs	Work-related musculoskeletal disorder
ÖMPQ	Örebro Musculoskeletal Pain Questionnaire

CHAPTER ONE: INTRODUCTION

1.1. Background and Justification of The Study

The clothing business is very important to the world economy since it provides jobs and brings in a lot of money from exports in many nations (S. Selvanathan, 2018). This companies relays a lot on skilled sewing, cutting, and finishing operators, who are the backbone of production operations and make sure that clothing items are made on time and efficiently (Tilahun, 2020). However in many developing countries, these burgeoning sectors frequently work with little regulatory monitoring and in less than ideal conditions, which puts workers at more risk of occupational risks (Yifokire Tefera Zele, 2021). The health and safety of these workers is very important because bad ergonomic circumstances can cause musculoskeletal disorders (MSDs), lower productivity, and higher absenteeism (Gebrye et al., 2025)

In the garment business, the high number of MSDs among garment operators is a big worry. Studies have found that work in the garment business often include sitting for long periods of time, doing the same thing over and over, and having bad posture. This is why MSDs are so widespread (Biadgo et al., 2021; da Costa, 2015). Vadivelan K. and Vignesh P. research showed that garment workers typically have work-related musculoskeletal disorders (WMSDs), which cause pain in the neck, shoulders, and back. This is because their work is static and repetitive (Vadivelan Kanniappan, 2020). MSDs are one of the most common health problems at work around the world.

Lack of proper intervention or training on appropriate posture is an unavoidable reason. This exposes workers to repetitive motions of the upper extremities as well as sustained awkward lower back postures. Carpal Tunnel Syndrome, trigger finger, elbow, along with cervical and lumbar disorders are examples of WMSDs that can be alleviated through appropriate ergonomics and proper training(Michelle M. Robertson, 2008), (Attia et al., 2023).

More and more people are realizing that the operators' ergonomic conditions need to be better for their health and productivity (Jayathilaka & Karunarathne, 2021). Ergonomic interventions can lead to reduced physical strain, lower injury rates, and improved job satisfaction (Machado, 2023). Using ergonomic solutions not only helps the workers, but it also makes the manufacturing process more efficient and profitable (Marchisio & Collao-Díaz, 2023).

The situation in Ethiopia's Tigray region, particularly at ALMEDA Textiles Plc, provides a case in point. Established in 1989, ALMEDA has long been one of the country's largest integrated textile and garment manufacturers, playing a key role in local employment and economic development. However, even prior to the recent conflict in Tigray, concerns about poor ergonomic practices and worker safety had been noted. Operators were already performing repetitive and physically taxing tasks under ergonomically unfavorable conditions, without adequate support systems or preventive measures in place(Zinabu et al., 2024). This ongoing neglect of occupational health has long posed challenges for worker welfare and organizational efficiency.

The conflict in Tigray severely disrupted operations at ALMEDA, causing extensive damage to infrastructure and halting production. As the factory moves through a recovery phase, the primary focus has been on restoring output. Yet, the longstanding neglect of ergonomic standards continues to threaten the health of the workforce. This is particularly alarming considering that over 38% of illness-related absenteeism in similar Ethiopian industries is linked to MSDs (Legesse et al., 2024); (Zele et al., 2021). Without timely ergonomic interventions, these risks are likely to increase, undermining both worker safety and the broader economic revitalization of the Tigray region (Rosak-Szyrocka et al., 2023)

The Rapid Entire Body Analysis (REBA) is a useful technique for figuring out how to make workplaces more comfortable and safe by looking at the risk of musculoskeletal disorders (MSDs) and making suggestions on how to do so (Manohar et al., 2025). Along with tools such as the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) and the Work Productivity and Activity Impairment (WPAI) questionnaire, REBA offers a robust framework for assessing ergonomic risks and their impact on worker productivity and health.

This study is motivated by the pressing need for evidence based ergonomic assessment in the Tigray garment industry, particularly in historically unprivileged and high-risk environments like ALMEDA Textiles. Despite the high incidence of MSDs, ergonomic practices have received little attention in such contexts. By applying REBA in conjunction with CMDQ and WPAI, this study aims to provide a comprehensive understanding of ergonomic risk factors and their implications. The results will support targeted interventions, including workstation redesign, ergonomic training, and the provision of adjustable tools measures that are essential for creating a healthier, more productive workforce.(Ford et al., 2023).

1.2. PROBLEM STATEMENT

Work-related musculoskeletal disorders (WMSDs) represents a significant occupational health concern, particularly in developed countries, where they contribute to reduced productivity, increased employee absenteeism and substantial healthcare and compensation costs (Ming-Lun Lu, 2022). According to the international Labor Organization, proximately 160 million work-related illnesses occur worldwide each year, with musculoskeletal disorder being among the most prevalence (Ayoub Parno, 2020). In the U.S., WRMSDs accounts for 40% of all work-related compensation claims, resulting in annual costs exceeding 50 billion dollars (J. Torres da Costa, 2014). In East Asia, the prevalence of WMSD in the industrial workers is found to be 60% (Subrata Das, 2022). Similarly, in Ethiopia, a study by Zele et al. revealed that out of 27,320 workers in three integrated textile and garment industries, 16,993 had taken sick leave. Among the causes, respiratory diseases accounted for 34%, while musculoskeletal disorder represented 29% (Yifokire Tefera Zele, 2021).

ALMEDA Textiles. One of Ethiopian's major garment manufacturers, faces significant ergonomic challenges in its operations. The repetitive nature of tasks, and prolonged fixed postures, heavy lifting, fabric handling, intricate stitching contribute to muscular fatigue & increase the risk of WMSDS among its workers. According to data from the company's engineering officers (2020 G.C.) the number of recorded absenteeism cases was 21,303 while sick leave cases totaled 31,303. Among these, respiratory diseases accounted 40%, musculoskeletal disorder 33% were the most widespread illness, and the rest were bodily injuries. While conditions like respiratory illnesses and minor body injuries can often be treated with medication, MSD typical require long-term intervention strategies involving physical adjustments and ergonomic improvements.

To effectively mitigate these challenges, ALMEDA Textiles requires comprehensive ergonomic intervention strategy. This includes redesigning workstation, providing regular ergonomic training, increased awareness about work posture & movement tools & assessment tools such as the Rapid Entire body Assessment (REBA). These measures aim to reduce the incidence of MSDs, enhance workers physical well-being, and increasing overall productivity. By implementing these strategies ALMEDA textiles can create a safer and more sustainable working environment, ultimately improving worker well-being & support the company's long-term operational efficiency.

1.3. RESEARCH QUESTIONS

- To what extent do demographic factors influence the prevalence and severity of musculoskeletal disorders among garment operators?
- What is the relationship between job-related factors & the development of musculoskeletal disorders among garment operators?
- To what extent do psychological factors contribute to the occurrence of musculoskeletal disorders among garment operators?
- What physical work-related factors are most associated with musculoskeletal disorders among garment operators?
- How do musculoskeletal disorders impact productivity and work performance among garment operators, as measured by the Work Productivity and Activity Impairment (WPAI) questionnaire?

1.4. OBJECTIVE

1.4.1. General Objective

To investigate the impact of ergonomic risk factors on musculoskeletal disorders and their implication to productivity through REBA tool at ALMEDA Textiles.

1.4.2. Specific Objective

1. To examine the impact demographic characteristics on Musculoskeletal disorder.
2. To analyze the influence of job-related risk factors on Musculoskeletal disorder.
3. To assess the role of psychological risk factors on Musculoskeletal disorder.
4. To evaluate the effect of physical risk factors on Musculoskeletal disorder.
5. To estimate productivity loss associated with MSDs using the WPAI questionnaire.

1.5. Scope of the study

The study examines the impact of ergonomics risk factors on WMSD and Their Implication to productivity among garment operators at ALMEDA Textiles one of Ethiopia's oldest and largest textiles companies offer a unique and valuable case due to its long-established workforce and historical data on ergonomic risks. This long-term perspective allows for a deeper understanding of how ergonomic factors contributing to WMSD prevalence over time.

The study is limited to the three principal assessment tools REBA for postural analysis, the CMSDQ for symptom reporting & WPAI instrument for productivity measurement.

1.6. Significant of the study

This study is significant both academically & practically. Academically, it adds to the little research on musculoskeletal disorder (MSDs) & ergonomic risk factors in Ethiopia's textile sector, especially in post conflict areas like Tigray. By applying tools such as REBA, CMSDQ, & WPAI it provides a comprehensive model linking workplace ergonomics to health productivity outcome. Practically, the study offers valuable insight for ALMEDA Textiles & similar industries by identifying ergonomic risk factors and quantifying productivity loss & guiding targeted ergonomic intervention. This insight can help reduce operator injuries improve working condition & enhance overall productivity.

1.7. Limitation of the study

This study has limitations even if it offers insightful information on how ergonomics risk factors affect musculoskeletal disorder and its implication on productivity among ALMEDA Textiles garment operators. first cross-sectional design capture data at a single point in time, limiting the ability to establish casual relationships. Second reliance on self-reported data through questionnaire like CMSDQ & WPAI may introduce response bias due to underreporting or overreporting of symptoms. The post conflict revitalization phase at ALMEDA Textiles may also have influenced working condition & worker response, potentially limiting the generalizability of findings to stable industrial environments.

1.8. Conceptual Framework

In this study its grounded in the WRMSD model and the ergonomics risk factors which collectively explain how poor ergonomic design in the workstation contributes to the development of musculoskeletal disorder (MSDs) & subsequently affects operators' productivity according to those models' exposure to demographic (eg Age, gender, doing physical exercise) physical (e.g. repetitive motion, awkward posture), job-related (e.g. job satisfaction, lack of ergonomics training), psychological (e.g. work overload, poor work management, poor working r/ships etc.) physical (e.g. repetitive movements, awkward postures, and forceful exertions) risk factors increasing the likelihood of developing MSDs. This disorder in turn leads to physical discomfort, fatigue, absenteeism, & presenteeism all of which reduces individual and organizations productivity.

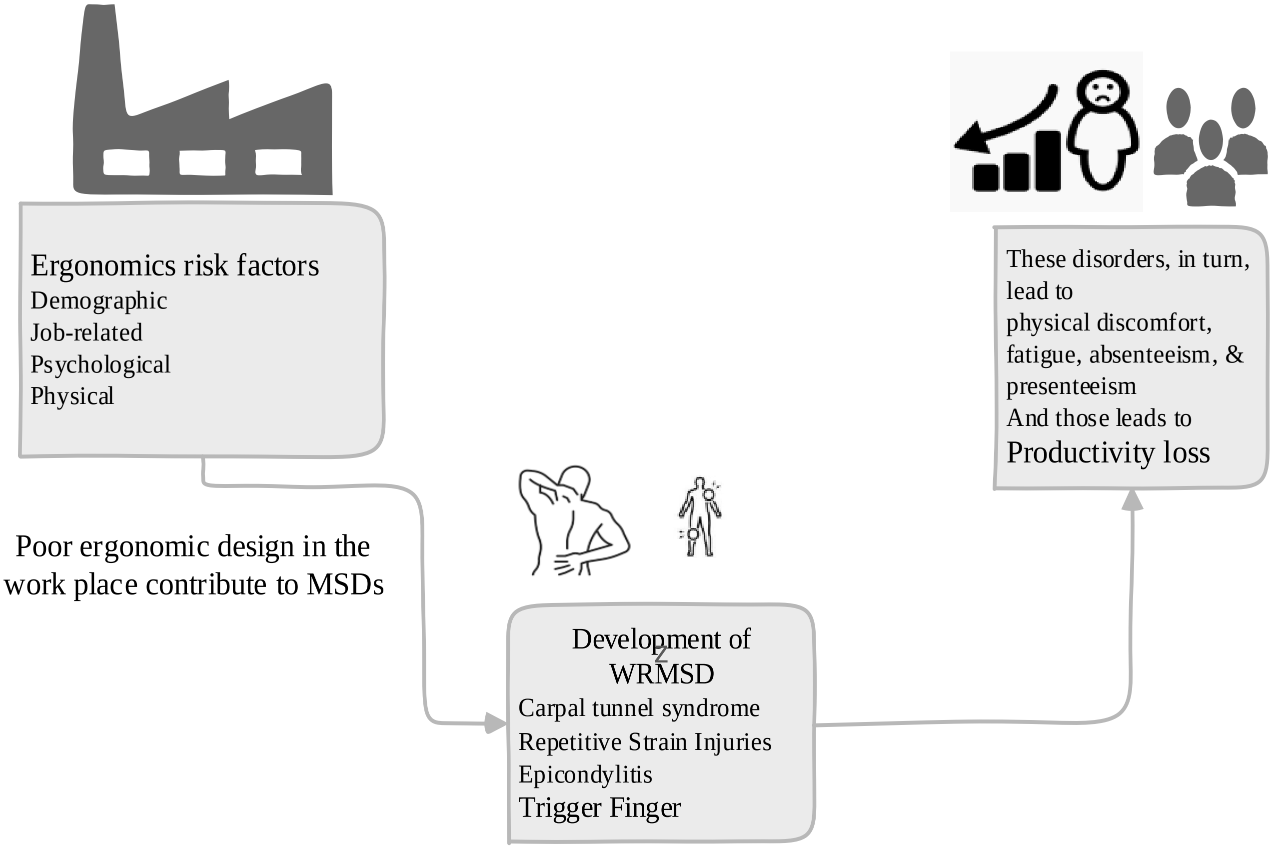

Figure 1 Conceptual farmwork

CHAPTER TWO: LITERATURE REVIEW

2.1. Ergonomics and its Occupational Health Significance

The term Ergonomics comes from the Greek word “Ergon” meaning work and “Nomos” means l

Ergonomics is the science of work, focusing on systematically dividing tasks and aligning them with the person performing them. It involves designing chairs, tools, machines, systems, tasks, jobs, and work environments for safe, comfortable, and effective human use. An appropriate ergonomics design, training, and awareness are essential to reduce risk factors like Work Related Musculoskeletal Disorder (WRMSD), a prevalent occupational health problem caused by high physical demands.(Narendra, 2020).

Concurrent with industrial growth, human health threatening disease patterns have changed. From the middle of the twentieth century, a meaningful number of infectious diseases have been witnessed; however, an incredible increase has also been observed in diseases associated with industrial life such as accidents, cardiovascular diseases, and musculoskeletal disorders(Nadri H, 2015).

Despite worldwide concern and effort for preventing work-related musculoskeletal disorders (MSDs), this progress is still slow, and MSDs remain a substantial burden. Questions have been raised regarding the assessment of ergonomic exposure and the validity and reliability of different methods being used (Espíritu Anaya et al., 2024).

Definition: ergonomics also known as the human factor is the field of study that concerned with the understanding of interaction among human and other element of a system and the profession that applies theory, principle, data and method to design to minimize human wellbeing and over all human performance (Gokulakrishnan Janarthanan, 2024)

2.2. Occupational Health & Safety in Manufacturing Industry

Occupational health and safety are crucial in the manufacturing industry, which is a leading cause of work-related illnesses and accidents. The assembly industry, due to its heavy equipment and manual labor, is more prone to musculoskeletal disorders (MSDs), responsible for 33% of occupational illnesses and injuries. Despite the adoption of ergonomic treatments, there is still limited progress in reducing MSD risks in manufacturing industries(Simon Dagenais DC, 2007).

2.3. Musculoskeletal Disorder (MSDs)

Work-related musculoskeletal disorders (WMSDs) are a common health problem and a major cause of disability(Greggi et al., 2024). MSDs are a broad category of conditions that affect the muscles, nerves, tendons, joints, cartilage, and spinal discs. These disorders can result from acute trauma or chronic exposure to ergonomic risk factors such as repetitive motion, forceful exertions, awkward postures, and vibration. MSDs are prevalent in various industries and can significantly impact workers' health, productivity, and overall quality of life (Yang et al., 2023)

2.4. Related Ergonomic Risk Factors

Workplaces traditionally have been designed to move products or support machines efficiently. Since people have always seemed so adaptable, how they fit into the workplace has received less attention. The increasing number of injuries caused by repetitive motion, excessive force, and awkward postures; ergonomics has become a critical factor in workplace safety(N. Jaffar, 2011), ergonomics and human factors are often used interchangeably in workplaces. Both describe the interaction between the worker and the job demands. The difference between them is ergonomics focuses on how work affects workers, and human factors emphasize designs that reduce the potential for human error (Mao et al., 2015)

Risk factors are defined as actions or conditions that increase the likelihood of injury to the musculoskeletal system. Applied ergonomics literature recognizes a small set of common physical risk factors across many occupations and work settings (Somnath Kolgiri, 2016)There are different types of risk factors that may cause illnesses including physical, demographic, Psychological, job-related.

2.4.1. Demographic factors

Demographic factors, such as age, gender, physical fitness, and pre-existing conditions, can significantly influence an individual’s vulnerability to ergonomic-related injuries. As workers age, they may experience a decline in muscle strength and flexibility, making them more susceptible to musculoskeletal disorders (MSDs). Gender differences also play a role, as women are more prone to certain ergonomic risks due to biological differences in body structure and hormonal influences. Furthermore, individuals with lower levels of physical fitness or pre-existing conditions such as arthritis may be at a higher risk for injury, particularly when performing tasks that involve repetitive movements or awkward postures (Nygaard et al., 2022)

2.4.2. Job-Related Factors

Job-related factors, including job-satisfaction, overall working environment, & training, play a crucial role in determining ergonomic risks. High job demands, like repetitive tasks or sustained high work pace, often lead to MSDs injuries. Workers who face pressure to meet tight deadlines may engage in poor postures or forego breaks, exacerbating physical strain. Moreover, inadequate training on proper ergonomics & workstation setup can further contribute to injuries as employees may not be aware of the best practices to reduce strain (Bazazan et al., 2019).

2.4.3. Psychological factors

Psychological factors such as stress, & mental health are critical components that influence ergonomic risks. Workers under high levels of stress or suffering from mental health issues may experience increased muscle tension, reduced focus on ergonomic practices, neglect proper posture, skip breaks, or perform tasks with poor body mechanics and greater fatigue. The combination of these psychological strains can exacerbate the likelihood of developing musculoskeletal disorders (Hammig, 2020).

2.4.4. Physical risk factors

Physical risk factors, including repetitive movements, awkward postures, & forceful exertions, are primary contributors to ergonomic injuries. Repetitive tasks, such as typing or assembly line work, put strain on muscles and tendons, leading to conditions like carpal tunnel syndrome or tendinitis. Awkward postures, such as bending, twisting, or working with raised arms, can cause musculoskeletal stress on joints and ligaments. Forceful exertions, such as lifting heavy objects or using excessive force with tools, can lead to back injuries or muscle strains. These risk factors are exacerbated by prolonged exposure without proper rest or ergonomic intervention (Hulshof et al., 2021)

The major physical risk factors for developing work-related MSDs are forceful excretion, repetition movement, static posture, awkward posture, vibration, lifting or moving heavy loads, and extreme temperatures. WRMSDs are the most common cause of loss by means of human, time and money in many industries and the risks factors must be analyzed and eliminated (Descatha et al., 2020); (Ashish Kumar Singh, 2017).

2.5. Accidents Caused by Ergonomics Associated Risk Factors

Accidents caused by ergonomics-associated risk factors often result from improper workplace design, leading to repetitive strain injuries, musculoskeletal disorders, and other health issues. These accidents are typically due to poor posture, inadequate seating, repetitive movements, or poorly designed tools and workspaces that fail to accommodate the user's physical needs. Addressing these risks through ergonomic assessments and improvements can significantly reduce injury rates and enhance overall workplace safety and productivity(Fan et al., 2022); (Laura Punnett, 2004). These incidents can manifest in several ways: (Teris Cheung, 2015).

- ✓ Carpal Tunnel Syndrome (CTS)
- ✓ Repetitive Strain Injuries (RSIs)
- ✓ Epicondylitis
- ✓ Hand-Arm Vibration Syndrome (HAVS)
- ✓ Chronic Fatigue
- ✓ Stress

2.6. Ergonomic Assessment Tools

Ergonomic assessment tools are essential for identifying and mitigating risk factors associated with workplace ergonomics. These tools help evaluate the physical demands of tasks, assess the fit between workers and their environments, and recommend improvements to reduce the risk of musculoskeletal disorders (MSDs) and other injuries(Laura Punnett, 2004). Current techniques for assessing exposure to risk factors associated with WMSDs include self-reports, observational methods, and direct measurement (Okka Adiyanto, 2021). Here are some commonly used ergonomic assessment tools.

