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SCHOOL OF MECHANICAL AND INDUSTRIAL ENGINEERING

Work place Ergonomics Assessment and its Impact on Social Sustainability in Garment Manufacturing: a Case Study of Senmul Garment Manufacturing.

Thesis submitted to school of mechanical and Industrial Engineering for the partial fulfillment for the degree of Master of Science (M.Sc.) in Mechanical and Industrial Engineering (Industrial Engineering Stream)

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This is to certify that the thesis prepared by: **Tagesse Amtachew, entitled: "Workplace Ergonomics Assessment and Its Impact on Social Sustainability in Garment Manufacturing: A Case Study of Senmul Garment"** and submitted in partial fulfillments of the requirements for the degree of Master of Science (Mechanical and Industrial Engineering) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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DECLARATION

I ,Tagesse Amatchew, hereby declare that the research thesis entitled *Work place ergonomics assessment and its impact on social sustainability in garment Manufacturing: a case study of senmul garment* is my original work and has not been submitted in part or full to any other university, and further declare that all information my thesis work derived from published or un published sources has been acknowledged in the relevant sections of the thesis.

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Abstract

Workplace ergonomics in garment industry relates to the arrangement of workplaces, tools, and equipment that are arranged to fit and align with the skills of the workers, and its objective is to create workplace and work activities that are fit for the employee. Ensuring employee health and well-being is important to social sustainability in garment manufacturing industry. In addition to this, the research is mainly focused on an assessment of the existing workplace ergonomics in Senmul garment manufacturing. The main aim of this study is to evaluate and identify workplace ergonomics based on existing ergonomic practices and their impacts on social sustainability in Senmul garment manufacturing. The methodology includes a comprehensive literature review, collecting and analyzing qualitative and quantitative data's. The data has been gathered by using both primary and secondary data from site visit assessments, selected grouped interviews discussions, company data reviews, organized questionnaires, interviews, document reviews. In addition to this, the study uses the REBA rapid entire body assessment soft wares and MS Excel and Visio software to analyze the research and to find the hazards of musculoskeletal disorders occurring at workplaces. Result from the study employees at senmul garment manufacturing face high risk of job related ergonomic hazards injuries and social sustainability in work ethics, work environment, community relationship, health and safety, human rights In order to address these problems implementing suggested strategy mechanisms for the improvement of workplace ergonomics such as a compressive ergonomics program in routine evaluation, continuous monitoring to support social sustainability, investing in ergonomics trainings for the managers and employee and focus on ergonomics risk identification and the social sustainability objectives of the industry that employee rights, encouraging ethical labor practices, crate standard working hours and enhancing the employee quality of life these makes a more ethical industry. Moreover implementing ergonomic interventions like job rotation schedules, adjustable workstations, and task and tool design can reduce musculoskeletal disorder.

Key words: Ergonomics, Garment manufacturing, REBA, Workplaces, Social sustainability.

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List of Acronym

MSD: Musculoskeletal disorder

WHO: World Health Organization

WMSDs – Work-Related Musculoskeletal Disorders

RULA: Rapid Upper Limb Assessment

REBA: Rapid Entire Body Assessment

OSH: Occupational safely Health

MOLSA: Ministry Of Labor and Social Affairs

FDRE Federal democratic republic of Ethiopia

OWAS: (Ovako working posture analyzing System)

(IPAQ) International Physical Activity Questionnaire

Chapter One

1. Introduction and Problem Justification

1.1 Introduction

Industrial ergonomics is a branch of science, and its objective is to develop workplace and work activities that are fit for the employee. an employee efficiency can be impacted by work place in many ways , such as the physical strain, working position, high lift and carrying, human and machine interaction, as well as noise, lighting, and thermal comfort, are all included in the field of ergonomics (Suárez Sánchez & Ana, 2014). In addition to this ergonomics focuses on designing workplaces, machinery, tools, products, environments, and systems that optimize productivity and effectiveness of work systems while ensuring the health, safety, and well-being of employees Megiso (2017). It considers human physical, physiological, biomechanical, and psychological capabilities, Generally speaking, ergonomics aims to fit the task to the individual, not individual to the task. according to the study, Sundstrup et al. (2020) since 1990, the quantity of disability resulting from back pain has risen by 50% globally. This indicated that MSDs are one of the major problems in workplace physical demanding jobs such as lifting, pulling, pushing, standing, walking, bending, forceful or fast repetitive tasks, etc. and difficult to perform their daily work tasks.

In addition to this the study conducted by Subramanya et al. (2021) states that India is one of the world's second-largest producers of textiles and garments. This sector's contribution to the nation's Gross domestic Product (GDP) is 4%. Approximately 45 million people in India are employed in this sector. Ready-made garments were the largest contributors to the total textile and apparel exports from India, accounting for around 40% of the total.

When we come to our country, in Ethiopia, there are 102 garment industries out of these, 79 were located in Addis Ababa, while 22 were found in the Oromia Special Zone near Addis (Abate, 2022). This sector employed over 10,000 workers, with approximately 70% of them being female and used as source of employment. Among these industries, the garment industry stands out as one of the most hazardous sectors. which is faced to the repetitive nature of the work, strong visual demand, involve in improper postural position and longtime of either sitting or standing in one position (Abate, 2022) .

According to ministry of Labor and Social Affairs in Ethiopia has reported that among 14,914 organizations, there were 25,812 employees who suffered from permanent disability, temporary disability, or death (Berhan, 2020). This situation could potentially lead to an unsafe working environment for the employees. Out of the of reported work accidents, 56.05% took place in the manufacturing sector, which is quite significant compared to other industries such as construction (22.25%), as well as others combined (20.58%) (Berhan, 2020).

More over accident reports don't clearly show the detailed information about the nature and causes of work accidents; it is notable that the manufacturing industries had the highest percentage of accidents at 56.05%. In order to enhance the development of the metal and textile sectors, this has been prioritized by the Ethiopian government. Therefore, it is recommended to implement a comprehensive ergonomic assessment throughout the company to ensure a safe working environment (Kassaneh & Tadesse, 2019).

Workplace ergonomics in garment industry relates to the arrangement of workplaces, tools, and equipment are arranged to fit and aligns with the skill of the workers. Ergonomic hazards are workplace conditions that cause musculoskeletal injuries in workers. these hazards include repetitive and forceful movements, uncomfortable or unnatural body postures resulting from incorrect work methods, and workstations, tools, and equipment that are not properly designed (Eugenia et al. (2023). On the other hand According to Abdullah et al. (2017) Musculoskeletal Disorders (MSD) are becoming a major issue in many developed nations. Ergonomic illnesses and injuries, also known as musculoskeletal disorders, affect various parts of the human body, such as muscles, nerves, and can result in back pain,

According to the study, ergonomics is the relationship between workers and the working environment. It is significant that workers be aware of these Potential ergonomic risk factors include things like hard lifting, repetitive motion, static posture, exposure to excessive vibration, and more (Tee et al., 2017).

Unsafe workplace and environment which causes discomfort ,particularly within the garment industry, the risk factors on occupational health and safety like noise, elevated

temperatures, fatiguing tasks, manual handling of chemicals, and musculoskeletal disorders . this cause the absence of employee and has an impact on productivity Kaya (2015). Similarly, researches predicted that ‘’Musculoskeletal complaints are experienced by 1.71 billion people in the world, contributing to disability, pain and reducing work productivity. In Indonesia, the Occurrence of MSDs is 11.9%, and the top position with 65.2% of cases was the garment sector’’. The garment sector generally applies a sitting posture, and standing posture. These cause a risk to health, muscles, skeleton and other body parts (Prima et al., 2022). On the other hand, management Commitment is required for the implementation and the advancement of workplace safety and health contributes to sustainable development by promoting the well-being of individuals, creating safer work environments, minimizing the Cost of accidents, ensuring controlled settings, effectively handling workplace incidents, and enhancing knowledge about workplace safety and Ergonomics (Jilcha & Kitaw, 2017).

Social sustainability is connected to establishing a social framework that promotes the improvement of workers' economic well-being and physical health, while also contributing to the nation development. Industrial factors that impact workers' health can lead to increased absenteeism and a loss of production hours, it is important to grasp the connection and interaction among workplace environment & well-being of workers (Karuppiah et al., 2020) .

According the study conducted by Gajšek et al. (2022) Among the economic, social, and environmental dimensions, the social dimension is often regarded as the weakest pillar of sustainable development, leading to demands for research and enhancements. While the relationship between ergonomics and social sustainability is Recognized, there is limited knowledge regarding how companies understood and incorporate this relationship into their practices.

On the other hand encouraging social sustainability within companies and the workplace is driven by the recognition that social sustainability and responsible use of natural and physical resources. This includes considerations regarding the sustainable of human resources and the overall well-being of employees within organizations (Gajšek et al., 2022). Moreover Social sustainability mentions that Creating work systems, environments, and

procedures that support employees' happiness, health, and well-being. It involves taking into account the social impact that affects individuals experience at workstation and making sure their wants, rights, and goals are satisfied.

For this study REBA rapid entire body assessment, approach is used to determine the risk of musculoskeletal disorders occurring in occupation. This strategy is applied to static, dynamic, and places where a lot of changes occur in the body while working; poor posture position is the major important issues of musculoskeletal disorder at work (Jambarsang & Anoosheh, 2020). In addition to this, using different supportive software such as MS Excel, IBM SPSS V.20 software, and Visio 2010 these tools will assist in analyzing the collected data and presenting it.

The garment manufacturing sector is generally very concerned about workstation ergonomics and how it affects employee health and wellbeing. Thus, using a case company senmul garment manufacturing as a model, the aim of this study is to investigate the effects of workstation ergonomics in garment manufacturing companies. The goal of the study is to shed light on expected future improvements in workstation ergonomics concerns in garment manufacturing companies..

In summary, the study in the case of the garment manufacturing industry is to identify and evaluate the existing ergonomic conditions and social sustainability practices in the workplace. This assessment aims to determine the ergonomic risks associated with different tasks and activities performed by workers as well as to identify the impact of these risks on social sustainability considering their work ethics, work environment, community relationships, health and safety, and human rights. By understanding the specific ergonomic challenges faced by employees in garment manufacturing, the goal is to recommend interventions and improvements that can enhance their working conditions and overall job satisfaction.

1.2 Background of the study

Garment manufacturing industry globally contribute to the economy and it makes a remarkable annual contribution of 2% to the gross domestic product (GDP) and is responsible for generating over 57 million jobs, out of which 24 million are belongs to garment manufacturing sector (Aquino Rojas et al., 2023).