2.6.1. Ovako Working Posture Analysis System (OWAS)

OWAS is a simple method for verifying the degree of comfort related to working postures and for evaluating the degree of urgency that must be assigning to corrective actions. In the 1970s, the technique was developed in the metallurgical industries of Finland by Ovako Oy. It is predicated on a categorization of body positions and an examination of job duties. The OWAS method involves using a four-digit code to evaluate the back of the body, arms, and legs in addition to the severity of loads that are present while carrying out a certain task. It is necessary to watch the activity being studied for a duration of roughly thirty seconds. Each step requires the roles and applied attributes to be recorded in accordance with a method of decomposing complex activities. The way that postures, recurring positions, and important positions are distributed is extremely focused. The collection of data and the analysis that follows allow for modifications to the working method to reduce or eliminate potentially dangerous positions (Tzu-Hsien Lee, 2013).

2.6.2. Quick Exposure Check (QEC)

The Quick Exposure Check (QEC) is an ergonomic risk assessment tool designed to evaluate the exposure of workers to various ergonomic risk factors associated with musculoskeletal disorders (MSDs). Developed in the late 1990s by David J. Griffin, QEC is particularly useful in occupational settings to quickly identify high-risk tasks and postures that could lead to MSDs. It assesses four main areas: back, shoulder/arm, wrist/hand, and neck. The QEC involves both worker and observer inputs, combining self-reported discomfort and observed work conditions to provide a comprehensive risk assessment (Ipaki et al., 2023)

2.6.3. Rapid Upper Limb Assessment (RULA)

Rapid Upper Limb Assessment (RULA) is a technique that was devised by McAtamney L. and Nigel Corlett E in the field of ergonomics with the goal of examining and evaluating the work positions that the upper body performs(Ajay Kumar, 2019). Special tools are not needed to measure the posture of the neck, back, and upper body, as well as the function of the muscles and the external load supported by the body. RULA does not take long time to complete and conduct a general scoring of the list of activities indicated to reduce the risk of physical lifting done by the operators. RULA is intended for ergonomics field with a wide area coverage(A H Wibowo, 2020). Additionally, it is a useful tool for novices to gain a basic concept of ergonomics and may support employees in maintaining proper posture(Janice D. Chen, 2014).

The RULA involves assigning a numerical rating to the posture of the upper limbs, neck, trunk, and legs, and another numerical rating for additional factors that strain the musculoskeletal system, such as repetitive action, static loading, and force exertion. These ratings are evaluated using an algorithm to produce an Action Level, which ranges from 1 to 4, and a Grand Score, which ranges from 1 to 7. These scores have consequences for corrective action. The RULA allows the left and right upper limbs to be assessed separately, yielding a Grand Score and Action Level for each side of the body (Janice D. Chen, 2014).

2.6.4. Rapid Entire Body Assessment (REBA)

REBA is a method developed in ergonomics and can be used to assess the quickly work position or posture of an operator's neck, back, arms, wrists, & feet. Apart from that, this method is also influenced by the coupling factor, external loads that are supported by the body and the activities of the workers. REBA assessment process is quick to complete & provides a general score on a list of activities that show which tasks require risk reduction according to the operator's work posture. It is possible to do REBA checks in a small area without bothering the workers. The first stage is taking the worker's posture by taking videos or photos, & the second stage is determining the angles of the worker's body parts, the third stage is determining the weight of the object being lifted, determining the coupling, and determining the worker's activity. finally, calculating the REBA value for the posture in question. By obtaining the REBA value, it can be seen the level of risk and the need for action that needs to be taken to improve work (Pałęga et al., 2019)

Rational for using REBA in ergonomic assessment: It was chosen because it provides a quick, comprehensive evaluation of postural risk across the entire body unlike other methods such as OWAS, QEC, & RULA which either focuses on specific part of the body or lengthy self-reports. REBA is specifically designed to assess dynamic, repetitive, & static tasks typically a firm like garment industries. Its ability to identify high risk postures in a fast-paced varied working environment make it the most appropriate tool for evaluating ergonomic risks(Abdalla Esmaee, 2024), (Melek Hat˙iboglu, 2025).

2.7. The Relationship of Work Productivity & Ergonomics

A fundamental idea was that when an individual is fit enough to work and motivated enough to do so, this can boost output and contribute to an increase in productivity. Health-promoting programs are also involved to target worker's health status to be improved and finally aimed to productivity enhancement and economic. To promote physical and emotional ability, mainly focus on cardiovascular and musculoskeletal problems, job condition, and ergonomic improvement and help them to cope with job stress. These health improvements lead to improved physical and emotional ability to work, which in turn reduce absenteeism and presenteeism There are two main types of productivity loss that can affect productivity in different ways: presenteeism, which is when a worker is at work but produces less because of an illness, and absenteeism, which is when a worker is not present at work. Presenteeism is usually easy to identify and can be calculated by counting the days that a worker is absent from work(Cheryl Jone, 2016).

2.8. Review of prior research on ergonomics, MSD, assessment tools & outcome

Many literatures have been written on ergonomic assessment of work-related musculoskeletal disorder (WMSDs). Out of those, some of the assessment methods are NMQ, REBA, RULA & others.

The study by T. Sakthi Nagaraj and colleagues evaluated ergonomic working conditions among Standing Sewing Machine Operators (SSMOs) in Sri Lanka's textile industry, focusing on the prevalence of musculoskeletal disorders (MSDs) and associated ergonomic risk factors. Unlike previous research that focused on seated work, this study addressed the lesser-studied area of standing work postures.

A Cross-sectional study was employed, it involved 552 randomly selected female sewing machine operators, chosen based on experience and medical history. Data collection included self-reported surveys using the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) and demographic/job-related information. Observational assessments were also conducted using tools like the Rapid Entire Body Assessment (REBA) and Strain Index (SI), led by trained Industrial Engineering officers. Statistical analysis involved both univariate and multivariate ordinal logistic regression to identify key risk factors for MSDs.

The findings showed a high prevalence of MSD symptoms, particularly in the lower limbs and lower back—most notably the knees, feet, thighs, and lower legs. REBA scores indicated that many working postures were at medium to very high risk (scores 4–11), while the Strain Index highlighted medium to high risks for upper extremity disorders. Factors such as age, BMI, marital status, job satisfaction, job stress, walking distance, interest in job rotation, and machine design satisfaction were significantly linked to MSD prevalence. To reduce these risks, the researcher recommended several ergonomic interventions, including anti-fatigue mats, opportunities to sit or lie down during breaks, stretching exercises, and structured job rotation programs. These strategies aim to decrease physical strain and improve the health, comfort, and productivity of standing sewing machine operators. The study stresses the importance of addressing ergonomic risks in standing work environments to promote better occupational health and efficiency.

Farheen Bano, an Associate Professor conducted a study focusing on ergonomic interventions to enhance productivity and safety among sewing workers in the garment industry. The research aimed to identify ergonomic hazards contributing to musculoskeletal disorders (MSDs) and propose solutions to reduce these risks and improve worker well-being.

The study used a Job Factor Questionnaire (JFQ) administered to 39 sewing workers, consisting of 15 questions on work-related discomforts, rated on a scale of 0 to 10. Descriptive statistics and a two-sample t-test were used to analyze the data, comparing it with a similar study from Brazil. Factory visits were also conducted to visually assess environmental hazards such as dust accumulation and machine vibrations.

Key findings revealed major ergonomic concerns. About 65.6% of workers reported taking unscheduled breaks due to discomfort, highlighting inadequate break scheduling. The mean discomfort score for "Performing the same task over and over" was 7.26, significantly higher than the Brazilian study's 4.75 ($p < 0.001$). Other issues included "Working in awkward or cramped positions" (mean 6.59) and "Insufficient breaks" (mean 6.05). Environmental hazards like dust and machine vibration were also identified as contributing factors to worker fatigue and health risks.

To mitigate these issues, the study recommended flexible break allowances, improved environmental controls, and the use of personal protective equipment (PPE) such as dust masks and goggles. Enhancing lighting, reducing dust through better housekeeping, and minimizing machine vibrations were also advised. These interventions are expected to reduce MSD prevalence, improve safety, and increase productivity by addressing both ergonomic and environmental challenges in the workplace (Bano, 2019).

The study by Yifokire Tefera Zele and colleagues examined the prevalence of health problems and demographic characteristics of workers in an integrated textile factory in Ethiopia, with a focus on occupational health issues across departments.

Using a cross-sectional approach, the researchers collected data over a year from factory clinic records, including clinical diagnoses, personal details, and job-related factors. Among 7,992 workers, 3.4% were diagnosed with at least one health condition. Health problems were more common in the textile and garment departments especially respiratory diseases, musculoskeletal disorders, injuries, and ear conditions with textile workers showing notably higher rates of respiratory issues, consistent with previous studies.

The study also found significant associations between health conditions and factors such as work department, sex, age, and education. Compared to the national average of 0.5%, factory workers had a much higher rate of diagnosed health problems, and their outpatient visit rate for work-related issues was about four times the national figure, highlighting a serious occupational health burden. Although limited by incomplete diagnostic coding and lack of detailed exposure data, the study underscores the urgent need for better occupational health surveillance, standardized diagnostic practices, and targeted interventions to reduce health risks in industrial environments.(Zele et al., 2021)

Abate AE conducted a study focused on the ergonomic evaluation of sewing workstations and the prevalence and risk factors of work-related musculoskeletal disorders (MSDs) among sewing machine operators in Ethiopia, specifically within the Desta Garment PLC sewing section.

Using a cross-sectional design, the study collected both primary and secondary data from 217 sewing machine operators selected through purposive sampling. Standardized Nordic MSD questionnaires were used to assess discomfort across different body parts, while the strain index (SI) tool evaluated ergonomic risks to the upper extremities. Logistic regression analysis helped identify significant personal, job-related, and ergonomic factors linked to MSD prevalence.

The findings showed a very high prevalence of MSDs: 93.9% reported lower back pain, 93.3% upper back pain, 76% neck pain, and 65.4% hip/thigh/buttocks discomfort in the past year. Additionally, 52% experienced shoulder pain, 45.8% elbow pain, 40.2% wrist/hand discomfort, and over 30% reported knee and ankle/foot pain. The SI results revealed that 57% of operators were at a hazardous risk level for upper extremity disorders. Significant factors associated with MSDs included workstation comfort, job satisfaction, prior medical history, experience, education, and gender. To address these issues, the study recommended ergonomic improvements to workstation design such as proper seating, optimized work surface heights, and regular assessments. The author emphasized that applying ergonomic principles and responding to worker needs are essential steps toward reducing MSDs, enhancing operator health, and boosting productivity in the garment industry. (AE, 2022)

Shalemu Sharew Hailemariam and Adbaru Esubalew Abate conducted a study aimed at improving ergonomic conditions for sewing machine operators (SMOs) in Ethiopia's garment industry. The research focused on assessing the prevalence of work-related musculoskeletal disorders (WRMSDs) and identifying ergonomic risk factors, particularly those related to workstation design and the sitting chairs used by operators.

A mixed-method approach was used, including observational assessments, the standardized Nordic MSD questionnaire, and ergonomic risk analysis via the strain index (SI). Data collection involved direct observations, structured questionnaires, and anthropometric measurements. Logistic regression analyses helped determine significant risk factors linked to MSDs, focusing on the relationship between ergonomic risks and reported symptoms.

The findings revealed high rates of MSDs, with 93.9% of operators reporting lower back pain, 93.3% upper back pain, and 76% neck pain in the past year. Additionally, 86.6% of operators considered their chairs uncomfortable, correlating strongly with the occurrence of MSDs. Operators with high SI scores (>7) were more than twice as likely to experience MSDs in the neck and upper limbs. In response, the researcher recommended redesigning sewing workstations, especially the chairs, to align with operators' anthropometric data. The proposed ergonomic chair aims to reduce discomfort, prevent MSDs, and improve both safety and productivity. The study underscores the importance of evidence-based ergonomic interventions in enhancing occupational health (Abate & Hailemariam, 2023).

The study by Kiritkumar BK and colleagues focused on the prevalence of work-related musculoskeletal disorders (WMSDs) among sewing machine operators and evaluated working postures using the Rapid Entire Body Assessment (REBA) tool. It also examined whether physical activity levels outside work influenced WMSD risk.

This cross-sectional study involved 100 sewing machine operators aged 19–59, selected through purposive sampling. Data were collected using demographic questionnaires, the International Physical Activity Questionnaire (IPAQ), and ergonomic tools such as REBA and the Quick Exposure Check (QEC). Postural analysis was conducted using Kinovea software, and musculoskeletal symptoms were assessed with the Örebro Musculoskeletal Pain Questionnaire (ÖMPQ). Chi-square tests were used for statistical analysis, with significance set at $p<0.05$.

Results showed that 70% of participants experienced WMSDs, with low back pain being the most common (60%). REBA scores indicated that 55% were at high risk and 44% at very high risk for musculoskeletal issues. The QEC assessment revealed that the neck region was particularly vulnerable. Interestingly, no significant correlation was found between physical activity levels and WMSD risk (r=0.040, p=0.62).

The study concluded that poor working postures significantly contribute to WMSDs and recommended ergonomic interventions, including workstation redesign and posture training. While physical activity outside of work did not show a direct link to reduced WMSDs, promoting regular exercise and exploring structured activity programs were suggested as potential areas for future research to enhance musculoskeletal health in this workforce.

The study by Etika Muslimah and colleagues focused on assessing ergonomic risks among sewing machine operators in the garment industry to reduce musculoskeletal disorders (MSDs). It specifically examined discomfort in the waist, back, buttocks, and calves and evaluated risks related to repetitive tasks and poor workstation design.

Using the Nordic Body Map (NBM) questionnaire and the Assessment of Repetitive Tasks (ART) method, the study surveyed 36 sewing operators through interviews, direct observations, and questionnaires. The NBM identified common pain areas, while the ART method assessed risks linked to repetitive arm/hand movements, force, posture, and workstation conditions.

Results showed that 89% of operators experienced waist pain, 61% reported calf pain, 53% buttock pain, and 50% back pain. The ART results classified all participants as being at moderate risk for MSDs. Contributing factors included prolonged static sitting, lack of back support, and poorly designed workstations. To address these issues, the study recommended several ergonomic interventions: adjusting sewing table heights to 762–787 mm, angling the table 10° toward the operator, and providing ergonomic chairs with proper back support and optional pillows. These changes aim to improve posture, reduce physical strain, and prevent long-term MSDs among sewing machine operators.

2.9. Summarized Literature Survey

Table 1 literature survey

Study	**Focus Area**	**Methodology**	**Key Findings**	**Proposed Solutions**
Evaluation of ergonomic working conditions among standing sewing machine operators in Sri Lanka T. Sakthi Nagaraj, et al. (2019)	Evaluate MSD prevalence & ergonomic risks in standing sewing machine operators in Sri Lanka	Cross-sectional study; 552 female operators; used CMDQ, REBA, and Strain Index (SI)	81% of operators experienced daily MSDs, mainly in the lower limbs and back, affecting work in 69% of cases. 91.5% of operators had medium risk levels based on REBA scores	Anti-fatigue mats, job rotation, posture improvement, stretching breaks, provision to sit/lie down during breaks, ergonomic machine design
Ergonomics Intervention for Increasing Productivity and Safety in Garment Industry Farheen Bano (2019)	WMSDs and productivity	Job Factor Questionnaire (JFQ)	65.6% took unscheduled breaks due to discomfort; 40.6% worked in awkward postures; High JFQ scores showed discomfort from repetitive tasks (mean 7.26) and lack of breaks (mean 6.05).	Ergonomics interventions, proper rest breaks, and safe working environments.
Registered health problems and demographic profile of integrated textile factory workers in Ethiopia. Yifokire Tefera Zele et al. (2021)	Occupational health risks in textile factory workers	Cross-sectional study, clinical diagnosis data,	66% of textile factory workers were diagnosed with at least one disease in a year, with respiratory (34%) and MSDs (29%) being the most common. Injuries caused the most-sick leave exposures.	Ergonomic improvements and policies addressing workplace exposures and health risks.
Ergonomic evaluation of workstation for sewing machine operators in Ethiopia. Abate AE (2022)	Assess prevalence and risk factors of WMSDs among sewing operators	Cross-sectional; 217 participants; Nordic MSDs questionnaire, strain index,	High WMSD prevalence: lower back (93.9%), upper back (93.3%), neck (76%); major risks linked to poor seating, uncomfortable environment, low job satisfaction, and high strain index scores	Improve seating ergonomics, enhance work environment comfort, promote physical activity, improve job satisfaction, and conduct regular ergonomic assessments

Prevalence of work-related musculoskeletal disorders and analysis of working posture using rapid entire body assessment tool amongst the sewing machine operators in a garment industry Kavita et al (2023)	Prevalence of WMSDs, posture risk, and PA influence	Cross-sectional; 100 operators; ÖMPQ, REBA, QEC, IPAQ tools	70% had WMSDs (mostly low back pain); 55% high risk, 44% very high (REBA); 100% neck at very high risk (QEC); no PA correlation	Ergonomic workstation changes, posture training, regular assessments, physical conditioning, awareness programs
Improving work-related musculoskeletal disorders for sewing machine operators in Ethiopia. Adbaru E. et al. (2023)	Work-related musculoskeletal disorders	Standardized NMQ, SI assessment tool	93.9% had lower back pain, 93.3% upper back, and 76% neck issues; 86.6% reported uncomfortable chairs, increasing MSD risk.	Redesign of sitting chairs based on anthropometric measurements, ergonomic interventions to reduce pain & discomfort.
Ergonomic Assessment of Sewing Machine Operators to minimize Musculoskeletal Disorders. Etika Muslimah et al. (2024)	Identifying MSD risks in sewing operations	Nordic Body Map (NBM) and ART (Assessment of Repetitive Tasks) applied to 36 sewing operators	High complaint rates: waist (89%), right calf (61%), buttocks (53%), back (50%), All operators fall under "moderate" risk level in ART assessment	Use ergonomic chairs with back support -Redesign workstation, adjust work layout for accessibility & comfort, regular machine check -Educate workers on ergonomic practices
Prevalence and risk factors of musculoskeletal disorders in garment workers in Malaysia. Nurshatira et al. (2024)	MSDs and ergonomic risks in garment workers	Cross-sectional study, RULA assessment tool	Over 50% of garment workers reported MSDs. Notably, the upper back (85.6%), wrists/hands (75.4%), shoulders (74.9%), neck (72.7%), and lower back (72.7%) were the most affected areas. 39.5% of workers were at medium ergonomic risk, 30.9%	Systematic ergonomic interventions, adjustable workstations, ergonomic tools, and training on safe practices.
Ergonomic Assessment in the Apparel Industry Using Rapid Entire Body Assessment (REBA) Among Workers in India in Finishing Department. Arna Dey et al (2025)	Assessment of ergonomic risks and musculoskeletal disorders among garment workers	REBA analysis on 35 workers, video/photo observation using Kinovea,	Medium ergonomic risk (REBA score: 4–5) across tasks like ironing, packing, stain removal. Poor posture, prolonged standing, and repetitive tasks elevate MSD risk	Redesign workstations posture Implement ergonomic interventions in finishing tasks Use lighter irons, provide adjustable tables - Promote posture training and frequent breaks

2.10. Literature Gap

Research in ergonomics within Ethiopia's textile industry remains limited, particularly in in relation to the specific operational context of large garment factories like ALMEDA Textile. Additionally, Garment industries utilize various production system such as progressive bundle system, unit production system, and modular production system, each with unique workstation designs and ergonomic demands. In the case company, which utilizes the progressive bundle system, input arrives in bundles of 15-100 pieces, depending on fabric thickness. These bundles are maneuvered back and forth, often from either side of the operator, requiring lifting and twisting actions. However, many workstation designs fail to accommodate these physical demands resulting in poor ergonomic condition. Moreover, while previous studies have often examined some individual ergonomic risk factors in isolation, this study specially incorporate four major domains demographic, job-related, psychological, & physical into a unified analytical framework. By applying tools Such as the Rapid Entire Body Assessment (REBA), Cornell Musculoskeletal Disorder Questionnaire (CMSDQ), & Work Productivity & Activity Impairment (WPAI) questionnaire, this study develops a comprehensive model linking workplace ergonomics to both musculoskeletal health outcomes and productivity loss. This multidimensional approach enables more accurate & holistic understanding of how the accumulative effect of poor ergonomic design influence the development of musculoskeletal disorder & productivity loss.