Ergonomics includes the study of designing workspaces, tools and systems to optimize the well-being and performance of workers (Megiso, 2017). more over according to the study conducted by (Ramdass, 2013) ergonomics assessment is very importance in the garment industry as it helps identify and address ergonomic hazards that can lead to musculoskeletal disorders (MSDs) and the implementation of ergonomics in the garment industry is important in improving worker health, safety, and productivity (Ramdass, 2013). MSDs are a significant concern in Garment industry due to the repetitive motions and prolonged periods of standing and sewing involved in garment manufacturing and this can be achieved through user-oriented clothing design that considers body position and posture (Bragança et al., 2015). Identifying ergonomic risks as well as interventions to address specific issues such as work area congestion, ventilation, and noise (Parimalam et al., 2006).and implementing appropriate measures can prevent work-related injuries, enhance worker satisfaction and well-being, reduce absenteeism and turnover, Furthermore, the use of ergonomics interventions, such as height-adjustable workstations, can reduce postural discomfort in specific tasks(Ganguli et al., 2009) and improve overall productivity and quality in the workplace. In the workplace, applying ergonomic principles can enhance productivity and promote the well-being of employees (Corlett & McAtamney, 1988).In ergonomic research, Ergonomic issues can have a negative impact on employees, resulting in reduced productivity and impacting turnover. The main purpose of this study is to identify the ergonomic problems that dominate the textile industry and to offer suggestions to overcome the problems.(Prabhakumari & saravana, 2019). The study focuses on exploring the relationship between sustainability and ergonomics. In the frame work of ergonomics, key elements are chosen, taking into account the three dimensions of sustainability and their associated sub-dimensions. The modified ergonomic indicators are subsequently organized

within these sub-dimensions. This approach allows for a comprehensive analysis of how ergonomics aligns with the various aspects of sustainability (Sarbat et al., 2020).

This study has been carried out at Senmul garment manufacturing plc, Senmul garment manufacturing industry organized and established on March 2012 G.C under the auspices, proclamations, polices, regulations and rules formulated and issued to promote trade and investment in the country by (FDRE) federal democratic republic of Ethiopia. the company has been producing different kind of shirts including men's formal shirts, blouses, females and children shirts and school uniform shirts for local and foreign (export standard) market. The factory focus is producing of different varieties & types of Shirts and the products of the company includes plain colored and color patterned shirts of different sizes including small (37-38) ,medium (39-40), large (41-42cm) ,extra-large (43-44) and double extra –large shirts (45-46cm).

The data below represents two years of data collected through interviews and by referring to sick leave records, which were collected from the company but not properly recorded, particularly in terms of work-related illnesses. Additionally, employees take leaves for various reasons, and they often hesitate to directly attribute them to work-related stress. The collected data from the factory is to provide a summary of this information in table format, which is displayed in the form of a bar graph to graphically illustrate the existing situations.

Based on the information in Table 1 causes of injuries and observed data in tables, graphs and pictures, the situation of the existing workstation practice of the case company is the prevalence of ergonomic injuries in employee wellbeing, health, and it impacts sustainability. However, it prioritizes the critical factors that affect employee wellbeing and health. In addition to this, working for the enhancement of workstations and addressing the issues.

Table 1.1 Prevalence of workplace musculoskeletal disorder WMSD'S, Source case company record data

Year	Causes of injury	Body parts injured	Male	Female	Total injury
2014	Force full exertion	Back pain	1	3	4
	Cutting tools	hand Pain	0	4	4
	Ironing & Pressing	wrists & hand	1	3	4
	Standing long time	Leg pain	0	4	4
	sewing machine	Neck and shoulder	1	6	7
	packing Line	Overall posture	1	2	3
2015	Force full exertion	Back pain	2	4	6
	Cutting tools	hand Pain	0	4	4
	Ironing & Pressing	wrists & hand	2	4	6
	Standing long time	Leg pain	0	4	4
	sewing machine	Neck and shoulder	2	6	8
	packing Line	Overall posture	1	2	3

Figure 1.1, in the company workstation, the company workplace is one of the causes of injury for employee health and wellbeing and is exposed to different ergonomic and social sustainability factors that have been the causes of injury and affect the health, wellbeing, and social sustainability of the workers in Senmul garment manufacturing.

Figure 1.1 Existing workstations in the case company

Workstation ergonomics assessment and its impact on sustainability are not done in this specific case company and the study aims to fill the literature gaps in the topic area. The research conducted by Scafà et al. (2019) and according to the study Social sustainability has often been neglected in the past few years. Moreover in the literature, there are no methodologies or tools to objectively evaluate processes impacts on humans. According to the literature the study has limitations that require further elaboration to ensure adequate consideration of social sustainability. Additionally, there is a lack of objective correlations between the well-being of the operator and the performance of the company.

Moreover social wellbeing condition has received less attention to this manufacturing industry equally considers the three pillars of sustainability dimensions such as economic, environmental and social dimensions and implements the 6R principles in the total life cycle of the Product (Lin et al., 2019).

The Main goal of the workstations ergonomics assessment in the garment industry is to identify and asses the existing ergonomics practices within the workplace. This assessment aims to determine the ergonomic risks associated with different tasks and activities performed by workers in Senmul garment, as well as to identify the impact of these risks on their health, well-being, and productivity. By understanding these ergonomic challenges faced by employees in garment manufacturing, the aim of this research goal is to

recommend the best solution that can improve their working conditions and overall job satisfaction.

In conclusion, the impact of workplace ergonomics in manufacturing extends beyond the immediate health benefits for employees. It includes broader positive effects on productivity, absenteeism, product quality, employee satisfaction, and overall operational costs, making it a crucial consideration for any manufacturing organization aiming to create a sustainable and employee-friendly workplace.

1.3 Problem Statement

Globally ‘’Musculoskeletal complaints are experienced by 1.71 billion people in the world, contributing to disability, pain and reducing work productivity (Prima et al., 2022). In addition to this in Indonesia, the Occurrence of MSDs is 11.9%, and the top position with 65.2% of cases was the garment sector & this sector generally applies a sitting posture, and standing posture causes a risk to health, muscles, skeleton and other body parts (Prima et al., 2022). However, the study conducted by Karuppiah et al., (2020) employees working in garment industry are frequently faced with a variety of problems, including confined workspaces, varying scissors weights and sizes, poor lighting, and challenging thread and needle with great trouble. The listed cause affects the wellbeing of the Employee in garment manufacturing. moreover Musculoskeletal disorders (MSDs) are one of the most common global occupational and health problem, even developing countries are excessively affected with poor working condition due to lack of awareness about ergonomics problems ,inadequate training and education (Erick et al., 2022). The gap arises from the insufficient attention given to the social, ecological, and economic facets of sustainability in ergonomic studies. Most research has concentrated on economic factors, with economics receiving significantly more focus than the other dimensions, such as social and ecological aspects (Hasanain, 2024).