2.11. Hypotheses

Based on previous research findings, four hypotheses have been developed to examine the relationships between dependent and independent variables, particularly regarding the factors associated with the intensity of WMSD symptoms and implication to productivity. The validity of these hypotheses will be evaluated using logistic regression analysis.

$H0_1$: Demographic risk factors have no significant effect on the occurrence of musculoskeletal disorders (MSDs) among garment operators.

H1: Demographic risk factors have a significant effect on the occurrence of MSDs among garment operators

$H0_2$: Job-related risk factors have no significant effect on the occurrence of MSDs among garment operators.

H2: Job-Related risk factors have a significant effect on the occurrence of MSDs among garment operators

H_{03}: Psychological risk factors have no significant effect on the occurrence of musculoskeletal disorders (MSDs) among garment operators.

H3: Psychological risk factors have a significant effect on the occurrence of MSDs among garment operators

H_{04}: Physical risk factors have no significant effect on the occurrence of musculoskeletal disorders (MSDs) among garment operators.

H4: Physical risk factors have a significant effect on the occurrence of MSDs among garment operators

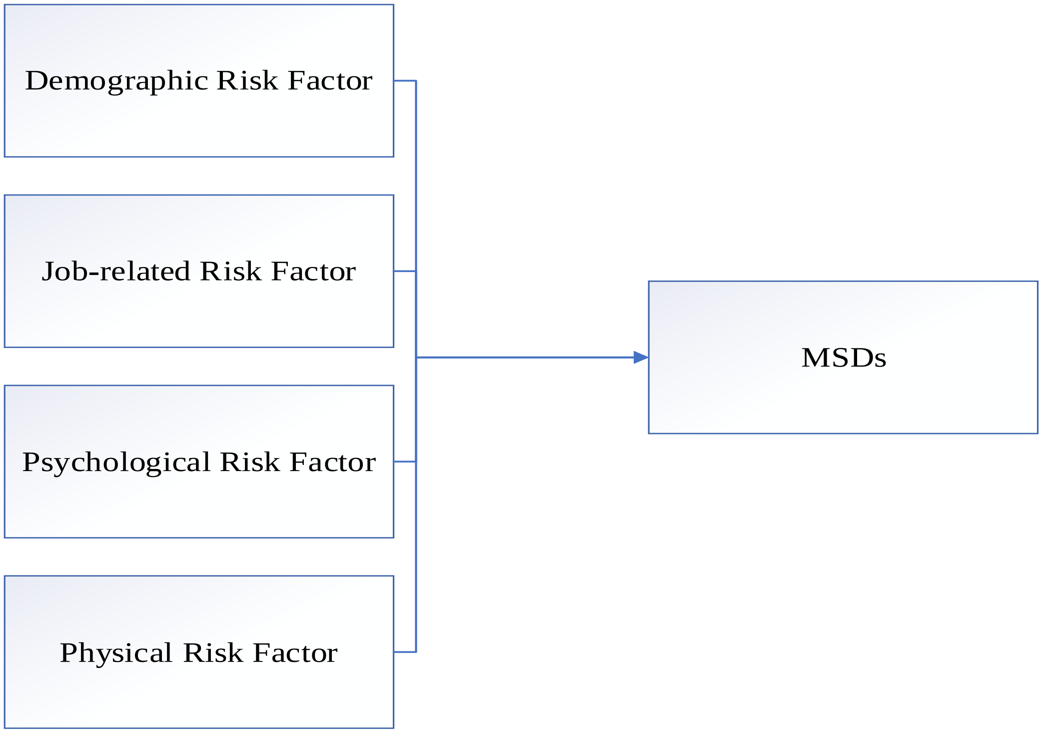

Figure 2 Hypothetical model.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. The Research Design

The study utilizes a cross-sectional research design to investigate the impact of ergonomic risk factors on musculoskeletal disorder MSDs & the implications to productivity among garment operators at ALMEDA Textiles. The cross-sectional approach allowed the collection of data at a single point in time providing a snapshot of current workplace ergonomics condition, health outcomes, and productivity levels.

A mixed method data collection strategy was adopted, combining both observational assessment and self-reported questionnaire to ensure a comprehensive understanding of ergonomic risks and their effects. Specifically:

- The **Rapid Entire Body Assessment** (REBA) tools were utilized to systematically evaluate workers postures during task execution, identifying high-risk movement and awkward positions that contribute to physical strain.
- The **Cornell Musculoskeletal Discomfort Questionnaire (CMSDQ)** was used to assess the prevalence, intensity, and frequency of musculoskeletal symptoms reported by the operators across various body parts.
- The **Work Productivity and Activity Impairment (WPAI)** questionnaire measured the extent of productivity loss, both in terms of absenteeism and presenteeism, due to work-related discomfort or health limitations.

To ensure proper representation across the workforce a stratified random sampling technique was employed. Operators were stratified based on their work section cutting, sewing, and finishing from which a total sample of 316 operators initially selected. After accounting for non-responses, 284 valid responses were retained and analyzed.

In addition, anthropometric measurements (e.g., body dimensions, weight, workstation measurements) were taken to inform ergonomic workstation design and assess physical compatibility between workers and their work environment.

The quantitative data collected were analyzed using a combination of descriptive statistics, Pearson correlation test and multiple regression analysis to examine the relationships between ergonomics risk factors, the occurrence of MSDs, and the extent of productivity loss.

While the cross-sectional design provides valuable insight into the current state of ergonomic risks and their effects, it inherently limits the ability to establish causal relationships. Nevertheless, the study offers critical base line data to inform future ergonomic interventions.

Ethical approval was secured from the relevant institute review board, and all participants provided informed consent. Confidentiality and anonymity were strictly maintained throughout the data collection & analysis processes.

3.2. Description of The Case Study Company

ALMEDA Textiles is a privet manufacturing enterprise established in 1989 in accordance with the commercial code of Ethiopia. With in initial share capital of 180,000,000 Birr, the company emerged as one of largest integrated textile and garment manufacturers in the country. Strategically located 7 Km from the center of Adwa town on the main road to Axum, ALMEDA Textiles played a significant role in the local economy by creating employment opportunities & contributing to Ethiopia's textile sector. However, the factory was severely affected by the armed conflict that occurred on the Tigray region. As a result of the war, production of halted, infrastructure was damaged, & production were disrupted for an extended period. The factory experienced a major setback in terms of physical assets.

Currently, ALMEDA Textiles is a phase of revitalization. Though its full operational capacity has not yet been restored, the company has resumed limited production activity with a focus on garment manufacturing. Instead of producing its own textiles as its once did, the company now outsource woven and knit fabrics from external suppliers. This shift has enabled the company to gradually return to the market while rebuilding its infrastructure, workforce, & supply chain networks.

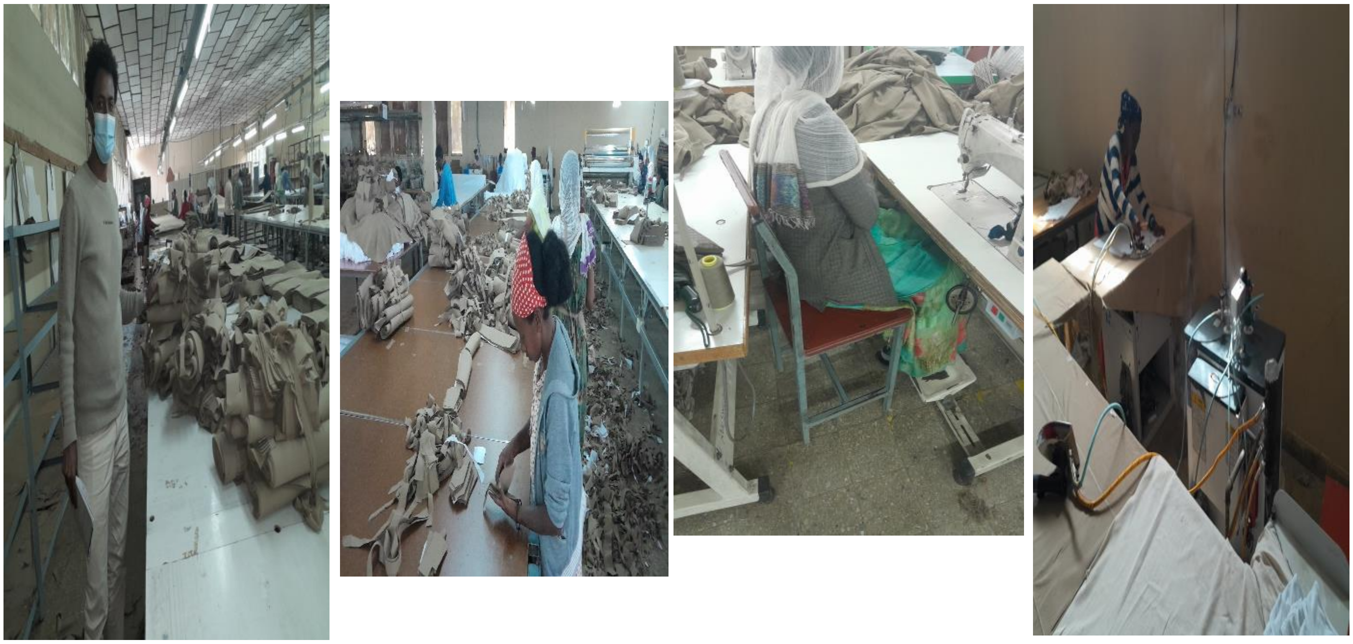

Figure 3 ALMEDA Textiles Garment Department in a Glance

3.3. Data Collection Methodology

In this study both primary and secondary data collection method have been employed to obtain relevant data regarding to the investigation of ergonomic condition of the garment operators of ALMEDA Textiles.

3.3.1. Primary Data

The data collection method is done by direct observation of activities, situation, working condition, and work-related questionnaires incorporating with ergonomics assessment tool (REBA). The REBA tool, work-related questionnaires, and a mobile camera were employed as a particular instrument. REBA assess the risk of WMSDs of the operators & the prevalence of musculoskeletal disorder occur during performing the operation in ALMEDA Textiles. The responses are collected using paper-based questionnaire and observation of working conditions during daily activity are recoded using mobile camera and put the score into REBA scoring sheet, findings were utilized to ascertain the prevalence of MSDs and related variables in the study's chosen company.

3.3.2. Secondary Data

Secondary data are obtained from a wide range of sources to provide comprehensive background and support for the study. Those sources included peer reviewed journal articles, authoritative textbooks on ergonomics and occupational health online databases for updated statistics and case studies, internal company manuals detail current practices and historical data, monthly data reports from ALMEDA Textiles, and reviews conducted either internally or by external bodies. This diver's array of sources ensured a well-rounded understanding of the ergonomic conditions and their impact on the garment operators at ALMEDA Textiles.

3.4. Data collection Instruments and Equipment

To facilitate accurate ergonomic assessment, a combination of observational and measurement tool was employed:

A **high-resolution mobile camera** was used to capture both photographs and video recordings of the operators during task performance, the video record allows repeated reviews of posture and movements allowing for detailed analysis of awkward or sustained position, as required by REBA assessment.

A **measuring tape** was utilized to collect anthropometric and workstation related data, including operator height, seat heat, seat pan width, thigh clearance, knee clearance, table height and sewing machine height. These measures supported the evaluation pf workstation design and its compatibility with operator's dimensions.

A **standard protractor** was employed to estimate the angle of the operator's joint postures from the captured images, aiding in the accurate scoring of postural risk factors.

A **digital weight scale** was used to measure the body weight of the operators, contributing to a more comprehensive ergonomic profile and risk evaluation.

Together, these tools enabled a reliable and systematic collection of data essential for the postural risk assessment and ergonomic evaluation.

Figure 4 Mobile camera.

Figure 5 Tape measurement.

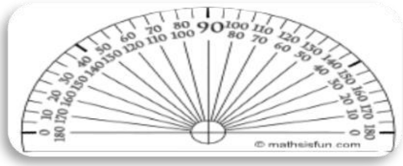

Figure 6 Protractor.

Figure 7 Weight balance.

3.5. Data Analysis Tools

To get the accurate outcome from the study the collected information or data must be analyzed. Various tools have been used in different research's in analyzing data. The data analysis in this study utilized both descriptive and inferential statistical mothed to evaluate the r/ship between various factors and severity of MSDs among the operators. Descriptive statistics summarized the data, provides means, frequency, and percentage. Inferential analysis employed logistic regression to test the formulated hypotheses, examining the influence of demographic, psychological, physical, job-related risk factors on MSDs. REBA, CMDQ and other job-related questionnaire were utilized for primary data collection while secondary data supplemented the analysis. A regression model was used to test the relationship between the variables. Multiple regression was used to help indicate if selected variables have a significant relationship with MSDs and to indicate the relative strength of different independent variables effect on MSDs. The algebraic expression of the regression model which consists of constant term coefficient & error term took the format below:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + e$$

Where:

- Y = Musculoskeletal Disorder (MSDs)
- β0 = constant

- β1, β2, β3, β4= Co-efficient
- X_1 = Demographic Risk Factor (MSDs)
- X_2 = Job-related Risk Factor (JOB_R)
- X_3 = Psychological Risk Factor (PSY_R)
- X_4 = Physical Risk Factor (PHY_R)
- e = residual error

Diagnostic tests namely test for normality, linearity, multicollinearity, and autocorrelation were conducted to ensure that the data met the assumptions of regression All analysis were conducted using SPSS V27. Regression analysis was performed at a 95% confidence level. Findings were presented using tables, figures & diagrams. Furthermore, the proposed design of the ergonomic chair was developed using solid-works 2022 SP1 V20.

3.6. Ethical Issues

Ethics are standards that regulate human behavior & have a big influence on people's wellbeing (Kothari, 2004). This investigation was carried out in alignment with established ethical standards for research. Prior to data collection, permission to perform the research was garneted from ALMEDA Textile management. Participants were received information about the purpose, objective, & the anticipated result of the study. All respondents gave their informed consent, & participation was entirely voluntary. Respondents were assured that their information would be kept privet & anonymous & that they could leave the study at any time without facing any repercussion the data gathered was solely used for academic purpose and handled with strictly confidentiality. Ethical approval was sought & obtained from the school of mechanical and industrial engineering, Ethiopia institute of technology-Mekelle, Mekelle University.

3.7. Research Method and Procedure

The study followed a structured sequence of methods and procedures to ensure reliable data collection, analysis and data collection the process was carried out in the following steps.

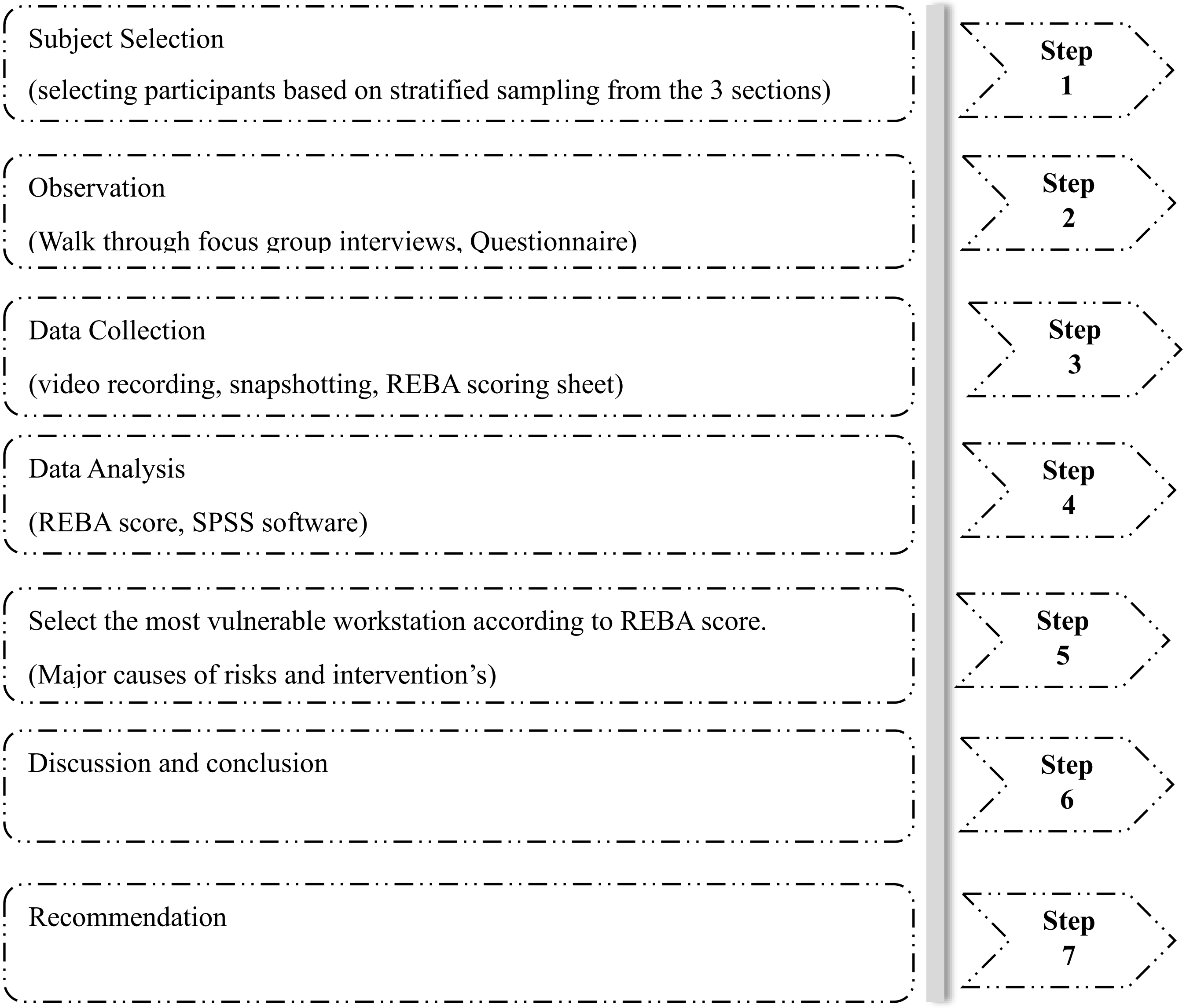

Figure 8 procedure of the study.

3.8. Pilot test

A preliminary study was carried out to determine the MSDs as well as the research instruments practically, clarity, & dependability before to the start of full-scale data gathering process. Sample to be used in preliminary study should be 10% of the total population (Paul A. Ogula, 2005).

To work on this reliability test was employed, Reliability is the degree to which a data collection instrument will yield consistent data & Cronbach alpha was used to calculate reliability. As Cronbach's alpha establishes the internal consistency (Taherdoost, 2016). Analysis of the preliminary data yields a Cronbach's alpha coefficient of 0.899 which is in the acceptable level.

3.9. Validity of instrument

Validity refers the degree to which a data gathering tool accurately measures what it's supposed to measure. Both content validity and face validity were assessed to ensure the precision and stability of the study tools (Taherdoost, 2016); (Korhonen et al., 2022).Content validity was determined subject matter experts in ergonomics, health experts, industrial engineers and statisticians. The questionnaires covering demographic, job-related, psychological, physical risk factors & MSDs symptoms were reviewed to ensure sufficiently captured the constructs to be measured. Whereas REBA, WPAI, CMSDQ all are internationally acknowledged. Face validity was assessed through the pilot study. Based on the comment, adjustment was made to wording & translation to make sure cultural & linguistic clarity. Specially in the Tigrigna translated version. This step improved the instrument validity ensuring that the collected data would be a true representation of the ergonomic & health condition of the garment operators at ALMEDA Textiles

3.10. Subject (Participant) Selection

The subject selection is based on the employee who work on the garment department which are specifically garment operators. Currently, the company works 16 hours, therefore there are two shift each shift is 8 hours per shift, ALMEDA Textiles has a total of 971 operators in three key garment department: cutting, sewing, and finishing. Specifically, the cutting section consists of 49 operators, the sewing section has 856 operators, and the finishing section includes 66 operators. To ensures representation from each section based on their proportion in the total workforce, stratified random sampling was applied.

Cutting section = 49

Sewing section = 856

Finishing section = 66

And the total population (N) is 971 Sampling error = 95% or 0.05

Sampling size??

N = 49 (cutting section) + 856 (sewing section) + 66 (finishing section)

Then based on the TARO YAMANE method of sampling from the total population then the sample size (n) will determine. now calculate the number of operators to sample from each stratum using proportional allocation. The formula is,(Adam, 2020).

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

Where:

- N is the whole population that is under study = 971
- e is the precision or sampling error = (95% or 0.05)
- n is the total sample size

$$\text{n} = \frac{971}{1 + 971(0.05)^2} = 284$$

3.10.1.Adjustment for Nonresponse Rate

Since some participant may not respond, the sample size was adjusted using non-respondent formula to make sure enough data for analysis. This adjustment accounts for potential non-response by increasing the sample size based on non-response rate; is determined by

$$n_{\text{Adjusted}} = \frac{n}{1-non\ responce\ rate}$$ (C.R.Kothari, 2004)

Where:

- n $_{\text{Adjusted}}$ = adjusted sample size
- n = initial sample size
- non-respondent rate = expected non-respondent rate

Then, the adjusted non-respondent rate as of 10%

$$n_{\text{Adjusted}} = \frac{284}{1-0.1} = 315.556$$

Therefore, the adjusted sample size 316 operators

then for cutting section ($\text{N}_1 = 49$)

$$n_1 = \frac{N_1}{\text{N}} * \text{n}$$

$n_1 = \frac{49}{971} * 316$ $\text{n}_1 = 15.95$ which is 16 operators

For sewing section ($\text{N}_1 = 856$)

$n_2 = \frac{856}{971} * 316$ n2 = 278.57 which is 279 operators

$n_2 = 278.57$ which is 279 operators

For finishing section ($N_3 = 66$)

$$n_3 = \frac{66}{971} * 316$$

$n_3 = 21.475$ which is 21 operators

Now, random selection was utilized (use a random number generator or draw names from a list to ensure randomness in each stratum)

Table 1 Summarized of Proportional Sample Size Allocation

Section	**Total Operators (N_i)**	**Sample Size (n_i)**
Cutting	49	16
Sewing	856	279
Finishing	66	21
Total	**971**	**316**

The Taro Yamane formula is used to determine the sample size for this study because it's a simple, efficient, and widely accepted method for calculating sample size in finite population. With a known population size of 971 garment operators at ALMEDA Textiles Plc, the formula ensured a statistically representative sample size of 295 operators with a 95% confidence level and a 5% margin of error. This approach balances accuracy and practicality, allowing for reliable and generalizable results while remaining feasible for data collection. Before proceeding to the result let's see general characteristics of the risk factors and MSD.

CHAPTER FOUR: RESULT AND DISCUSSION

4.1. Introduction

This chapter deals with the analysis and interpretation of the findings of the data obtained from questionnaires, interview, observation, and document analysis. Both quantitative and qualitative data analysis techniques were used. The data obtained from questionnaire were analyzed using frequency, mean, standard deviation and regression. It also presents and discusses the study findings. Which includes characteristics of the demographic, job-related, psychological, and physical risk factors and MSDs with its implication to productivity along with posture analysis using REBA. This chapter is structure in two parts descriptive and inferential analysis

4.2. Survey Session

The rational of this study was to evaluate the impact of ergonomic risk factors on musculoskeletal disorders and their implication to productivity through REBA tool at ALMEDA Textiles. Regarding to those items a 5-point liker scale from strongly agree (5) to strongly disagree (1), are being employed. The questionnaire was translated from English to Tigrigna and the content includes Demographic Risk Factors (age, gender, marital status, education, Body Mass Index etc.) Psychological Risk Factors (work overload, poor work management, poor working r/ships etc.), Job Related Risk Factors (previous training on health and safety, job satisfaction payment mothed etc.) and physical risk factors (repetitive movements, awkward postures, and forceful exertions). Also, for identifying the perceived musculoskeletal discomfort, this study used Cornell Musculoskeletal discomfort questionnaire (CMDQ) developed by Dalen Hedge in 1999. CMDQ is a subjective rating scale for the participant discomfort from work, for measuring the productivity loss I used Work Productivity and Activity Impairment (WPAI) Questionnaire.

4.3. Response Rate

Table 2 Response Rate

Section	No. of questionnaire distributed	No. of questionnaire returned
Cutting	16	15
Sewing	279	260
Finishing	21	20
Total	**316**	**295**

A total of 295 provided questionnaires were returned out of 316 possible questionnaires as shown in the table 11. And this implies a response rate of 93.35 % which is adequate as it exceeds than the average based on Yehuda Baruch and Brooks C. Holtom (Yehuda Baruch, 2008). Twenty-one (6.65%) questionnaires were not returned out of 316.

4.4. Reliability Result

Cronbach's alpha was used to assess the reliability of the questionnaire.

Table 3 Reliability test result

Variables	Cronbach's alphas coefficient	N of items
Job-related Risk Factors	0.703	6
Psychological Risk Factors	0.892	6
Physical Risk Factors	0.82	9
MSDs	0.901	54
Average	0.829	

An average coefficient of 0.829 was attained with all variables recorded coefficient of all variables are above. This shows that good reliability of the study instrument, reliability is based on the correlation coefficient between two variables with the data falling between a 0, which indicates no reliability, and a 1 which will indicate perfect reliability (General rule of thumb for interpreting Cronbach's Alpha is 0.7 – 0.8 acceptable 0.8-0.9 good and above 0.9 excellent),(Karnia, 2024).

4.5. Demographic Risk Factors Characteristics of Respondent

Table 4 Demographic risk factors associated with MSDs

Category of variable		**Frequency (n = 295)**	**%**
Age	<22	2	0.7
	22-31	81	27.5
	32-41	144	48.8
	>42	68	23.1
Gender	Male	9	3.1
	Female	286	96.9
Marital Status	Single	30	10.2
	Married	231	78.3

	Divorced	34	11.5
Educational Level	Primary	87	29.5
	Secondary	181	61.4
	College	27	9.2
Year of Work Experience	≤ 5 years	7	2.4
	6-10 years	93	31.5
	>10 years	195	66.1
Section/ Job Type	Cutting	15	5.1
	Sewing	260	88.1
	Finishing	20	6.8
Monthly Income	<1200	47	15.9
	1200-1700	226	76.6
	>1700	22	7.5
Working Hour	7 - 8 Hours	295	100
Physical Excursive Habit	Yes	25	8.5
	No	270	91.5
Smoking Habit	No	295	100
BMI	Under weight	159	53.9
	Normal weight	109	36.9
	Overweight	27	9.2

NB: BMI=Body Mass index

The demographic data show that most operators were over the age of 22 years, female (96.9%), and married (78.3%), with over 66% having more than 10 years of work experience indicating prolonged exposure to ergonomic risks. The majority work in sewing, a job associated with repetitive movements and awkward postures. Most have only secondary education and earn low monthly incomes, which may limit health awareness and access to care. Additionally, almost all do not exercise, and more than half are underweight, both of which can increase vulnerability to musculoskeletal disorders (MSDs). These factors highlight a workforce at high risk of MSDs and reduced productivity, necessitating ergonomic interventions, health education, and wellness support.

4.6. Job-related risk factor associated with MSDs for garment operators

Table 5 Job-related risk factors associated with MSDs

Category of variable		Frequency (n = 295)	%
Receive Ergonomic Training	Strongly Disagree	125	42.4
	Disagree	157	53.2
	Neutral	13	4.4
Job Satisfaction	Strongly Disagree	56	19.0
	Disagree	120	40.7
	Neutral	35	11.9
	Agree	80	27.1
	Strongly Agree	4	1.4
Adequate Light, Ventilation, & ergonomic seating	Strongly Disagree	79	37.6
	Disagree	145	56.3
	Neutral	39	4.4
	Agree	31	1.7
	Strongly Agree	1	0.3
Availability of Ergonomic Tools (adjustable chair, lifting aids...)	Strongly Disagree	124	42.0
	Disagree	115	39.0
	Neutral	37	12.5
	Agree	15	5.1
	Strongly Agree	4	1.4
Chairs & Tables Comfort, Suitable for Tasks	Strongly Disagree	88	29.8
	Disagree	141	47.8
	Neutral	16	5.4
	Agree	47	15.9
	Strongly Agree	3	1.0
Comfortability & Conductive of Overall Working Env't	Strongly Disagree	60	20.3
	Disagree	159	53.9
	Neutral	36	12.2
	Agree	4	13.6

In Job-related risk factors 295 garment operators had been participated to evaluate their workplace condition, ergonomics training, overall job satisfaction and others. Alarmingly 95.6% of operators reported never received ergonomic training, which implies limited awareness of safe working postures and practices. The result is consistent with (Dereje Dagne, 2020) who also reported lack of ergonomic training among workers with 89.3%. This lack of preparedness can increase vulnerability to injuries and long-term health complication. More than half (59.7%) of the operators are unhappy with their job, indicating potential workplace morale issues (feeling of unvalued, over worked or unsupported). This is result is in line with the findings of (AE, 2022) , (Begashaw & Kassie, 2022) also reported low level of job satisfaction with 67.5%. The majority find their workplace lacking adequate in lighting, ventilation, ergonomic seating, which could contribute to discomfort and reduce productivity and affect health over time. Similarly, 81.0% reported lack of ergonomic tools such as adjustable chairs & lifting aids, which are essential for reducing strain & preventing WRMSD. When assessing workstation comfort 77.6% operators felt their chairs and tables were not comfortable or suitable for their task. Further exacerbating ergonomic risks. This finding is consistent with the study by (Kebede Deyyas & Tafese, 2014) states that about 72.7% their chair is not suitable for task. Moreover, operators found the overall working environment to be uncomfortable & not conductive to work, such poorly design workstation can force workers into awkward posture, increasing the risk of discomfort and chronic injuries. This finding paints a clear picture of operator are struggling with poor working condition limited support and low morale, all of which could have serious consequences for both productivity and operator wellbeing.

4.7. Psychological Risk Factors associated with MSDs for garment operators

Table 6 Psychological Risk Factors associated with MSDs

Category of variable		Frequency (n = 295)	%
Frequent Task Overload	Strongly Disagree	11	3.7
	Disagree	31	10.5
	Neutral	59	20.0
	Agree	120	40.7
	Strongly Agree	74	25.1
Reasonable Amount of Work	Strongly Disagree	80	27.1
	Disagree	112	38.0
	Neutral	51	17.3
	Agree	45	15.3
	Strongly Agree	7	2.4
Management are Effective & Supportive	Strongly Disagree	46	15.6
	Disagree	77	26.1
	Neutral	90	30.5
	Agree	61	20.7
	Strongly Agree	21	7.1
Management Practice Hinders My Performance	Strongly Disagree	3	1.0
	Disagree	26	8.8
	Neutral	148	50.2
	Agree	73	24.7
	Strongly Agree	49	15.3
Good Working R/ship with Coworkers or Supervisors	Strongly Disagree	13	4.4
	Disagree	32	10.8
	Neutral	45	15.3
	Agree	105	35.6

	Strongly Agree	100	33.9
Experience Conflict with Coworker or Supervisor	Strongly Disagree	11	3.7
	Disagree	28	9.5
	Neutral	42	14.2
	Agree	101	34.2
	Strongly Agree	113	38.3

Over two-thirds of workers reported frequent task overload, indicating high job demands that can lead to fatigue, stress, and reduced performance. Only small portion agreed they have a reasonable workload, suggesting most of them faces excessive pressure, which may contribute to burnout. A large portion (41.7%) disagreed that management is effective and supportive, which may lower morale and weaken problem-solving support. Half of respondents were neutral on whether management hinders their performance, which highlights a potential gap in leadership quality and communication. Positively, 69.5% reported good working relationships with coworkers or supervisors, which can buffer job stress. However, 52.2% experienced conflict at work, a concerning factor that can increase tension, reduce cooperation, and hinder productivity.

4.8. Physical risk factors associated with MSDs for garment operators

Table 7 Physical risk factors associated with MSDs

Category of variable		Frequency (n = 295)	%
Repetitive Movement for Prolonged Period	Disagree	12	4.1
	Neutral	23	7.8
	Agree	109	36.9
	Strongly Agree	151	51.2
Frequently Work in Awkward Postures (Bending, Twisting ...)	Disagree	17	5.8
	Neutral	27	9.2
	Agree	123	41.7
	Strongly Agree	128	43.4
Lift, Push, or Pull Heavily Objects Regularly	Strongly Disagree	49	16.6
	Disagree	71	24.1
	Neutral	80	27.1
	Agree	62	21.0
	Strongly Agree	33	11.2
Access to Mechanical Aids (lifting, adjustable workstation) assist with heavy task	Strongly Disagree	99	33.6
	Disagree	119	40.3
	Neutral	45	15.3
	Agree	32	10.8
Prolong Standing or Sitting in a Fixed Position	Disagree	7	2.4
	Natural	11	3.7
	Agree	151	51.2
	Strongly Agree	126	42.7

Experience Fatigue or Discomfort Due to Maintaining Static Posture	Disagree	9	3.1
	Neutral	16	5.4
	Agree	142	48.1
	Strongly Agree	128	43.4
Workstation and Tools are Ergonomically Design to Minimize Physical Strain	Strongly Disagree	143	48.5
	Disagree	136	46.1
	Neutral	11	3.7
	Agree	5	1.7
Use of Vibration Including Tools (Cutting Machine, Sewing Machine...) Frequently.	Strongly Disagree	6	2.0
	Disagree	33	11.2
	Neutral	55	18.6
	Agree	133	45.1
	Strongly Agree	68	23.1
Experiencing Numbness, Tingling, or Pain in My Hands, Arms, or Legs Due to My Work Environment	Strongly Disagree	46	15.6
	Disagree	77	26.1
	Neutral	45	15.3
	Agree	86	29.2
	Strongly Agree	41	13.9

The findings reveal that most operators engage in repetitive hand or arm movements for prolonged periods, this kind of repetition increases strain on joints and muscles, leading to repetitive strain injuries. This is aligned with a study by (van Tulder et al., 2007) highlighted that prolonged, repetitive hand/arm movements significantly increase musculoskeletal strain and RSI such motion leads to tendonitis, carpal tunnel syndrome, and muscle strains. Additionally, most operators frequently work in awkward postures such as bending and twisting, which contributes to ongoing physical stress. Heavy lifting is also a concern, as nearly one-third of operators regularly lift, pull, or push heavy objects, which leads to increasing of in MSDs particularly in the lower back, shoulder, & arms. This finding is partially consistent with (Kiran Mondal, 2019) reported heavier weights, significantly increases spinal compression forces, thus elevating the risk of low back pain. Alarmingly, a large majority of the operators reported lack of access to mechanical aids like lifting equipment or adjustable workstation tools, which are essential for reducing physical strain and preventing injuries. The physical toll is further evidenced by the fact that nearly all operators reported prolonged sitting or standing in fixed positions, leading to discomfort, and nearly as many experience fatigue or discomfort from maintaining static postures indicating high physical strain during working hours. This result aligns with findings from the Fifth Korean Working Conditions Survey (Jo et al., 2021) which reported that 48.7% of full-time workers stood for more than half of their working hours, correlating with increased risks of low back pain, lower extremity muscle pain, and overall fatigue. Ergonomic support remains highly inadequate, as nearly all operators stated that their workstations and tools are not ergonomically designed to reduce physical stress, showing a critical lack of preventive infrastructure. The use of vibration tools, including cutting and sewing machines, was reported by more than two-thirds of the operators, potentially contributing to musculoskeletal strain such as fatigue and nerve-related symptoms. As a result, a considerable number of operators experience numbness, tingling, or pain in their hands, arms, or legs likely due to poor ergonomic conditions. Similar results were reported by (Gerhardsson & Hagberg, 2023) reported nearly 90% of workers exposed to hand-arm vibration, experienced tingling and numbness in fingers and hands. These symptoms are hallmark indicators, potentially worsened by long-term exposure to improper ergonomic practices.

4.9. Musculoskeletal disorder symptoms among the operators

The study assessed the symptoms of musculoskeletal disorder among the 295 participants the table 8 reveals that prevalence of work-related musculoskeletal disorder symptoms

Table 8 Prevalence of MSDs among operators related to the different body parts

Body Part		Prevalence of discomfort in the last week;					Severity of discomfort			Discomfort interfered with work		
		Never	1-2 times last week	3-4 times last week	Once every day	Several times every day	Slightly uncomfortable	Moderately uncomfortable	Very uncomfortable	Not at all	Slightly interfered	Substantially interfered
Neck		16(5.4)	**19(6.4)**	**61(20.7)**	**96(32.5)**	**103(34.9)**	73(28.0)	**99(35.5)**	**107(38.4)**	84(29.6)	**103(36.6)**	**97(34.2)**
Shoulder	(Right)	19(6.4)	15(5.1)	**78(26.4)**	**84(28.5)**	**99(33.6)**	91(33)	**106(38.4)**	**79(28.6)**	102(37.0)	**110(39.9)**	**64(23.2)**
	(Left)	24(8.1)	17(5.8)	**81(27.5)**	**81(27.5)**	**92(31.2)**	119(43.9)	**100(36.9)**	**52(19.2)**	**118(43.5)**	**101(37.3)**	**52(19.2)**
Upper Back		16(5.4)	34(11.5)	59(20)	**85(28.8)**	**101(34.2)**	109(39.1)	93(33.3)	77(27.6)	115(41.2)	118(42.3)	46(16.5)
Upper Arm	(Right)	75(25.4)	64(21.7)	70(23.7)	49(16.6)	37(12.5)	94(42.7)	110(50)	16(7.3)	99(45.0)	92(41.8)	29(13.2)
	(Left)	86(29.2)	73(24.7)	61(20.7)	39(13.2)	36(12.2)	111(53.1)	92(44)	6(2.9)	94(45.0)	94(45.0)	21(10)
Lower Back		9(3.1)	15(5.1)	**61(20.7)**	**99(33.6)**	**111(37.6)**	16(5.6)	**110(38.5)**	**160(55.9)**	46(16.1)	**134(46.9)**	**106(37.1)**
Forearm	(Right)	81(27.5)	72(24.4)	87(29.5)	31(10.5)	24(8.1)	99(46.3)	115(53.7)	0	100(46.7)	100(46.7)	14(6.5)
	(Left)	92(31.2)	66(22.4)	79(26.8)	41(13.9)	17(5.8)	121(59.6)	78(38.4)	4(2)	104(51.2)	82(40.4)	17(8.4)
Wrist	(Right)	96(32.5)	**71(24.1)**	**64(21.7)**	**41(13.9)**	**23(7.8)**	**86(43.2)**	**88(44.2)**	**25(12.6)**	47(23.6)	**67(33.7)**	**85(42.7)**
	(Left)	102(34.6)	**75(25.4)**	**67(22.7)**	**31(10.5)**	**20(6.8)**	**83(43)**	**77(39.9)**	**33(17.1)**	47(24.4)	**68(35.2)**	**78(40.4)**
Hip/Buttocks		89(3.2)	**75(25.4)**	**93(31.5)**	**32(10.8)**	6(2)	**111(53.9)**	**74(35.9)**	**21(10.2)**	138(67.0)	**57(27.7)**	**11(5.3)**
Thigh	(Right)	105(35.6)	86(29.2)	70(23.7)	21(7.1)	13(4.4)	116(61.1)	71(37.4)	3(1.6)	63(33.2)	74(38.9)	53(27.9)
	(Left)	99(33.6)	80(27.1)	77(26.1)	25(8.5)	14(4.7)	95(48.5)	99(50.5)	2(1)	72(36.7))	79(40.3)	45(23)
Knee	(Right)	93(31.5)	**87(29.5)**	**71(24.1)**	**24(8.1)**	20(6.8)	**79(39.1)**	**103(51)**	**20(9.9)**	88(43.6)	**76(37.6)**	**38(18.8)**
	(Left)	88(29.8)	**82(27.8)**	**84(28.5)**	**22(7.5)**	19(6.4)	**101(48.8)**	**93(44.9)**	**13(6.3)**	84(40.6)	**73(35.3)**	**50(24.2)**
Lower Leg	(Right)	98(33.2)	84(28.5)	69(23.4)	26(8.8)	18(6.1)	132(67)	61(31)	4(2)	87(44.2)	101(52.3)	9(4.6)
	(Left)	101(34.2)	87(29.5)	73(24.7)	21(7.1)	13(4.4)	135(69.6)	59(30.4)	0	95(49.0)	88(45.4)	11(5.7)

The study revealed a clear pattern of musculoskeletal discomfort among garment operators. 75.8% of operators are reported symptoms of MSDs specifically in the lower back, with over one-third of workers reporting pain several times a day, followed by the neck, which also showed a high frequency of discomfort. The shoulders were next, with the right shoulder slightly more affected than the left. The knees and wrists were also reported as painful, though to a lesser extent, indicating strain from prolonged sitting or standing and repetitive hand movements. These findings highlight that the lower back, neck, shoulders, knees, and wrists are the key areas of concern, reflecting the impact of repetitive tasks, awkward postures, and inadequate ergonomic support. Similar trends were observed in previous study by (Md Abid et al., 2023);(He et al., 2023) that highlights 31.2% for neck 45.4% for lower back 26.6 for shoulder were the most frequent affected body areas. Among the operators who reported pain, severity peaked in the lower back very uncomfortable, while the right forearm and left upper arm reported at least slightly uncomfortable, demonstrates that less frequent pain can still impact full. When examining work interference specifically among affected operators, the lower back substantially interfered, followed by neck, shoulder, showed notable consequence.