Work-related musculoskeletal disorders (MSDs) and discomfort are linked to extended periods of sitting, fast-paced tasks, static or awkward postures, and repetitive movements. Additionally, unsuitable and insufficient workplace conditions can lead to MSDs, impact individuals' wellbeing, and decrease productivity(Besharati et al., 2020).

According to the study conducted by Kiritkumar and Pothiraj (2023) the study investigates work-related musculoskeletal disorders (WMSDs) among sewing machine operators in the garment industry, identifying risk factors like poor working position, poor light, and challenging thread and needle are contributing problems for sewing operators. in addition the use of ergonomics interventions, such as height-adjustable workstations, can reduce postural discomfort in specific tasks in Garment Manufacturing (Ganguli et al. (2009).

The study conducted by Hoque et al., (2022) The main ergonomic factors include limited movement due to congested work areas and the absence of adjustable chairs, tables, and workstations. Furthermore, adopting improper work postures, engaging in repetitive actions and strong visual have detrimental effects on workers' physical and mental health. As a result, these factors lead to higher compensation costs, decreased efficiency, and reduced overall productivity.

On the other hand Most of research studies confirmed that enhancing the mental health and overall well-being of employees, the quality of an individual's work environment is strongly interconnected with their performance and output and directly influences productivity improvement and Encouraging employee with the organizations (de Pinho Pessoa et al., 2023).

According to the studies all Garment industry is often challenged by related to workplace ergonomics, which not only affects the health and well-being of workers but also has significant impacts for the sustainability of businesses within the sector. A challenge of work place ergonomics seen in Case company and may causes a risk on both its workforce and its long-term sustainability goals.

Senmul Garment industry faces challenges related to the well-being of workers and the overall social sustainability of their Manufacturing operations. There are factors that lead the industry to poor working conditions and increased risk of musculoskeletal disorders, Sitting and standing postures, work environment, work ethics, work area congestion, health and safety, and human rights because of this reason the employees experience fatigue and ergonomic injuries, which reduced worker productivity and these causes impact on working Environment.

In this regard, the study conducted on Senmul garment manufacturing company with site observation, interviews, discussion with selected groups, and the recent two-year data collected from the company. The injuries that are related to workstation ergonomics as per this data, with the highest number, indicate 15 neck and shoulder injuries working on a sewing machine, 10 in forceful exertion causing back pain, and 10 in using an ironing and pressing machine causing hand and wrist pain. The data shows that there is an indication of workplace ergonomics in the organization. Moreover social sustainability in related with work ethics, work environment, health and safety and human rights are causes of injury for employees. The issue is addressed according to the higher causes of injury and risk factors at workstations. Moreover reads and understands Literature gaps Overall workplace ergonomics assessment, specifically garment manufacturing.

In addition to the above problems from Senmul garment manufacturing and findings from different literature gaps de Pinho Pessoa et al. (2023) highlights the need for further research on improving communication and innovative monitoring technologies to measure work intensity, duration, social conditions, skill levels, career prospects, and earnings.

And also the study conducted by Kiritkumar and Pothiraj (2023), focus on investigating the occurrence of (WMSD) work-related musculoskeletal disorders among sewing machine operators in garment industry. Literature gap highlighting the need for future research to workplace interventions

- Ergonomic training,
- Adjustable workstations, and
- Regular breaks for the sewing machine operators.

Therefore, based on the problem and the gap identified from literatures there is a need to investigate the current state of workplace ergonomics at senmul Garment and explore its potential impact on workplace ergonomics. the study aims to identify Ergonomic issues, assess their effects on workplace ergonomics, evaluate the associated environmental impacts, Review Literature arguments and propose solutions for improving workplace ergonomics in the garment industry, finally leading to the overall enhancement of worker well-being, sustainability & it will increase the overall performance of senmul garment manufacturing.

1.1 Research Questions

The research has been answering the following related questions in relation to Senmul Garment Manufacturing Company:

1. What are the critical workplace ergonomic factors that affect workstation ergonomics in the garment manufacturing industry?

2. What are the Prevalence's of (MSDs) musculoskeletal disorders in garment manufacturing firms?

3. What strategies and mechanisms can be implemented to enhance social sustainability and optimize workstation ergonomics in garment manufacturing sector?

1.2 Objectives

General Objectives

The general objectives of the research is to assess the existing workplace ergonomics and its impact on social sustainability in garment manufacturing, identify the effect of risks on their health, well-being, and enhance their working conditions and overall job satisfaction and sustainability.

Specific Objectives

The specific objectives listed below are considered in the study related with the general objectives indicated:

- To assess the existing ergonomic issues in the workplace related to musculoskeletal disorders (MSDs) and to identify the factors that affect garment manufacturing.
- To identify and analyze root causes of workstation ergonomic factors that affect employee in the garment industry.
- To assess and identify areas that is exposed to the occurrence of musculoskeletal disorders (MSDs) in garment manufacturing firms.
- To identify strategy and mechanism to enhance social sustainability and improves workstation in garment manufacturing.