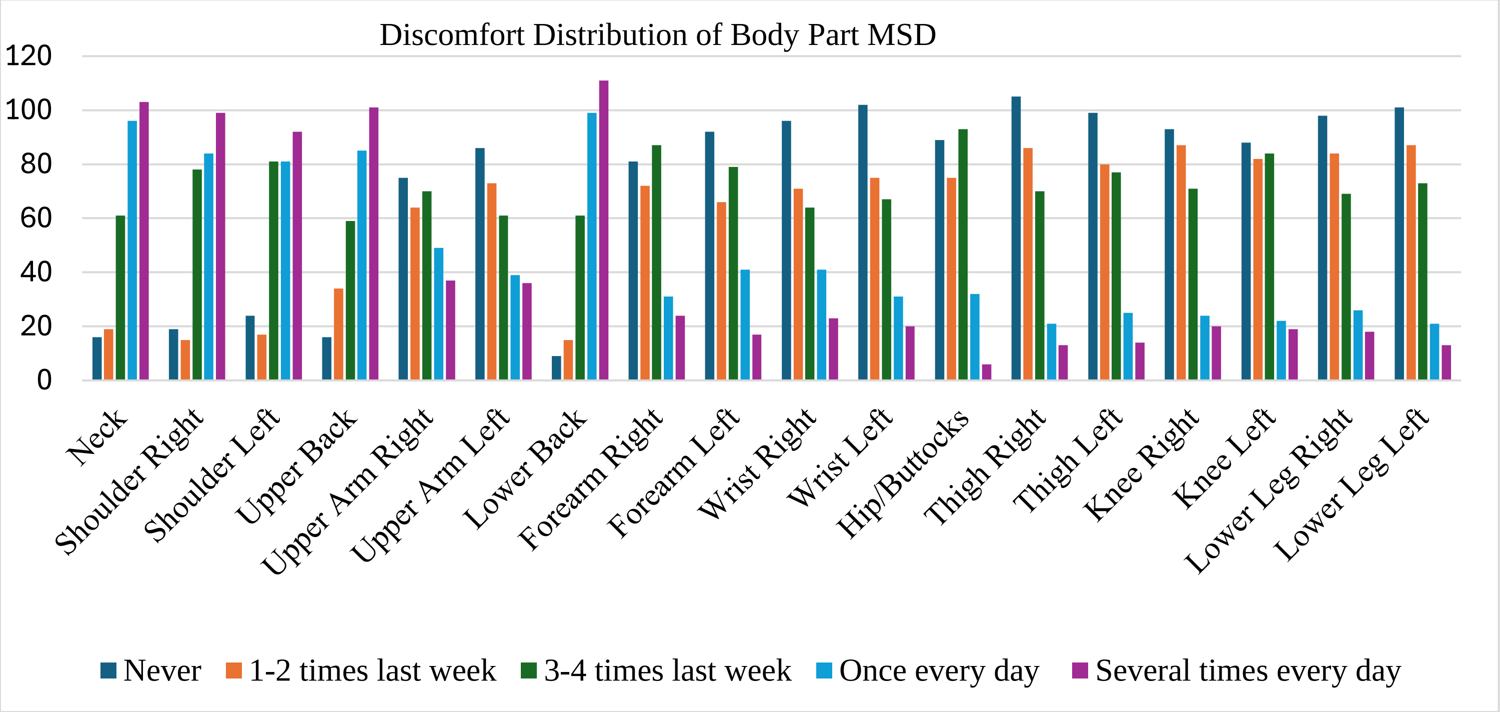

Figure 9 Distribution of discomfort of different body part (WRMSD)

4.10. Normality, Linearity

Numerous parametric statistics include the assumption that some variables have roughly normal distribution that is, the frequency distribution would resemble a symmetrical bell-shaped.

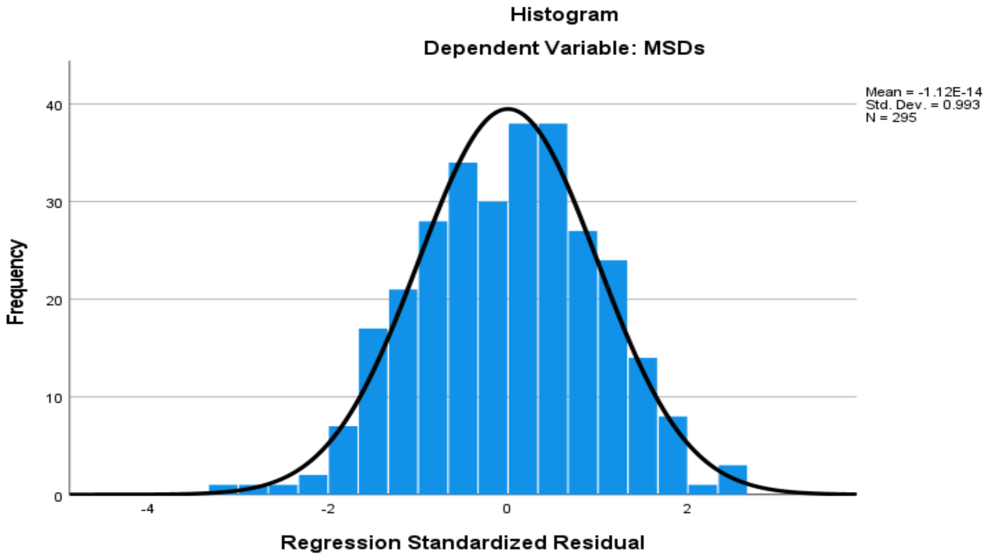

Figure 10 Normality distribution of variables

And a normality of distribution is tested by Histogram. So, it indicates a normal distribution

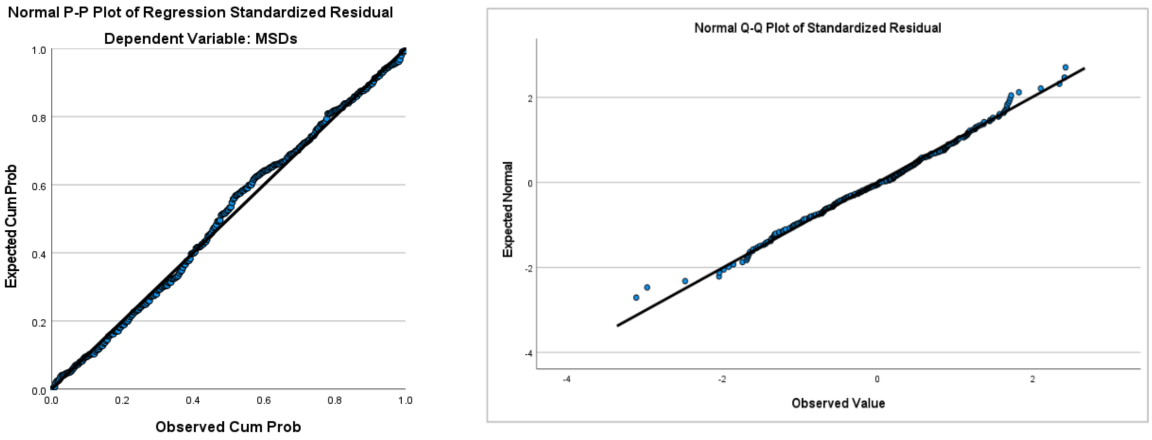

Figure 11 Normal values of the data

The graph (Fig. 11) above illustrates how the response variables' normality was straight or very close to a straight line. Therefore, the distribution is normal. (shows no major violation of normal distribution)

Table 9 Descriptive Standardized residual

		Statistic	Std. Error	Interpretations
N		295		Sample size
Mean		.0000	.057825	Residual centered at zero
95% Confident	L. Bound	-.1138031		Range where the true mean likely falls
Interval for Mean	U. Bound	.1138031		
5% trimmed Mean		.0084833		Mean after removing 5% of extreme value
Median		.0359		middle value of Residual
Variance		.986		variability of Residual
Std. Variance		.9932		spread of Residual (close to 1, as expected)
Minimum		-3.108		largest negative value
Maximum		2.423		largest positive Residual
Range		5.5304		Total spread of Residual
Interquartile Range		1.3836		Spread of middle 50% of data
Skewness		-.159	.142	Approximately symmetrical distribution
Kurtosis		-.247	.283	Slightly flatter tails than the normal distribution

Table 10 Kolmogorov-Smirnova and Shapiro-Wilk Normality test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Standardized Residual	.046	295	.200*	0.994	295	.252

* This is a lower bound of the true significance.

[a] Lilliefors significance correction

The Kolmogorov-Smirnov[a] & Shapiro-Wilk test was used to determine whether the standardized residual was normal. Both tests determine whether the distribution of the data deviates significantly from a normal distribution, the result showed the P-value of .200* for the Kolmogorov-Smirnov[a] & .252 for the Shapiro-Wilk test since both P-values are greater than common significance level of .05, then we don’t have enough evidence to say that the residual are not normally distributed (in a simple term, the test suggests that the residual data is consistent with a normal distribution).

4.11. Linearity Test

When the predictor variables in a regression have a straight-line connection with the result variables, this is known as linearity. You do not need to worry about linearity if your residuals are normally distributed.

4.12. Correlation Analysis

Table 11 correlation analysis Pearson correlation

Pearson Correlation	DEM	JOB_R	PSY_R	PHY_R	MSDs
DEM	1				
JOB_R	.637**	1			
PSY_R	.657**	.750**	1		
PHY_R	.636**	.760**	.811**	1	
MSDs	.703**	.812**	.816**	0.780	1

Correlation is significant at 0.01 level (2-tailed)

The Pearson correlation analysis shows that MSDs are strongly positive corelated with Job-related (r =.812, p-value<0.01), Psychological (r =-.816, p-value<0.01), Physical (r =.780, p-value<0.01) ergonomics risk factors. And this indicate that improvement in the ergonomic risk factor was associated with significant reduction in MSDs frequency. Furthermore, a positive correlation was observed between Demographics characteristics and MSDs (r =.703, p-value<0.01) this also reveals that certain demographic groups were susceptible to MSDs.

4.13. Multicollinearity Test

Multicollinearity refers when two or more independent variables in a regression model are highly correlated. Multicollinearity can be examined using variance inflation factor (VIF) values & correlation coefficient (Upendra et al., 2023). From those the study employed variance inflation factor (VIF) values. VIF is a measure of the extent of multicollinearity in a regression model. It assesses how much the variance of an estimated regression coefficient is “inflated” by the existence of correlation among the predictor variables in the model.

- A VIF 1 indicates no multicollinearity
- VIF < 5: Generally acceptable
- VIF ≥ 5 and < 10 moderate multicollinearities, investigate further if necessary

- VIF ≥ 10 serious multicollinearity problem. Consider removing (combining) variables together

Table 12 multicollinearity test through VIF values

Model	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
	B	Std. Error	Beta	t	Sign	Tolerance	VIF
(constant)	-2.686	.413		-6.512	<.001		
DEM	1.058	.227	.179	4.669	<.001	.511	1.956
JOB_R	0.491	.064	.415	7.633	<.001	.353	2.836
PSY_R	0.306	.049	.399	6.311	<.001	.285	3.515
PHY_R	0.187	.070	.108	2.657	.008	.285	3.512

Table 20 All VIF values are below 5, the highest being 3.515 for PSY_R, & 3.512 for PHY_R. And this refers to that multicollinearity is not major concern.

4.14. Regression Analysis

In this study, multiple regression was carried out. The purpose of the regression analysis was to determine the degree of correlation between the MSDs and the multiple independent variables & to determine the statistical significance of the attempted prediction. The result from the regression also helped us to reveal to what extent operators are being affected by WRMSD. The regression analysis was carried out using SPSS at 95% confidence level.

Table 13 Model Summary [b] the Combined Effect

Model	R	R Square	Adjusted R Square	std. Error the Estimate
1	0.885[a]	0.782	0.779	0.386

[b] Dependent variable: MSDs

[a] Predictors (constant): PHY_R, DEM, JOB_R, PSY_R

The result from the table 13 reveals a strong positive linear relationship between the predictor variables and the dependent variable as indicated by the multiple correlation coefficient are (R) of .885. this means the model predicts MSDs will be based on the combined influence of the predictor variable. Moreover, the R square value of .782 reveal that 78.2% of the variability is explained by these predictor variables, demonstrating a substantial proportion of variance in the dependent variable is accounted for by the model.

Table 14 ANOVA[a] Results for Predictors of MSDs

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	155.428	4	38.857	260.816	<.001[b]
Residual	43.205	290	.149		
Total	198.632	294			

[a] Dependent variable: MSDs

[b] Predictors (constant): PHY_R, DEM, JOB_R, PSY_R

The AVOVA Table 14 shows that the regression model significantly predict the dependent variable MSDs as indicated by the statistically significant F-statistics ($F = 260.816$, $P < .001$), meaning that the independent variable collectively explains a significant portion of the variance in MSDs.

Table 15 Standardized and Unstandardized Coefficients[a] for Predictors of MSDs

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sign
(constant)	-2.686	.413		-6.512	<.001
DEM	1.058	.227	.179	4.669	<.001
JOB_R	.491	.064	.352	7.633	<.001
PSY_R	.306	.049	.324	6.311	<.001
PHY_R	.187	.070	.136	2.657	.008

[a] Dependent variable: MSDs

The unstandardized coefficient in the table 15 can be substituted into the study model to enable prediction of the value of MSDs from the value of multiple independent variables.

$$Y = -2.686 + 1 \cdot 058x_1 + 0.491x_2 + 0.306x_3 + 0.187x_4$$

Where:

- Y = Musculoskeletal Disorder (MSDs)
- X_1 = Demographic Risk Factor (DEM)
- X_2 = Job-related Risk Factor (JOB_R)
- X_3 = Psychological Risk Factor (PSY_R)
- X_4 = Physical Risk Factor (PHY_R)

The regression equation above showed that, if all independent variables were held constant, the MSD score would be -2.686. this is the intercept of regression equation. The beta value shows the relative change in the musculoskeletal disorder outcomes within the respective variable. Demographic risk factors have positive & statistically significant effect on MSD at the 0.05 level (β=1.058, t=4.669, P=0.001). this implies that a one unit increasing DEM results in a 1.058 unit in MSDs. Job-related risk factors have a positive and highly significant effect on MSD (β=0.491, t=7.633, P=0.001). this shows that one-unit increasing in job-related risk factors result in a 0.491 unit increase in MSDs. Psychological risk factors also show a positive and significant effect on MSD at the 0.05 level (β=0.306, t=3.311, P=0.001) this indicates that an increasing psychological stress leads to a 0.306 unit rise in MSDs levels. Physical risk factors have a positive and statistically significant effect on MSDs (β=0.187, t=2.657, P=0.008). this suggests that as physical demand or ergonomic risk increase, so do MSDs complaints by 0.187 units.

4.15. Implication Of Productivity Loss Associated with Musculoskeletal Disorder

This section discusses the implications of productivity loss among garment operators at ALMEDA textiles Plc., with a particular focus on how musculoskeletal disorder (MSDs), stemming from ergonomic risk factors, directly and indirectly impact work efficiency, absenteeism, presenteeism and overall organizational performance. The relationship is examined using both quantitative and qualitative insight derived from the work productivity impairment (WPAI) questionnaire and CMDQ assessment outcomes.

MSDs are widely recognized as a significant cause of productivity loss in the workplace affecting both individual performance and overall organization efficiency. Productivity loss associated with MSDs typically occurs through two primary mechanisms absenteeism and presenteeism. Absenteeism refers to the time workers are unable to attend work due to musculoskeletal pain or injury, while presenteeism describes the reduction in work performance when employees are present but limited by physical discomfort (Bernfort et al., 2021). To quantify these impacts, they can be calculated using the formula:

$$Abs\ (\%) = \left(\frac{Number\ of\ working\ hour\ missed\ due\ to\ MSDs}{Total\ available\ working\ hour}\right) \times 100$$

Similarly, the loss due to presenteeism is measured

$$Pres\ (\%) = \left(\frac{Degree\ health\ problem\ affected\ productivity\ while\ working}{Total\ number\ of\ rating}\right) \times 100$$

Where 0= no effect, 10=complete inability

Let’s do one of the operator’s overall productivity losses from the WPAI questionnaire response

- Hours missed from work due to work-related health problem (Q_2) = 7.33 hour
- Missed work for other reasons (Q3) = 0
- Hours worked (Q4) = 6 days (43.98)
- On scale of 0-10 rate the effect of health on your productivity while you are working = 4

$$Abs\ (\%) = \left(\frac{7.33}{7.33 + 43.98}\right) \times 100$$

$$\text{Abs} = 14.3\%$$

$$Pres\ (\%) = \left(\frac{4}{10}\right) \times 100$$

$$\text{Pres} = 40\%$$

There for the overall productivity of the operator is

- $Overall\ productivity\ loss = Abs + ((1 - Abs) * presenteesim$

$$Overall\ productivity\ loss = .143 + ((1 - .143) * .4$$

$$\text{Overall productivity loss} = .486 \text{ or } 48.6\%$$

Table 16 Summery of overall work productivity loss among the operators

Statistics	Value
Sample Size (N)	295
Missing Value %	0
Mean Productivity Loss %	43.87
Median Productivity Loss %	47.02
mode Productivity Loss %	30.0
Minimum Productivity Loss %	24.68
Maximum Productivity Loss %	77.14
Range %	52.47

The table 16 reveals that the descriptive statistics of productivity loss reported by garment operators. The mean loss indicates that nearly half of the workforce capacity is impaired due to work related musculoskeletal disorder (WMSDs), this finding is aligned with the study by (Rmadi et al., 2023) whose reported with a mean work productivity loss was 44.9%. The range of response from 24.68% to 77.14 highlights the variation in severity across individuals.

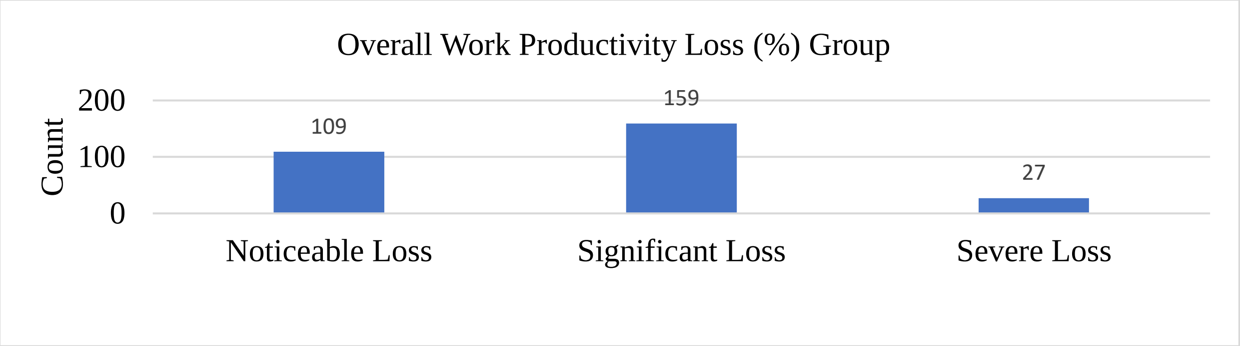

Figure 12 Summery of overall work productivity loss

Table 17 MSDs & Productivity Loss Correlation

Variables	Pearson Correlation (r)	Sig.	N
MSDs ↔ Productivity loss	0.554	.001	295

Correlation is significant at 0.01 level (2-tailed)

A Pearson correlation analysis was conducted to examine the relationship between Musculoskeletal disorder (MSDs) & overall productivity loss. Result showed a moderate, positive, statistically significant correlation between the two variables. This suggests that workers with higher levels of musculoskeletal discomfort are more likely to experience a greater loss in productivity, this result mirrors with the study by (Daneshmandi et al., 2017) higher level of MSDs are significantly associated with a greater productivity loss.

Causal pathway

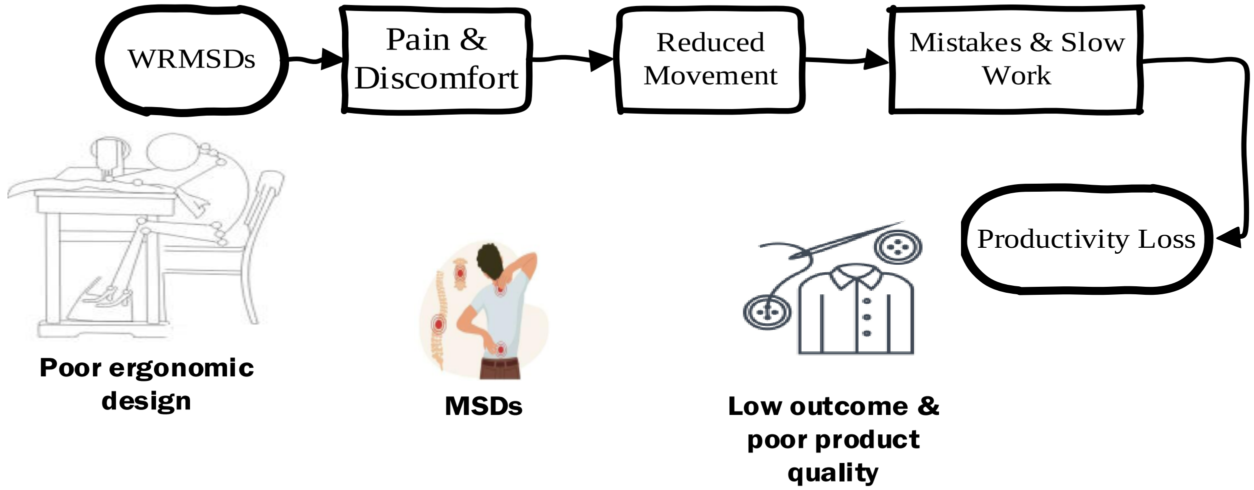

Figure 13 Causal pathway of WRMSD & productivity loss

Table 18 Productivity Loss section wise

Section	Mean	N	Std. Deviation
Cutting	41.8664	15	10.29809
Sewing	44.0024	260	10.19041
Finishing	43.1043	20	10.21315

The analysis of the mean productivity loss across the three sections reveals that the sewing section with mean productivity loss of 44.0024 indicating a greater ergonomic strain and vulnerability. Following by finishing section & cutting section

4.16. Postural observation

In the postural assessment the operators (participant) were observed for over 25 minutes (5th, 10th, 15th, 20th, 25th) while performing their daily tasks on their workstation. For quantifying the observed operators body posture the REBA tool has been utilized. This ergonomic assessment tool evaluates operators (participants) exposure to different posture for prolonged period, forces and muscle activities that have been proven to contribute to RSIs.

In this study REBA is the targeted technique for estimating the risk of work-related entire body disorder by swift and methodical assessment of postural risk of workers, its developed for assessing workers posture for determining risk index of WRMSDs. For each task, postural risks are assessed by assigning score to each associated by region. Appendix B.

Here are REBA postural scoring assessment section wise with its operators conducting their routine activity.

Figure 14 cutting, transporting bundle, & loading fabric roll to spreading machine

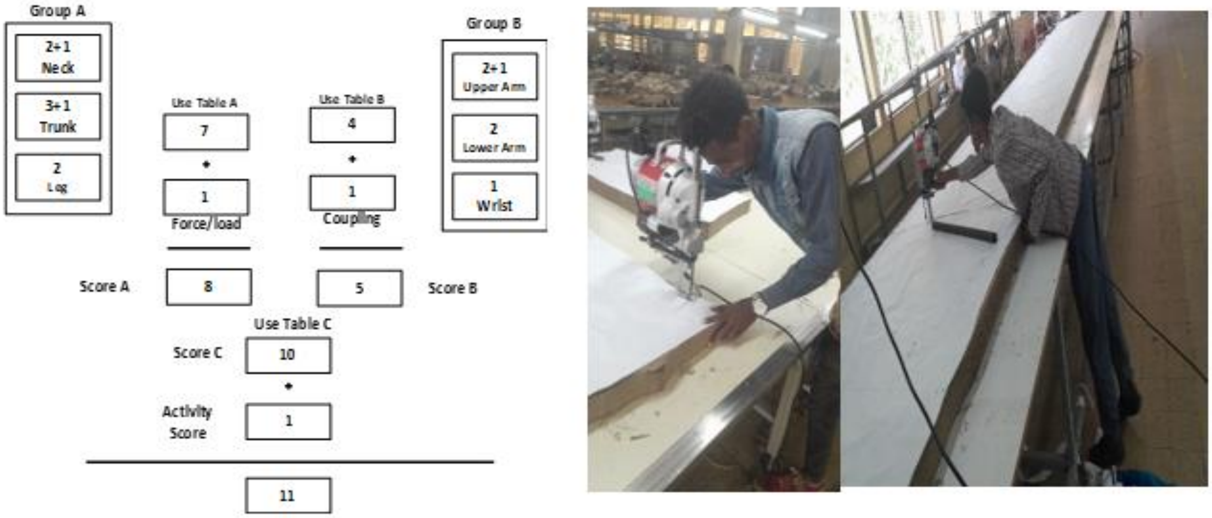

Figure 15 REBA Score and fabric cutting process

The cutting section has different process before getting different panels of the design cutting process is one of them, & it's performed manually by the operator using a straight cutting machine. As shown in the assessment figure 15 the posture involves significant trunk bending & wrist deviation, as well as upper arm elevation. Based on the REBA worksheet, the calculated REBA score was 11, which corresponds to a high-risk level. This indicates the current working task method pose a serious ergonomic hazard to the worker.

Figure 16 sewing with awkward position, flexion neck, & poor sewing layout

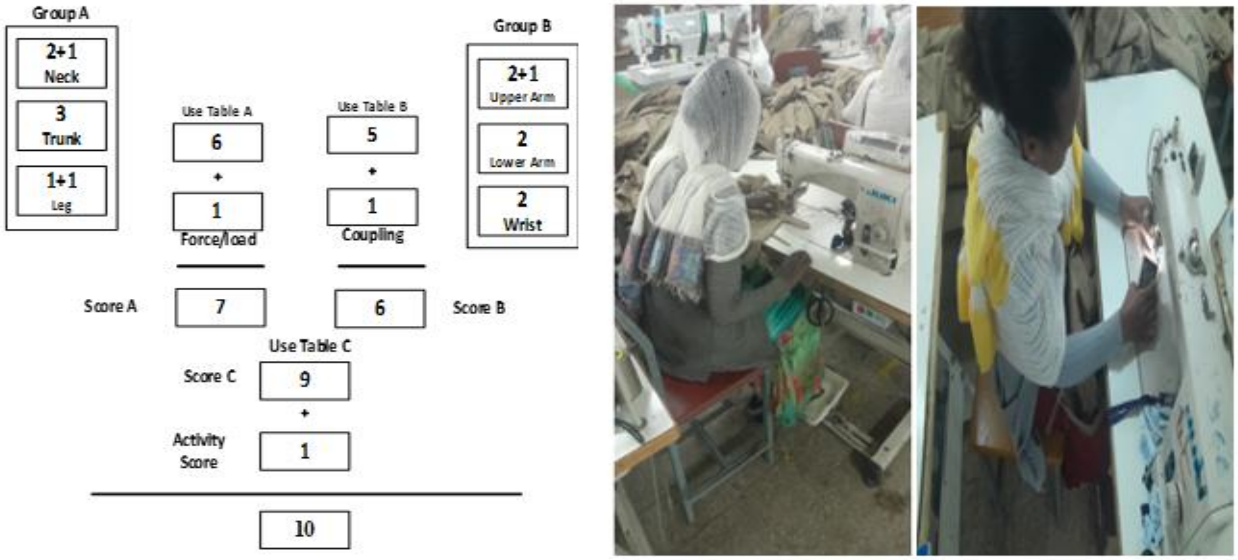

Figure 17 REBA score and sewing operation

In the sewing workstation, operators manually operator sewing machines to assemble different part of garment components. The task involves prolong sitting, frequent forward trunk bending neck flexion, & static upper limb posture while guiding fabric through the machine.

As calculated in the REBA assessment figure 17, for this single operation (operator) the REBA score is 10, corresponding to a very high-risk level. This indicates a significant ergonomic hazard due to awkward & sustained posture.

Figure 18 awkward way of working in packing and ironing

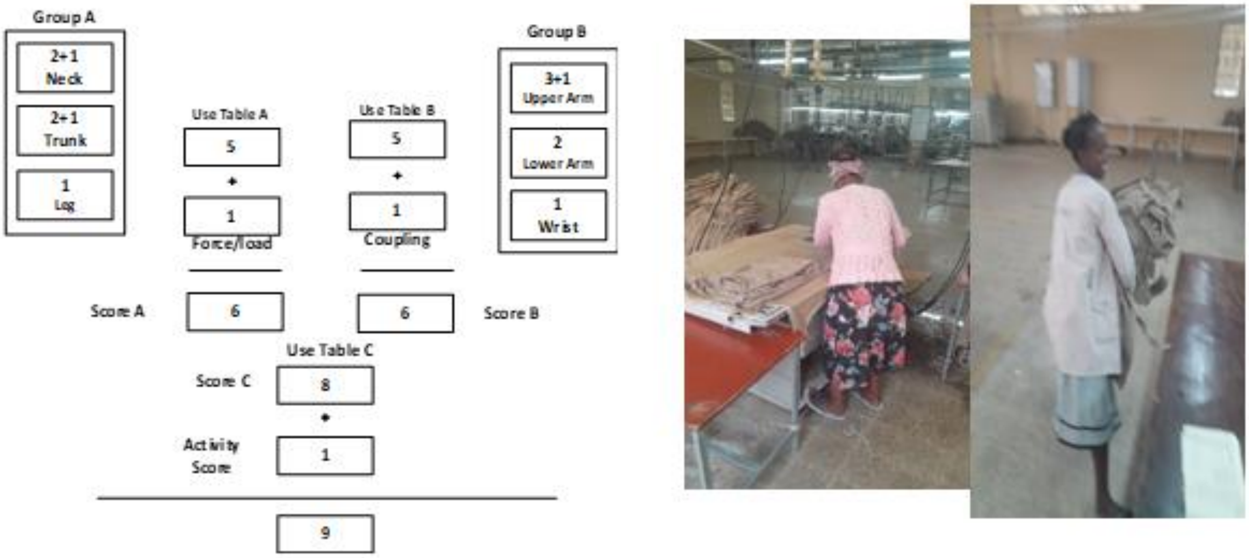

Figure 19 REBA score and ironing, transporting output from sewing to finishing section

In the finishing section, operators are involved in a task such as ironing, folding, washing, packing etc. these activities often required repetitive, frequent trunk bending, & sustained standing postures. As shown in the REBA assessment Fig. 19, the calculated REBA score is 9, which corresponds to a high-risk level. This indicates that the physical demand and awkward posture during finishing operations pose a significant ergonomic risk for musculoskeletal issues, especially in the lower back, neck, knee, & upper limbs.

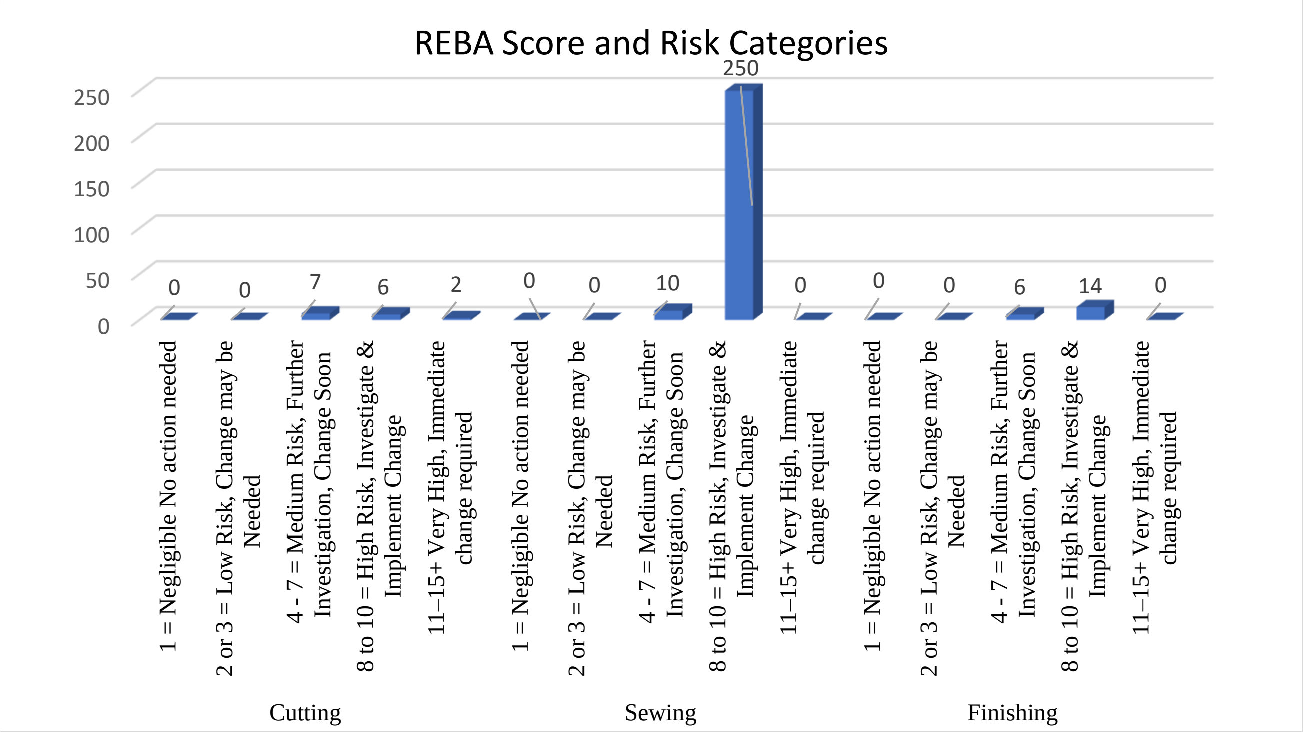

Figure 20 operators REBA score and risk categories

The bar chart illustrates the distribution of REBA which reveals that majority of ergonomics are concentrated in sewing section as its operator intensive in the garment organization. 250 operators falling under high risk, 10 falling to medium risk. Cutting and finishing section also showing notable high-risk scores, this shows sewing as most ergonomically hazardous tasks among the three sections. This finding is predominantly consistent with study by (Das et al., 2023).

Table 19 Frequency of REBA risk level

Variables	Frequency	Percent
Medium 4-7 (investigation further, change soon)	25	8.5
High 8-10 (investigation and implement change urgently)	268	90.8
Very high 11-15+ (immediate change required)	2	0.7

The output from the table 19 shows that out of the total cases assessed, almost all fall into the high REBA risk level, indicating an urgent need for ergonomic intervention. Smaller portion, are at a medium risk level, suggesting that change should be planned soon to prevent future issues. Meanwhile only 0.7are classified under the very high-risk level (score 11-15^{+}) where immediate corrective action is required to address critical ergonomic hazard. The result partially aligns with the conclusions drown in earlier study by (Kiritkumar & Pothiraj, 2023) shows that the sewing machine operators were at 55% & 44% at high & very high-risk level respectively

4.17. Analysis of the most vulnerable workstation

To determine the ergonomic risk in the production area REBA method was used for the three sections (cutting, sewing, & finishing), every & each station was observed & scored according to posture, movement, force, and load. The average REBA score was used to specify the most ergonomically vulnerable workstation.

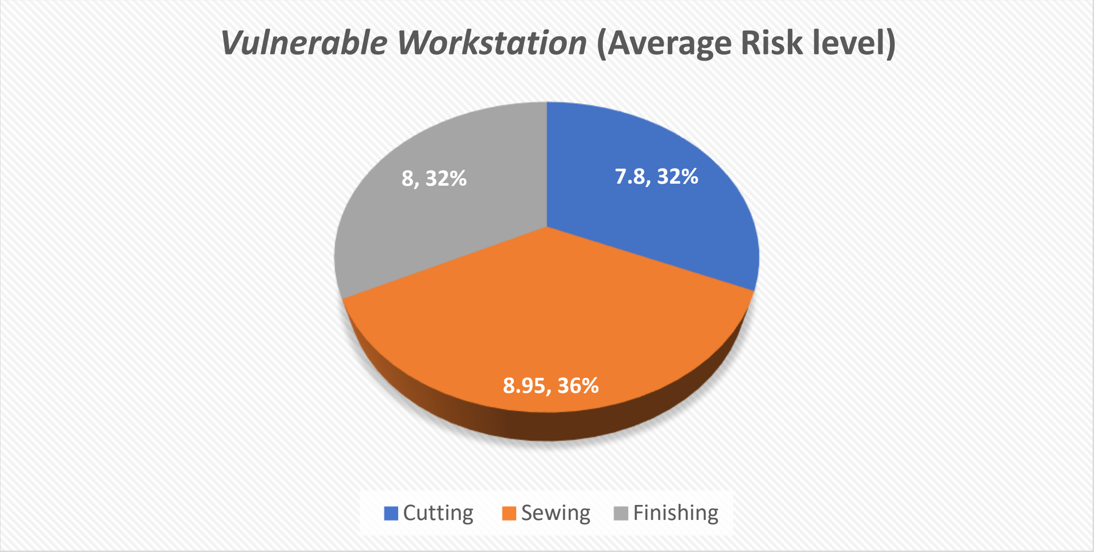

Figure 21 vulnerable workstation according to REBA score (Average risk level)

The pai chart (Fig. 21) reveal that among the evaluated workstations the sewing workstation has the highest average REBA risk score, indicating it's the most vulnerable area requiring urgent ergonomics improvement. Both the cutting and finishing workstation have similar average risk level. Overall, the sewing station poses the greatest ergonomic concern, while cutting & finishing section shows moderately high-risk level that warrant further investigation and corrective measure.

Following the assessment across the three sections (cutting, sewing, & finishing) the workstation with the highest average REBA score was identified as the most vulnerable in terms of ergonomics risks. The work in sewing section demands continuous focus and precision, as operators must ensure the needle follows the intended sewing line this task often results in sustained trunk flexion, with operators leaning forward for extended period due to non-adjustable heights and poor visibilities. Additionally, repetitive upper limp movement such as guiding garment component and operating the sewing machine place considerable strain on the shoulder, elbows, wrists, & fingers(Habib, 2015), Operator who frequently maintain static & awkward seated posture which combined with limited lower body movement, which leads to muscle fatigue static loading in the back & thigh. The absence of lumber support further exacerbates discomfort and the risk of MSDs. Moreover, improper pedal positioning often forces the right leg into continuous, misaligned activity, contributing to lower limb discomfort long term ergonomic issues (Ahmad et al., 2021), (Abate & Hailemariam, 2023).

Those results are aligned with earlier studies such as conducted by (Bano, 2019), (S. Kirin, 2020) reported a high incident of neck, shoulder, lower back and wrist disorders among sewing machine operators due to repetitive movement & non neutral postures. The REBA finding clearly indicates immediate ergonomic intervention to reduce potential development of MSDs in this workstation.

4.18. Integration of Anthropometry in Ergonomic Chair Design

The foundation of ergonomic design is matching items to the physical attributes and abilities of its consumers. As it relates to chair design, this involves making sure that important elements like lumbar support, seat height, and backrest angle match the anthropometric measurements of the target user group. The scientific study of human body measurements, or anthropometry, gives designers vital information that enables them to accommodate a broad range of body sizes, usually aiming to cover the 5th to 95th percentile of users. Prior research highlights how anthropometry might help reduce musculoskeletal diseases, weariness, and pain during extended periods of sitting. For example, it has been demonstrated that mismatches between furniture and user measurements result in bad posture, decreased blood circulation, and more pressure on the neck and lower back (Anik Kumar Saha, 2024).

This study supports the idea that anthropometric data should be the foundation of ergonomic design to guarantee user comfort and lower the risk of musculoskeletal disorder (Salihu Ahmed Abdulkadir, 2018).