1.3 Scope and limitation of the study

Scope of the study

The research scope is focused in workplace ergonomics assessment and its impacts on social sustainability in case company and will answers the critical factors that affecting workstation ergonomics, asses and analyze the prevalence of MDSs in garment manufacturing and identify the strategy mechanism that reduces the work station ergonomics issues. Moreover it is working on the higher causes of injury and risk factors in workstations which show high rate of impact on workstation ergonomics that lead to the emergence of musculoskeletal disorders. This study involves the evaluation of specific working area considered to have high ergonomic injury and priority improvement areas to isolate potential ergonomic risk factors in garment manufacturing. The study delimited on Physical ergonomics which is related to existing garment manufacturing work station areas.

Limitation of the study

In our county ergonomics doesn't receive much attention in most of manufacturing industries and there is expected challenges faced to obtain well organized data on worker injuries in Related to Ergonomics. Among the difficulties are a lack of properly documented data and the employee's reluctance to cooperate in providing relevant information. However the issue will be resolved by convincing face to face conversation with the company managers, employees, operators and taking different supportive pictures in the workstation and try to elaborate the problem and make evidence based decision making to achieve the research goal. However, the study of Human Factors Engineering, which focuses on designing products considering human capabilities and limitations, and Organizational Ergonomics, which focuses on designing organizational structures and policies, are not included and have their own limitations in this study.

1.4 Significance of the study

The importance of this study has potential benefit to garment manufacturing industry by addressing workplace ergonomics. Conducting a study on workplace ergonomics assessment in garment manufacturing holds great importance in improving the well-being of workers,

enhancing productivity, reducing costs, and contributing to the sustainability and competitiveness of the garment manufacturing. The study enables companies to identify, assess, and control implementation to avoid ergonomic hazards and minimize the risk exposure that can result in decreased productivity in the swing line. Furthermore, the importance of this study extends beyond the garment industry. It is valuable for researchers, other countries, government textile industries, and promoting social responsibility within the garment manufacturing sector. It also creates opportunities for further research in this field.

1.5 Organization of the Research

The research paper is organized in seven chapters. the first chapter one Introduction ,background, problem justification, research questions, objectives, Scope the study, expected limitations, significant of the study & organization of the research. chapter two Introduction to Literature topics, review of previous literature works & concept ergonomics. chapter three emphasize the research methodology and design frame work of the research . Chapter four data collection and analysis. chapter five discusses the data analysis results. chapter six conclusions and recommendation of the study. Chapter seven References.

Chapter Two

2. Literature review

2.1 Introduction

The primary aim of this chapter is to provide an introduction to the literature to the topic and present a detailed summary of previous research conducted in regarding to the topic and the summary includes all the subjects that are relevant to the overall topic of the study. Additionally, it helps to identifying and discussing all the key points or findings that have appeared on the research conducted on the topic. To conduct a complete review of a topic, it is essential to gather evidence from various sources such as academic journal articles, books, and government Journal. Recent research indicates that particularly valuable to show the case in a deep comprehension of the subject. The review of the literature aimed to find articles linked to Workplace ergonomics, impact on social sustainability musculoskeletal disorders (MSDs). The majority of the resources collected from online sources, including Google scholar articles, journals, policies, publications and manuals sourced from various references.

2.2 Concept of ergonomics

Ergonomics is the study of interaction between humans and work environment. It plays an important role in creating workplaces that are accommodating and user-friendly. Additionally, it includes organization of workplaces, products, and frameworks to ensure they meet the specific needs of the individuals who use them (Eugenia et al., 2023).

According to the study conducted by Aquino Rojas et al. (2023) the definition of ergonomics refers the field of analyzing workplace designs, tools, and tasks performed within these spaces. It aims to evaluate the physical, psychological, and anatomical capabilities of workers to protect their health while performing their duties.

It is also a scientific method used to design work, evaluate the work and its surroundings, and modify or redesign the work in order to enhance performance. It plays a significant role in identifying, developing, and implementing standardized work. As a result, ergonomics

can be considered a practical strategic choice for enhancing the work environment and the well-being of workers in garment manufacturing (Hoque et al., 2022).

According to the study conducted by Arana et al. (2022) ergonomics is defined as an interdisciplinary field, explores the connection between the human system, machines and the environment. The main objective is to enhance human-machine performance by identifying and mitigating risk factors in the workplace at an early stage and aimed to improve ergonomic factors and physical conditions, such as lighting and noise, to enhance productivity and reduce the risks of occupational diseases.

The study of ergonomics focuses requirements on an employee's surroundings and job needs to improve productivity, quality, and output while reducing fatigue, musculoskeletal problems associated to the workplace. Every job needs an ergonomic assessment, which should take into account both the physical demands and the psychosocial elements that affect the ergonomic results. a good workplace ergonomics implemented successfully it reduces and lower the risk of disease and injury, improve worker productivity, and increase satisfaction in workplace(Edwards; et al., 2022).

On the other hand ergonomics is the lack of an uncomfortable work environment on employees may reduce productivity within the firm and employee performance. Reviews of the literature show a high correlation between an ergonomic workplace and job performance. Organizations should assess employee perceptions to guarantee superior job performance (Z. K. M. Makhbul et al., 2022)**.**

According to Meyer et al. ((2017) the link between sustainability, ergonomics, and occupational health issues, focusing on workforce sustainability and identifying work-related imbalances. The study also highlights the importance of sustainable work systems, balancing workers' capacity with system demands, and the role of ergonomics in optimizing the employee-work environment interface. In addition to this it helps for regenerating and developing human resources, promoting quality working life, and creating sustainable change processes.

In general ergonomics is a field that analyzes workplace designs, tools, and tasks to evaluate workers' physical, psychological, and anatomical capabilities. It is a scientific method used

to design work, evaluate its surroundings, and modify or redesign it to enhance performance. Ergonomics is a strategic choice for enhancing the work environment and worker well-being in garment manufacturing. It aims to classify and mitigate workplace hazards, improve ergonomic factors, physical conditions, and reduce occupational diseases. Good workplace ergonomics reduces disease and injury risk, improves worker productivity, and increases satisfaction. Organizations should assess employee perceptions to ensure superior job performance. More over lack of an uncomfortable work environment can negatively impact employee productivity and performance.

2.3 Ergonomics risk factors in garment manufacturing

Risk factors are elements that, either due to frequent exposure or prolonged presence, can originate from physical, psychological, or social sources, or ultimately contribute to the development of musculoskeletal disorders (MSDs) (Ortiz Porras et al., 2022). In addition to these factors such as force, posture, repetition, and inadequate rest have been recognized as the most prevalent risk factors. However, it is important to acknowledge that additional factors, including heat, noise, lighting conditions, odors, dusts are also for the risk of musculoskeletal disorders(Ortiz Porras et al., 2022).

On the contrary the study mentioned that in related to this (MSDs) is a major problem, particularly for workers engaged in physically demanding jobs. These jobs involve specific physical tasks such as lifting, pulling, pushing, standing, walking, bending, and engaging in forceful or fast repetitive movements. They affect the performance of daily work. Considering these it is important employee engaged in physical demanding works are the growth of MSDs (Sundstrup et al., 2020).

Furthermore studies mentioned about ergonomic hazards, are workplace conditions that can potentially harm the musculoskeletal system of workers. These hazards result from activities such as repetitive and forceful movements, awkward postures or positions resulting from incorrect work methods, and inadequate design of workstations, tools, and equipment. And also poorly designed workstations can result in fatigue, frustration, and physical discomfort for workers and result in a less productive work force. Increases the risk of painful and costly injuries and decreases product quality. In garment manufacturing, musculoskeletal

disorders are prevalent ergonomic factors that result from poor working conditions (Eugenia et al., 2023).

In addition to this the research study mentions that one of the ergonomics risk factor is Poor workspace design can be a source of stress, and studies in social psychology indicate that a crowded and congested workspace can adversely impact an individual's job performance. Research has demonstrated that workspace congestion and discomfort are negatively correlated with focus and privacy, which may, in turn, elevate stress levels in the workplace include weariness, exhaustion, musculoskeletal issues, and injuries associated to the wrists (Z. Makhbul et al., 2022)**.**

In general risk factors, such as force, posture, repetition, and inadequate rest, play a role in the development of musculoskeletal disorders. Physically demanding jobs, such as lifting, pushing, and bending, can lead to the growth of MSDs. Ergonomics hazards, such as repetitive movements, awkward postures, and inadequate design of workstations, can harm the musculoskeletal system. Poor workspace design can also contribute to MSDs, as it can cause stress and lead to weariness, exhaustion, and wrist injuries. In garment manufacturing, poor working conditions are a prevalent risk factor for MSDs. Therefore, it is crucial to address these risks and improve workplace conditions to prevent the development of MSDs.

2.4 Integration of ergonomics and sustainability

The study focuses on exploring the relationship between sustainability and ergonomics. In the frame work of ergonomics, key elements are chosen, taking into account the three dimensions of sustainability and their associated sub-dimensions. The modified ergonomic indicators are subsequently organized within these sub-dimensions. This approach allows for a comprehensive analysis of how ergonomics aligns with the various aspects of sustainability (Sarbat et al., 2020).

According to the study conducted by (Sadeghi Naeini, (2020)) concept of sustainability the research highlights the strong link between the characteristics of products and the principles of sustainability the role of products in our lifestyle is interconnected with various factors, including the materials used, meeting human needs, and environmental considerations.

Moreover, there has been a growing emphasis on understanding the life cycle of products through research, as evidenced by recent studies conducting life cycle assessments.

Figure 2.1 Integration of ergonomics and sustainability

The below table 2.1, highlights several factors for sustainable manufacturing in the future. The worldwide trend toward sustainability in manufacturing is driven by the need to reduce the impact of global forces and manage resource and energy use through optimization.

Table 2.1 Elements for sustainable manufacturing practices source (Hasanain, 2024)

Time	Focus point	Factors to Focus
Conventional Manufacturing	Economical Sustainability	Economic benefits
		Cost-effective manufacturing
		Economic impacts
		Market analysis
Present Manufacturing	Environmental Sustainability	Emissions
		Material recycling
Future Manufacturing	Social Sustainability	Work ethics
		Work environment
		Health and safety
		Community relationship
		Human rights

Sustainability, on the other hand involves protecting the environment and promoting a healthy lifestyle. While there are existing approaches such as Ergo ecology, human factors engineering (HFE), sustainability, and green ergonomics, further research is necessary to

bridge potential knowledge gaps and better understand how ergonomics contributes to sustainability (Sadeghi Naeini, (2020)).

The study on the integration of ergonomic design and material sustainability in garmrnt manufacturing suggests a framework for incorporating these aspects. The study emphasizes the importance of ergonomic design and sustainable materials in enhancing various aspects within the garment manufacturing industry. This includes improving working conditions, reducing environmental impact, and enhancing productivity (de Pinho Pessoa et al., 2023).

Within the presence of ergonomics risk assessment techniques methods, more research is required to suggest the creation of a structural framework for managing an organization's operations processes. to assess ergonomic risks systematically and periodically in a sustainable manner, it can be helpful to establish a performance assessment system that uses this type of structural framework and its indicators to detect potential ergonomic risks throughout the business processes (Sarbat & Ozmehmet Tasan, 2022). With the help of these suggested ergonomic indicators and the integration of sustainability and ergonomics, coherence between the two may be presented.