4.18.1. Design Prioritization: Pneumatic Cylinder vs Screw-Type Adjustable Chair for Garment Sewing Operators

In the early phase of this ergonomic chair development, two mechanical adjustment concepts were proposed:

- A manually operated device that uses a threaded screw is called a screw-type lift chair.
- A gas-assisted mechanism chair called pneumatic cylinder chair.

To make sure the final product aligned with actual user expectations, a systematic but practical prioritization process was carried out.

I. Voice of the Customer (VoC)

Feedback was collected through observations and informal discussions with garment operators who typically work long, repetitive shifts. Key comments included:

Table 20 Voice of the Customer (VoC) from Garment Sewing Machine Operators

S/N	Customer voice
1	"I sit for 8–10 hours a day, my back and legs get tired easily."
2	"I need to quickly adjust the chair if a different person uses it."
3	"Sometimes I can’t reach the machine properly it depends on the height."
4	"I don't want to use too much effort adjusting anything."
5	"The chair should be stable I lean forward a lot while sewing."
6	"The fabric gets hot I don’t want to feel sweaty after sitting too long."
7	"Please don’t give us something complicated that breaks in a month."

II. Identification of Customer Needs (Translated from VoC)

Based on the collected feedback, the following customer needs were identified

Table 21 Translated Customer Needs Based on User Feedback

Customer Need (CN)	Description
CN1: Easy and fast height adjustment	For shift changes and personal comfort
CN2: Long-term durability	Reduces downtime and replacement costs
CN3: Stable and safe seating	Important due to forward-leaning posture
CN4: Low physical effort to adjust	Prevents fatigue from manual operations
CN5: Smooth, quiet function	Minimizes workplace distraction
CN6: Comfort over long sitting hours	Minimizes physical strain
CN7: Breathable and easy-to-clean materials	Hygiene and comfort in hot factory conditions

III. Simplified Prioritization Scoring

A lightweight score-based framework was applied to rank these needs based on:

- Importance to user (I) – How critical is this to customer satisfaction?
- Feasibility (F) – Can it realistically be implemented with available resources?
- Differentiation (D) – Does it make our product stand out?

Each CN was scored (1–5 scale), and a priority score was calculated:

Priority Score = (I × 2) + F + D

Table 22 Customer Need Prioritization Using Weighted Scoring (I–F–D Method)

CN	Description	I	F	D	Score	Priority
CN1	Quick & easy height adjustment	5	5	4	19	🔴 Very High
CN2	Durable over time	5	4	3	17	🔴 Very High
CN3	Safe and stable	5	4	3	17	🔴 Very High
CN4	Low effort to operate	4	5	3	16	🔴 Very High
CN5	Quiet operation	4	4	2	14	🟠 High
CN6	Comfort for prolonged sitting	5	3	2	15	🟠 High
CN7	Breathable & hygienic materials	3	4	2	12	🟢 Medium

IV. Comparison: How Each Design Addresses Operator Needs

Table 23 Comparative Evaluation of Pneumatic Cylinder vs Screw-Type Chair

Customer Need	Pneumatic Cylinder	Screw-Type Lift
CN1: Easy height adjustment	✅ Instant lever operation	❌ Manual turning required
CN2: Durability	⚠️ Moderate (gas wear over time)	✅ Mechanically durable
CN3: Stability & safety	✅ Good with wide base design	✅ Also stable, depends on build
CN4: Low effort to operate	✅ Very low effort	❌ High manual effort needed
CN5: Quiet operation	✅ Smooth & silent	⚠️ May cause mechanical noise
CN6: All-day comfort	✅ Can be padded, ergonomic add-ons	⚠️ Comfort depends on seat design
CN7: Breathable materials	✅ Compatible with mesh/fabric options	✅ Also possible, needs planning

V. Final Selection: Pneumatic Cylinder Chair

Considering the repetitive and posture-sensitive nature of sewing work, the Pneumatic Cylinder Chair offers superior ergonomic and functional benefits:

- Quick, tool-free adjustment is ideal for shared workstations.
- Minimal effort ensures less fatigue for operators working long hours.
- Compact and modern design enhances both usability and aesthetics.
- Despite moderate concerns around durability, the overall ease of use and comfort justify its selection.

4.18.2. Anthropometric Measurement of The Operators

To design an ergonomically suitable workstation, it’s very important to take in to account the anthropometric characteristics of the operators. Anthropometric data ensures that the furnishings and equipment fit the operator’s physical measurement. Anthropometric data helps to reduce awkward posture & minimize the risk of MSDs by ensuring that the furniture & equipment matches the physical dimension of the operators (Anik Kumar Saha, 2024).

Anthropometric measurement was taken from the 20 representative operators using standard tools such as tape measure, & weight balance, based on the ISO 7250-1 & ISO 8599-1standard the following dimension were recorded (Gupta, 2020).

Table 24 Anthropometric Data

Features	Female (cm)			Male (cm)		
	5th	50th	95th	5th	50th	95th
Functional forward reach	50.5	57.1	65.5	53	60	64.5
Tibial height	40	42.5	44.8	42.5	45	48
Elbow height (standing)	88	100.5	112	92	105	117
Shoulder height (standing)	120.5	130	140.5	125	140	155
Stature (full height)	148	155.5	164	157	169	181
Thigh clearance	11.3	13.5	15.5	13.9	16.5	18.8
Sitting elbow height	14.5	17	22	15	17.1	19.5
Sitting shoulder height	49.8	54.5	59.7	50.5	55.7	60.5
Sitting eye height	75.9	83	88.5	76.9	84.5	89.8
Sitting height	77.5	85.9	95.5	78	87.5	97
Popliteal height	34.7	40.5	46.9	34	37.5	42.1
Buttock–knee length	47	53.5	57	49.5	54	59.5
Buttock–popliteal length	37	42	47.5	39.9	41.5	46.3
Hip depth	21.5	25.5	32	20.9	25	30.5

Based on the anthropometric measurement of the operators provided in table 20 consideration was given to the operator's chair design to optimize the ergonomic condition of the sewing workstation. While the sewing machine height goes up to 76-88 cm (this includes special sewing machines). The chair's measurements were adapted to better suit operator's physical requirement. Anthropometric value from 5th and 95th percentile was used to ensure the workstation accommodates a wide range of users. Key measurements such as popliteal height, thigh clearance & buttock-popliteal length were applied to determine seat height, leg clearance, seat depth, while sitting elbow height was essential for evaluating the working posture in relation to the table surface. This anthropometric-driven approach redesign supports a more comfortable, efficient, & health-conscious working environment for a sewing machine operator (Hoque et al., 2021).

Based on the anthropometric measurement shown in the table 20 the sewing table heights, the key chair dimensions seat height, seat depth, seat width was calculated to ensure ergonomic comparability for 5th and 95th percentile operators.

The seat height was determined with the formula

Seat height = popliteal height + shoe clearance + tolerance – pedal height

Where:

- popliteal height (5th percentile) = 34 cm
- popliteal height (95th percentile) = 46.9 cm
- shoe clearance = 2.5 cm
- pedal height (foot presser) = 5 cm
- tolerance = 5 cm, the adjustable seat height was then

Minimum: seat height = 34 + 2.5 – 5 = 31.5 cm

Maximum: seat height = 46.9 + 2.5 + 5 – 5 = 49.4 cm.

Seat width: was derived using hip depth

95th percentile = 30.5

Comfort clearance = 4 – 6 cm

Therefore, the seat width = 34.5 – 36.5

Back rest height informed by sitting shoulder height

5th percentile = 48.9

95th percentile = 60.5

Therefore, the recommended back rest = 33.9 - 45.5 cm (lumber to mid back support)

The proposed design using solid work 2022 SP1 V20, the material used in appendix C.

Initial Design Alternatives

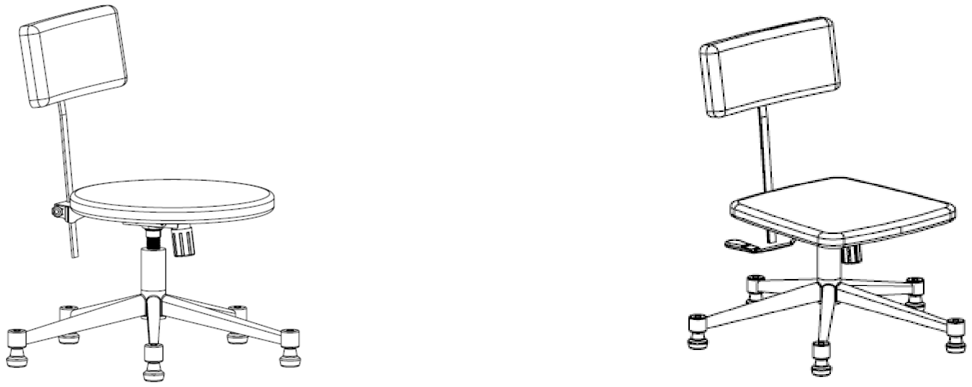

Figure 22 Screw-Type and Pneumatic Cylinder adjustable sewing chair

The proposed design using solid work, the material used in appendix C.

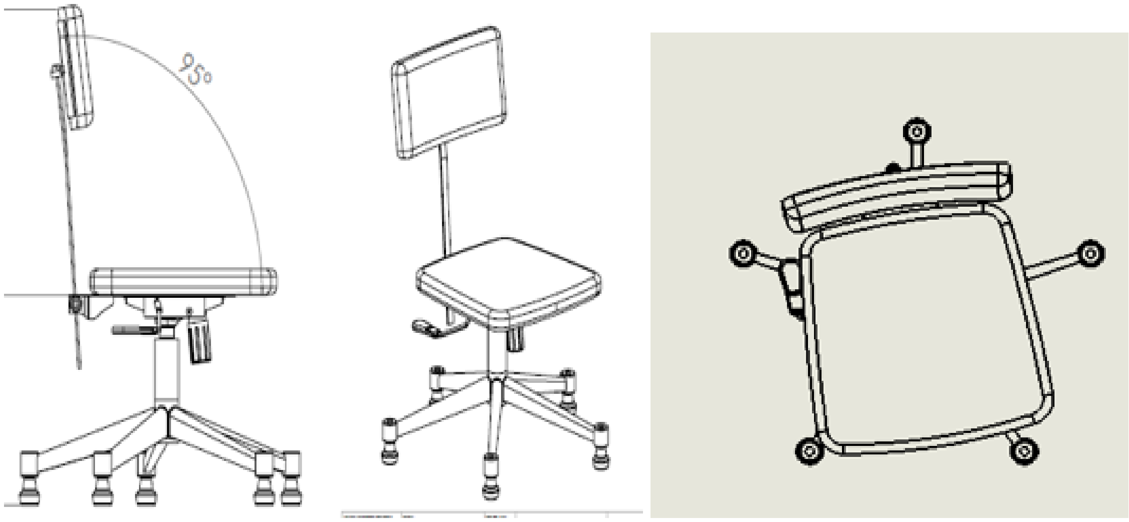

Figure 23 A proposed Pneumatic Cylinder adjustable sewing chair from different angles

Figure 24 the proposed 3D Pneumatic Cylinder adjustable sewing operator chair design

4.19. Observational Insight from The Exit Interviews

During this study, informal interviews were conducted with several garment operators who had recently resigned from ALMEDA Textiles. This interview revealed a compelling patter that underscores the long-term health impact of poor ergonomic conditions. According to most of the former employees, the musculoskeletal discomfort & pain they had experienced during years of continuous work subsided significantly during the production halt caused by the armed conflict in the Tigray region.

As operators were suspended, workers return home & had an extended period of rest in many cases, for the first time in years several interviews shared that the lower back, neck shoulder, wrist, knee pain they had endured eventually faded during this downtime. However, once ALMEDA Textiles resumed production & they returned to their original workstation & duties the same pains quickly reappeared. This recurring of symptoms was described not only as physically debilitating but also emotionally demotivating, leading many to the difficult decision of leaving their jobs altogether. These firsthand accounts provide qualitative validation of the quantitative findings of this study.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

1.1. Conclusion

The study assessed the impact of ergonomic risk factors on the prevalence of musculoskeletal disorders (MSDs) and their subsequent effect on productivity among 295 garment operators at ALMEDA Textiles. The study used REBA, CMDQ, and WPAI tools to assess postural strain, physical discomfort, and productivity loss. The overarching aim was to understand how ergonomic risk factors contribute to MSDs and how these disorders impair operator performance. Furthermore, the study aimed to identify high-risk workstations and propose specific ergonomic interventions.

Findings showed that a high prevalence of MSDs, specially affecting the lower back, neck, shoulders wrist & knee. At the case company, 75.8% of respondents reported symptoms of MSDs, with a significant portion experiencing daily discomfort. These conditions were closely associated with repetitive motions, awkward postures, and prolonged static positions.

Regression analysis confirmed that all four categories of ergonomic risks demographic, job-related, psychological, and physical factors, were statistically significant predictors of MSDs. These results affirm the study's hypotheses and emphasize that musculoskeletal pain is not only a physical burden but also negatively affects motivation, concentration, and overall work performance.

One of the most critical findings emerged from the REBA assessment, which showed that 90.8% of observed workstations fell into high or very high-risk categories (REBA score 8–10), indicating an urgent need for ergonomic intervention. Among the three departments assessed cutting, sewing, and finishing the sewing department was identified as the most vulnerable, with operators exposed to sustained awkward body postures, repetitive upper limb movements, and unsupported lower back positioning during long working hours. These working conditions not only increase the risk of MSDs but also severely compromise comfort, concentration, and physical endurance. If left unaddressed, such risks can lead to long-term health deterioration and significant productivity decline.

A statistically significant positive correlation was found between the severity of MSDs & Productivity loss. According to WPAI responses, the average productivity loss was 43.87%, with individual values ranging from 24.68 to 77.14%. The high impairment level suggests that operators who experience more physical discomfort also have significantly lower work efficiency, either through absenteeism decrease performance or while presenteeism (present).

As a practical intervention, the study proposed an ergonomic chair design tailored to the anthropometric data of sewing operators. This chair features adjustable height, lumbar support, and cushioning to maintain neutral posture and lessen lower-body strain. It directly addresses the ergonomic deficiencies identified and offers the potential to minimize discomfort, prevent injury, and enhance focus during extended work hours.

This study adds to the limited body of ergonomic research within Ethiopia's textile industry especially in post-conflict regions like Tigray. Through the combined use of REBA, CMDQ, and WPAI tools, it provides a multidimensional analysis of how poor ergonomics impact worker health and productivity. The results offer strong empirical support for targeted interventions in low-income manufacturing settings and highlight the importance of integrating ergonomic design into post-conflict industrial revitalization strategies.

1.2. Recommendation

To build a healthier & more productive employee, ALMEDA Textiles should take the chance to transform its work atmosphere through proactive ergonomic changes. And this includes redesigning high-risk workstation particularly those in sewing section, to promote more neutral body postures & lessen repeated strain. Equipping operators with adjustable chairs, ergonomic tools, sufficient lighting, well-ventilated, & well lit-work area would greatly lessen physical discomfort.

Equally importance is the introduction of routine ergonomic training for operators & supervisors to encourage safe practices. By integrating health surveillance measures such as REBA & CMDQ assessment & fostering a supportive management culture that addresses workload stress & encourages teamwork, the company can greatly enhance operator well-being while boosting overall productivity.

To enrich the body of knowledge workplace ergonomics, researcher should explore the economic return of ergonomics investments analyzing how redesigns, training, & health focused initiatives translate into cost saving & efficiency for manufacturing firms. Equally important is examining how workstation formats particularly seated versus standing arrangement, impact worker health & performance, offering evidence to guide ergonomic planning in dynamic production environments.

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Appendex

Appendix A

ናይ ሰራሕተኛ ናይ ስርሕ ቦታ ምቾት ፅንዓት

ኣነ ሳሙኤል ገ/ሄር ዝተበሃልኩ ኣብ መቐለ ዩኒቨርሲቲ ኣብ ኢትዮጵያ ኢንስቲትዩት ቴክኖሎጂ ናይ 2ይ ዓመት production industrial system engineering ተመሃሪ 'የ። ብምኳኑ ናይ መመረቂ ፅሑፈይ "The Impact of Ergonomic Risk Factors on Musculoskeletal Disorders and Their Implication to Productivity Through Rapid Entire Body Assessment (REBA): A Case Study at ALMED Textiles Plc." ብዝብል ፅሑፍ እንዳሰራሕኩ ይርከብ። እዚ ፅንሰ ሓሳብ ብዝተሳኸዐ ኩነታት ንክሰራሕ ናቶም ድጋፍ ብጣዕሚ ኣድላዪ ብምኳኑ ነዞም ኣብ ታሕቲ ዘለዉ ሑቶታት ግቡእ ዝኾነ መልሲ ንክትህቡ ብትሕትና ይሓትት። ☑ እታ ትኽክል ዝበልዋ መልሲ ኣብታ ስንጠረጅ ብናይ ራይት ምልክት የቅምጡ።

መተሓሳሰቢ፡ ኩሉ ዝቐርብ ዳታ ብጥብቂ ምስጢራዊ ክኸውን ምኧኑን፡ እቲ ዝተኣከበ ሓበሬታ ድማ ንመጽናዕቲ ጥራይ ከም ዝውዕልን ርግጸኛታት ኩኑ

ክፋል ሓደ: ብትፈጥሮ ዝመፅእ ናይ ህዝቢ ናይ ሓደጋ ምልክታት (ዲሞግራፊካዊ ረ ቛሒታት)

ዕለት: ______/______/________ ሹም: ____________________________________

ወርሒ መዓልቲ ዓምት ከም ኣድላይነቱ

1. ዕድመ: _______. ቁመት: ________ . ክብደት: _________ 2. ፆታ፡ ☐ተባ ☐ኣን

3. ናይ መርዓ ኩነታት? ☐ ሓዳር ዘይብሉ ☐ ባዓል ሓዳር ☐ ዝተፋተሕ/ት

4. ደረጃ ትምህርቲ ☐ ዘይተመሃረ/ት ☐ ቀዳማይ ደረጃ ☐ ካልኣይ ደረጃ ☐ ዩኒቨርሲቲ / ኮሊጅ

5. ናይ ሕጂ ዘለዎ ናይ ስራሕ ቦታ ንክንደይ ዛኣክል ሰሪሐን/ሰሪሖም? ☐ ≤ 5 ዓ. ☐6 – 10 ዓ. ☐≥10 ዓ.

6. ናይ ስራሕ ምደብ መፀዋዒ: __________________

7. ወርሓዊ ኣታዊ ☐ <1200 ብ. ☐ 1200 - 1700ብ. ☐ ≥1700ብ.

8. ናይ ስራሕ ሰዓታት ኣብ ማዓልቲ ☐ ≤ 6 ሰ. ☐ 7 - 8 ሰ. ☐ >8ሰ.

9. ስሩዕ ኣካላዊ ምንቅስቓስ ይገብራ/ሩ ድየን/ዮም? ☐ እወ ☐ ኣይፋሉን

10. ኣብዚ እዋን እዚ ሲጃራ የትክካ/ኹ ዲየን/ዮም? ☐ እወ ☐ ኣይፋሉን

11. ናይ ኣካላተን/ቶም(ቁመተን/ቶም ምስ ክብደተን/ቶም ምጥጥን) Body Mass Index (BMI)

☐ ትሕቲ ክብደት (≤ 18.5) ☐ ማእከላይ ክብደት (18.5-24.99)

☐ ልዕሊ ክብደት (25 -29.99) ☐ ብጣዕሚ ግዝፍ (≥ to 30)

ክፋል ክልተ: ምስ ስራሕ ዝተኣሳሰሩ ረቛሒታት ሓደጋ

1= ኣትሪረ ኣይሰማማዕን 2 = ኣይሰማማዕን (2) 3 = ገለልተኛ 4 = ይሰማማዕ 5 = ኣትሪረ ይሰማማዕ

ታ/ቁ	ሕቶታት	1	2	3	4	5
1	ኣብ ናይ ስራሕ ቦተእን/ኦም ንሓደጋታት ኤርጎኖሚክ ብኸመይ ከም እትቕንሰኦ/ዎ ስልጠና ረኺብክን/ኩም ዶ?					
2	ዕግበት ስራሕ?					
3	ናይ ስራሕ ቦታይ እኹል መብራህቲ፡ ንፋስ ዝኣትወሉን ንኤርጎኖሚክ ኮፍ መበሊን ኣለዎ?					
4	ኣብ ስራሕ ቦታይ ናይ ኤርጎኖሚክ መሳርሒታት (ንኣብነት፡ ዝስተኻኸሉ መንበር፡ ናይ ምልዓል ሓገዝቲ፡ መከላኸሊ ዳንቲን መነጽር ዓይንን) ኣለዉ?					
5	ናይ ስራሕ ጠረጴዛታተይን መንበርን ምቹእን ንዕማማተይ ዝምችእን እዩ?					
6	እቲ ሓፈሻዊ ናይ ስራሕ ሃዋህው ምቹእን ንስራሕ ምቹእን እዩ?					