The study conducted by Lin et al. (2019) a particular social wellbeing condition has received less attention to this manufacturing industry equally considers the three pillars of sustainability dimensions such as social, economic, and environmental dimensions and applying the principle of 6R in the total life cycle of the Product.

Quality of life and Sustainability is crucial not just for individuals but also for industrial sectors and organizations. The concept of sustainability is constantly growing, and its progress requires both systemic changes and structural enhancements. in this regard, creating synergy between these two areas can result in a more suitable and effective approach towards enhancing the quality of life for everyone (Sadeghi Naeini, 2020).

To summarize the above paragraphs, the study explores the relationship between ergonomics and sustainability, focusing on the three dimensions of sustainability and their sub-dimensions. It highlights the strong link between product characteristics and sustainability principles, emphasizing the importance of materials, human needs, and

environmental considerations in our lifestyles. Ergonomics is a multidisciplinary field that optimizes human-machine interactions for efficiency and comfort, while sustainability involves protecting the environment and promoting a healthy lifestyle. The study suggests a framework for incorporating ergonomic design and sustainable materials in garment manufacturing, enhancing working conditions, and reducing environmental impact. More research is needed to create a structural framework for managing organizational operations processes and systematically assess ergonomic risks throughout business processes. The integration of sustainability and ergonomics can lead to a more suitable and effective approach to enhancing the quality of life for everyone.

2.5 Musculoskeletal disorders (MSD's) in garment manufacturing

In worldwide MSDs is a common health problem and the majority of MSDs associated with the workplace are resulted from prolonged exposure to high- or low-intensity repetitive loads to evaluate the risk levels related to various postures by examining the body's overall position (Jambarsang & Anoosheh, 2020). This study argues and mentions that MSDs are one of the major world problems.

In Comparison to other occupations, garment manufacturing is more exposed to musculoskeletal problems than workers in other occupations because the majority of garment workers have low levels of education; they lack knowledge about basic work management skills, primary healthcare and proper working postures. Additionally, because Bangladeshi garment workers receive inadequate pay, they are unable to access better healthcare, and garment ownership does nothing to improve the health of its employees. These are the primary causes of the daily rise in these illnesses. Therefore, improve in economic condition, we must pay attention to their health and take the necessary actions (M. A. Hasan et al., 2023) .

Studies revealed that occupational risk factors, such as prolonged sitting or standing, awkward posture, manual handling of heavy loads, vibrations, forceful exertions, and physical and psychological stress at work, are responsible for the development of musculoskeletal disorders between garment employees in Bangladesh (Hoque et al., 2022).

Currently, MSDs are significant challenges to workplace ergonomics in worldwide. The sitting posture is a primary cause of low-back pain, which is a prevalent Musculoskeletal Disorder (MSD) experienced by a significant percentage of adults. Studies have reported that low-back pain occurs in 50% to 90% of all adults, and reappearance rates can be as high as 90%. Annually, approximately 15% to 20% of adults suffer from back pain. In certain tasks, such as operating machinery, individual's often forward with their trunk and head inclined to improve & enhance visual control of the task. in general, several studies conclude that many of garment manufacturing employees has been suffering from musculoskeletal disorder depending on the nature of the work being performed and the posture adopted by the workers (Abate, 2022) .

According to the World Health Organization (WHO), musculoskeletal disorders (MSD) are a major cause of disability among the elderly population. The WHO has identified four major MSD conditions that cause disabilities: osteoarthritis (OA), rheumatoid arthritis (RA), osteoporosis (OP), and back pain (BP).the prevalence of musculoskeletal problems in developed countries among the elderly population revealed that the most commonly reported MSD condition was back pain (29%), followed by osteoarthritis and osteoporosis (17%), RA (8%), ankle/foot pain (8%), knee pain (6%), hip pain (5%), shoulder pain (5%), hand/wrist pain (3%), and elbow pain (3%) (M. Hasan et al., 2023).

Musculoskeletal disorders (MSDs) include a group of inflammatory and degenerative conditions that primarily impact the muscles, tendons, ligaments, joints, or peripheral nerves. These conditions typically give rise to feelings of pain or discomfort. The growth of MSDs is commonly associated with repetitive manual labor, the lifting of heavy loads, engaging in prolonged periods of static work, overexertion, exposure to vibrations, or working in awkward postures. MSDs are a major public health challenge in both industrialized and developing nations. The result is increased absenteeism, and may even need to change jobs. These consequences are themselves linked to substantial economic costs, ultimately resulting in significant impacts on an individual's overall quality of life (Nabi et al., 2021) .

Ergonomics as a scientific subject aims to examine and adjust work conditions, employee tools, and job procedures considering psychological, physiological, and anatomical aspects

point of view. The research conducted to examine and evaluate the potentials of the body posture monitoring sensor integrated into clothing and its application as standard equipment. This sensor is intended to assist correct incorrect and dangerous upper body positions during extended periods of stationary work (Maksimović et al., 2022).

One of the major causes of workplace injuries worldwide is musculoskeletal problems. They have a major effect on Business cost and employee health. Work place ergonomic risk shows that employ observational evaluations to detect possible accidents and enable safety managers to act quickly to reduce the risks have been established. However, it is challenging to do these evaluations in real time since they are highly subjective. By creating an online algorithm using NIOSH index to calculate and give Additional data for the assessment of ergonomic risk, this work offers a method to digitalize this process (Leggieri et al., 2024). On the other hand according to (Polat & Kalayci, 2016) The major health issue in labor-intensive industries is work-related musculoskeletal disorder. Garment manufacturing remains one of the major labor-intensive sectors of the economy, even with advancements in technology and workshop procedures.