ክፋል ሰለስተ ስነ-ኣእምሮኣዊ ሓደጋ ዘስዕቡ ረቛሒታት

1= ኣትሪረ ኣይሰማማዕን 2 = ኣይሰማማዕን (2) 3 = ገለልተኛ 4 = ይሰማማዕ 5 = ኣትሪረ ይሰማማዕ

ታ/ቁ	ሕቶታት	1	2	3	4	5
1	ብተደጋጋሚ ብናይ ስራሕ ዕማማት ልዕሊ ዓቕን እየ ዝፃዓን					
2	ክውድኦ ትፅቢት ዝግበረለይ መጠን ስራሕ ርትዓዊ እዩ					
3	ኣብ ስራሕ ቦታይ ምሕደራ ውፅኢታውን ደጋፍን እዩ					
4	ኣሰራርሓ ምሕደራ ንኣፈፃፅመይ ዝዕንቅፍ ኮይኑ ይስምዓኒ					
5	ምስ መሳርሕተይ ጽቡቕ ናይ ስራሕ ርክብ ኣለኒ					
6	ምስ መሳርሕተይ ወይ ተቖፃፀርተይ ግርጭታት የጋጥመኒ					

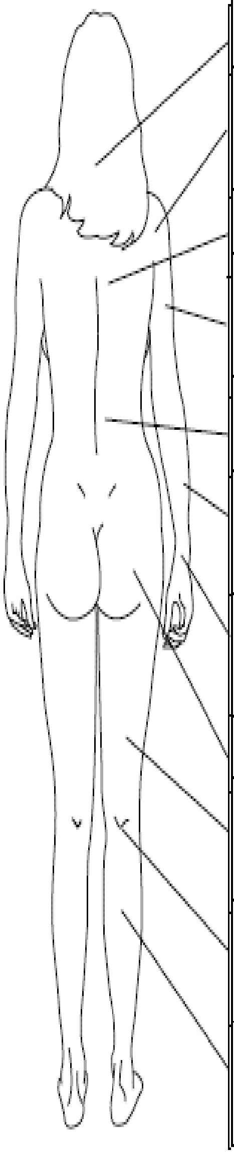
ክፋል ኣርባዕተ፡ ኣካላዊ ሓደጋ ዘስዕቡ ረቛሒታት

1= ኣትሪረ ኣይሰማማዕን 2 = ኣይሰማማዕን (2) 3 = ገለልተኛ 4 = ይሰማማዕ 5 = ኣትሪረ ይሰማማዕ

ታ/ቁ	ሕቶታት	1	2	3	4	5
1	ስርሐይ ንነዊሕ እዋን ተደጋጋሚ ምንቅስቓስ ኢድ ወይ ቅልጽም ይሓትት?					
2	ብተደጋጋሚ ኣብ ሕማቅ ዝኾነ ኣቅማምጣ ወይ ከዓ ኣቃውማ (ንኣብንት ምድናን ፣ ምጥዋይ) ይሰርሕ?					
3	ስርሐይ ከበድቲ ነገራት ኣዘውቲረ ከልዕል፡ ክደፍእ ወይ ክስሕብ ይሓትት?					
4	ኣብ ከበድቲ ዕማማት ንምሕጋዝ መካኒካዊ ሓገዝቲ (ንኣብነት፡ መሳርሒታት ምልዓል፡ ዝስተኻኸሉ ናይ ስራሕ መደበራት) ይረክብ።					
5	ስርሐይ ንነዊሕ እዋን ደው ምባል ወይ ኣብ ሓድ ቦታ ኮፍ ምባል ይሓትት?					
6	ብሰንኪ ስታትቲክ ኣቃውማ ምሕላው ድኻም ወይ ዘይምቾት የጋጥመኒ?					
7	ናተይ ናይ ስራሕ መደበርን መሳርሕታተይን ኣካላዊ ፀቕጢ ንምንካይ ብኤርጎኖሚክ ዝተዳለዉ እዮም?					
8	ምንቅጥቃጥ ዝድርኹ መሳርሒታት ወይ መሳርሒታት (ንኣብነት፡ መሳርሒታት ምቑረፂ፡ ማሽናት ስፌት) ብተደጋጋሚ እጥቀም?					
9	ብሰንኪ ናይ ስራሕ ሃዋህው ኣብ ኣእዳወይ፡ ቅልጽመይ ወይ እግረይ ምድንዛዝ፡ ምቅጥቃጥ ወይ ከባብያዊ ቃንዛ የጋጥመኒ?					

ክፋል ሽዱሽተ: መሕተቲ ናይ ጭዋዳታት ኣዕጽምቲ ጸገም

ኣብ ታሕቲ ዘሎ ስእላዊ ስእሊ፡ ግምታዊ ኣቀማምጣ ናይቶም ኣብቲ መሕተቲ ጽሑፍ ዝተጠቕሱ ክፍልታት ኣካላት ዘርኢ እዩ። በይዘአን/ኦም ኣብቲ ዝምልከቶ ሳፅን ምልክት ብምግባር መልሱ



		ኣብ ዝሓለፈ ሰሙን ስራሕ ክንደይ ግዜ ቃንዛ፣ ዘይምቾት ኣጋጢምወን/ዎም?					ቃንዛ፡ ዘይምቾት እንተ ኣጋጢምወን/ዎም፡ እዚ ክሳብ ክንደይ ዘይምቹው እዩ ነይሩ?			ቃንዛ ፣ ዘይምቾት እንተ ኣጋጢምወን/ምዎም እዚ ኣብ ናይ ምስራሕ ዓቕመን/ሞም ዕንቅፋት ድዩ ነይሩ?		
		ኣይፋሉን	ዝሓለፈ ሰሙን ካብ 1-2 ግዜ	ዝሓለፈ ሰሙን ካብ 3-4 ግዜ	ኣብ መዓልቲ ሓደ ግዜ	መዓልታዊ ብዙሕ ግዜ	ቁሩብ ዘይምቹ እዩ	ብማእከላይ ደረጃ ዘይምቹ እዩ	ኣዝዩ ዘይምእ እዩ	ኣይፋሉን	ቁሩብ ዕንቅፋት	ብዓቢኡ ዕንቅፋት
ክሳድ		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
መንኮብ	ፀጋም	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	የማን	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ላዕለዋይ ሕቖ		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ላዕለዋይ ቅልጽም	ፀጋም	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	የማን	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ታሕተዋይ ክፋል ሕቖ		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ቅድመ-ቅልጽም	ፀጋም	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	የማን	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ክሳድ ኢድ	ፀጋም	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	የማን	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
መዓኮር		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ሽለፍ	ፀጋም	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	የማን	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ብርኪ	ፀጋም	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	የማን	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ታሕተዋይ እግሪ	ፀጋም	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	የማን	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

ክፋል ሽዱሽተ: መሕተቲ ምጉዳል ኣፍራይነትን ምንቅስቓስን

1. ኣብዚ ሕጂ እዋን ተቖፂረን/ሮም ዲየን/ዮም (ንደሞዝ ዝሰርሓ/ሑ)?

   ☐ እወ ☐ ኣይፋሉን

2. ኣብ ዝሓለፈ ሸውዓተ መዓልታት ብሰንኪ ፀገም ጭዋዳታትን ኣዕጽምትን ክንደይ ሰዓታት ካብ ስራሕ ተሪፈን/ፎም? (ንዕረፍቲ፡ ንበዓላት፡ ወይ ካልእ ምስ ጥዕና ዘይተኣሳሰር ምኽንያታት ናይ ዕረፍቲ ግዜ ኣይተካትት)

   ____

3. ኣብ ዝሓለፈ ሸውዓተ መዓልታት ብኻልእ ምኽንያት ክንደይ ሰዓት ካብ ስራሕ ተሪፈን/ፎም?

   ____

4. ኣብዘን ዝሓለፋ ሸውዓተ መዓልታት ክንደይ ሰዓት ሰሪሕካ?

   ____

5. ኣብ ዝሓለፉ 7 መዓልታት፡ ገም ጭዋዳታትን ኣዕጽምትን ኣብ እትሰርሓሉ እዋን ንኣፍራይነትካ ክሳብ ክንደይ ጽልዋ ኣሕዲሩ? (ካብ 0 ክሳብ 10 ብዝብል መለክዒ፡ 0 ማለት "ናይ ጭዋዳታትን ኣዕጽምትን ጸገም ኣብ ስርሐይ ጽልዋ ኣይነበሮን"፡ 10 ድማ "ናይ ጭዋዳታትን ኣዕጽምትን ጸገም ምሉእ ብምሉእ ከይሰርሕ ከልኪሉኒ" ማለት እዩ)

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

6. ኣብ ዝሓለፈ ሸውዓተ መዓልታት፡ ጸገም ጭዋዳታትን ኣዕጽምትን፡ ኣብ ስራሕ ካብ ምስራሕ ወጻኢ፡ ስሩዕ ንጥፈታትካ ክትፍጽም ዘለካ ዓቕምኻ ክሳብ ክንደይ ጽልዋ ኣሕዲሩ? እዚ ድማ ኣብ ገዛ ዝግበር ንጥፈታት፡ መጽናዕቲ፡ ምንቅስቓስ ኣካላት ወይ ናይ ትርፊ ግዜ ንጥፈታት ከጠቓልል ይኽእል።

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

ክፋል ሽዱሽተ ሪኢቶታት፡

1. ናተን/ቶም ናይ ስራሕ ኩነታት ምቾው ንምግባር ወይ ካዓ ምህርቲ ንምውሳኽ ሪኢቶ ወይ ድማ ጥቆማ እንድሕር ሃሊወን/ዎም?

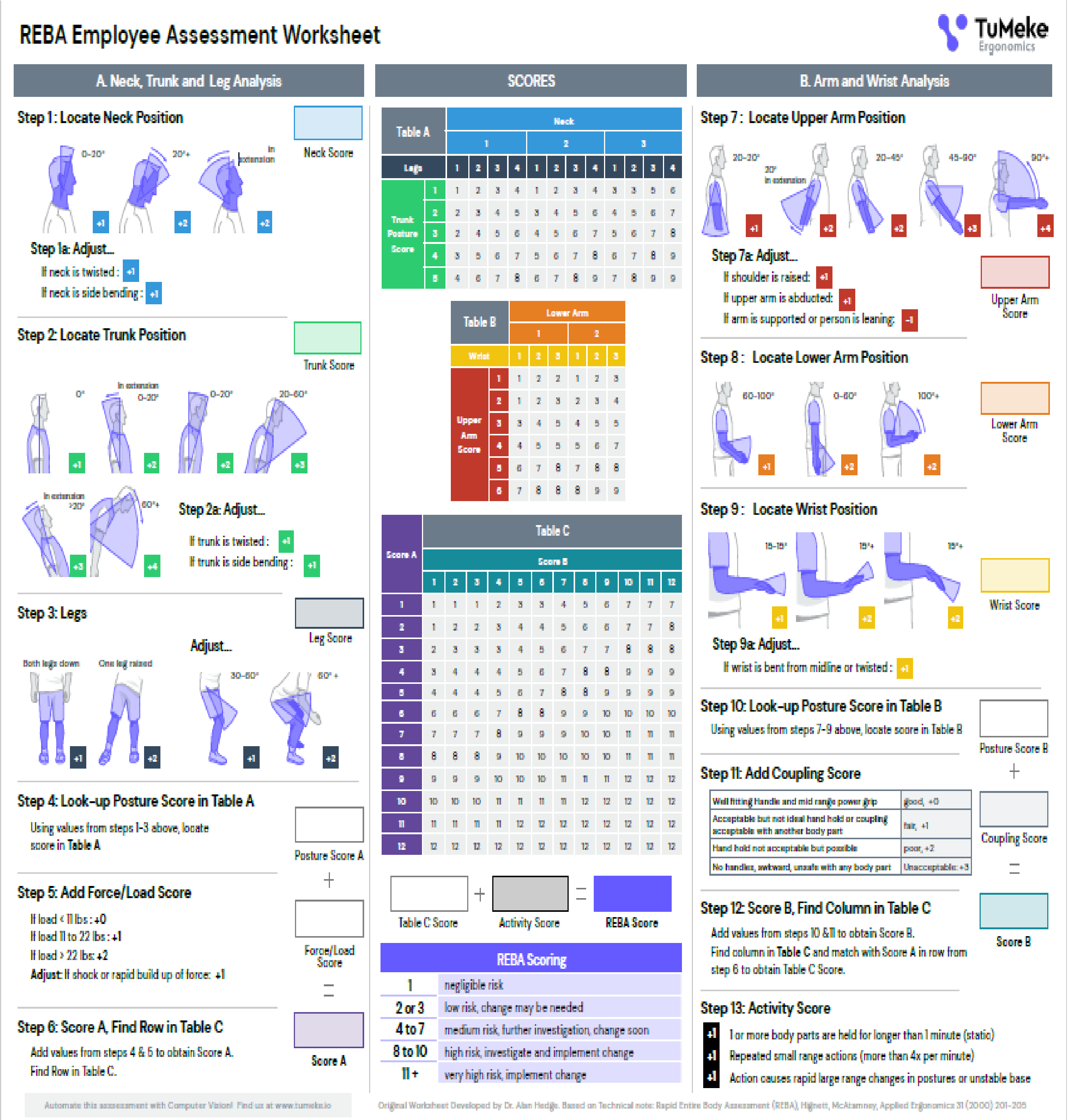
____

____

____

ስልትሕብብረን/ሮም ብጣዕሚ የመስግን።

Appendix B



REBA Employee Assessment Worksheet

TuMeke Ergonomics

A. Neck, Trunk and Leg Analysis

Step 1: Locate Neck Position

0-20° +1
20°+ +2
In extension +2

Neck Score

Step 1a: Adjust...

If neck is twisted : +1
If neck is side bending : +1

Step 2: Locate Trunk Position

Trunk Score

0° +1
In extension 0-20° +2
0-20° +2
20-60° +3
In extension >20° +3
60°+ +4

Step 2a: Adjust...

If trunk is twisted : +1
If trunk is side bending : +1

Step 3: Legs

Leg Score

Both legs down +1
One leg raised +2

Adjust...

30-60° +1
60° + +2

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: +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

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

REBA 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

B. Arm and Wrist Analysis

Step 7: Locate Upper Arm Position

20-20° +1
20° In extension +2
20-45° +2
45-90° +3
90°+ +4

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

60-100° +1
0-60° +2
100°+ +2

Lower Arm Score

Step 9: Locate Wrist Position

15-15° +1
15°+ +2
15°+ +2

Wrist Score

Step 9a: Adjust...

If wrist is bent from midline or twisted : +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 range 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

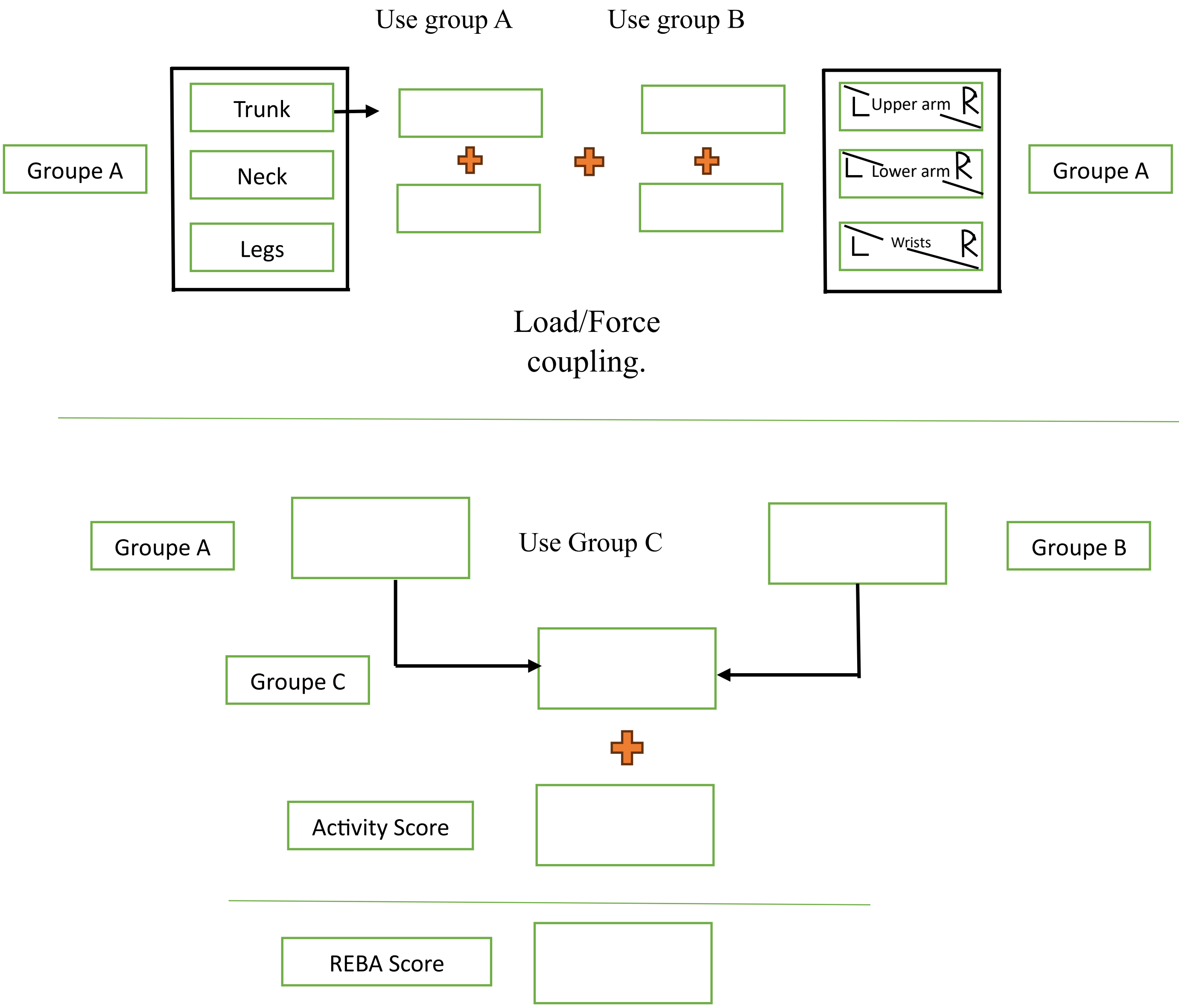
Step 13: Activity Score

+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

Automate this assessment with Computer Vision! Find us at www.tumeke.io

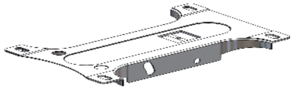
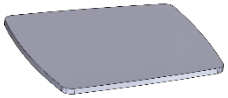
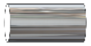
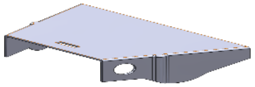
Original Worksheet Developed by Dr. Alan Hedge. Based on Technical note: Rapid Entire Body Assessment (REBA), Hignett, McAtamney, Applied Ergonomics 31 (2000) 201-205

Appendix C


Use group A
Use group B
Groupe A
Trunk
Neck
Legs
Upper arm
Lower arm
Wrists
L
R
Groupe A
Load/Force coupling.
Groupe A
Use Group C
Groupe B
Groupe C
Activity Score
REBA Score

Appendix D

Table 25 list of materials of the proposed chair design

Part name	quantity	image	Part name	quantity	image
Chair base	1		Cylinder	1	
Piston	1		Sheet metal chair base	1	
sheet metal support	1		Plastic busher	1	
Bolt pin	2		Adjustment knob	1	
Seat tilt adjuster	1		Lever handle	1	
Seat pan	1		Upholstery fabric	1	
Foot	5		Foot pin	5	
Shoulder adjuster	1		Chair shoulder beam	1	
Upholstery fabric for shoulder	1		Screw lock	1	
Shoulder pan	1