This shows us the future ergonomics assessment is done through posture monitoring sensor integrated into clothing in order to correct dangerous upper body positions during extended periods of static work. Industry 4.0 is the next demand of garment industry with a particular Important on the well-being of workers and the quality of their work (Pessoa et al., 2023).

Finally, the literature reviewed are helpful in finding the issue that affects the workplace ergonomics and its effect on social sustainability and all reviewed literatures argue that work place ergonomics is one of the major problem worldwide in Garment manufacturing sector and is caused by due to the nature of repetitive work, poor workstation design, environmental & social impacts causes the employee causes musculoskeletal disorders (MSDs) in the employee and not only affects the employee health but also affects the industry productivity and effectiveness and affects the sustainability of its future goal.

2.6 Strategy and Mechanism to Improve Workplace Ergonomics

The other strategy mechanism suggested research carried out by Choobineh et al. (2021) focus work related musculoskeletal disorders are identified mainly common compliant in various workplaces. The aim of this study is to implement an intervention program through which measures are dynamically localized in the workplace. These include three basic layers, such as workshop training, workstation redesign, and participatory ergonomics PE.

Moreover the study as mentioned by Scafà et al. (2019) discuss Industries are currently undergoing a technological shift that will towards to Industry 4.0. These new technologies offer new opportunities to evaluate ergonomics and the environment. However, they also introduce new stress related to human-machine interaction (HMI).

By incorporating both human factors and non-human elements through ergonomic principles, human-centered design becomes an interactive approach to system development aimed at making systems both useful and user-friendly. This method removes any potential negative effects on user pleasure, accessibility, sustainability, human health, safety, and performance while also increasing productivity and efficiency (Kaya, 2023).

The study reveals the relationship between ergonomic design and material sustainability within the fashion manufacturing sector. It puts forward a framework that highlights the importance of integrating these aspects. By incorporating ergonomic design principles and sustainable materials and this helps to improved working conditions, reduction in environmental impact, and enhancements in product quality, all within the context of the apparel industry (de Pinho Pessoa et al., 2023).

To achieve satisfactory results, a three hierarchy of controls comprising Engineering, Administrative measures, and Personal Protective Equipment (PPE) is commonly recognized as an effective strategy for reducing, eliminating, or managing workplace hazards, including ergonomic risks.

Engineering control: With-regard-to work organization and job design in workplace ,Rearrange ,modifying and replacing work processes and changing workstation lay out tool and equipment select ergonomic sewing machines, providing adjustable and ergonomic chairs with good back lumber support, ensure adequate legroom, knee/foot clearance

Administrative measures: job design in workplace to reduce repetitive strain rotate workers between different stations, schedule regular breaks, provide muscle relaxation time ,changing job rules and procedures and limit overtime to prevent fatigue.

Personal protective equipment (PPE): personal protective equipment (PPE) generally serves as a barrier between workers and hazards. Additionally, there are other devices like braces, wrist splints, and back belts that can help reduce the duration, frequency, and intensity of exposure to risk factors for musculoskeletal disorders (MSDs) (Odebiyi & Okafor, 2023).

2.6.1 Tools for Ergonomics Workplace

On the other hand the International Physical Activity Questionnaire (IPAQ) in the study used to measure the level of physical activity (PA). Physical activity levels were categorized as low, moderate and vigorous based on the scores. The reliable and sensitive ergonomic assessment method REBA used to examine postural risk to the body during the work (Kiritkumar & Pothiraj, 2023). Data was analyzed using SPSS 24 software this shows that most literatures argues that using different methods of questionaries' but to analyze the assessment, the REBA & OWAS assessment method is frequently used in most recent studies.

The proposed workplace social sustainability framework by (Gajšek et al., 2022) contains five elements: employee wellbeing, safety considerations, comfort workplace, musculoskeletal disorder, and environmental considerations.

Figure 2.2 Workplace frame work sustainability by (Gajšek et al., 2022)

The study conducted by Aquino Rojas et al. (2023) on his study he suggested that the model's integration relies on utilizing ergonomic assessment techniques and process analysis. This includes identifying the RULA, REBA, NIOSH assessments, and the 5S tool, along with conducting an environmental analysis.

The study summarizes that, Choobineh et al. (2021) propose an intervention program for workplace MSD hazards , focusing on workshop training, workstation redesign, and participatory ergonomics PE. Scafà et al. (2019) discuss the shift towards Industry 4.0, emphasizing the importance of human-centered design in system development. The study highlights the relationship between ergonomic design and material sustainability in the garment manufacturing sector, highlighting improved working conditions, reduced environmental impact, and enhanced product quality. The International Physical Activity Questionnaire (IPAQ) and REBA assessment method are used to measure physical activity levels. Gajšek et al. (2022) propose a workplace sustainability framework with five elements: employee wellbeing, safety considerations, comfort workplace, musculoskeletal

health, and environmental considerations. (Aquino Rojas et al., 2023) suggest integrating ergonomic assessment techniques and environmental analysis.

2.7 Ergonomics & Sustainability in garment manufacturing

Sustainable development refers to progress that fulfills the needs of the current generation without compromising the ability of future generations to meet their own needs. Companies recognize the significance of social sustainability and to establish goals and objectives for sustainable development that balances the three dimensions of economic, social, and environmental sustainability(Gajšek et al., 2022). By integrating the principles of social sustainability into ergonomics, organizations have the ability to construct work environments that not only prioritize physical comfort and productivity but also foster the well-being, satisfaction, and sustained commitment of their employees.

According the study conducted by Gajšek et al. (2022) among the economic, social, and environmental dimensions, the social dimension is often regarded as the weakest pillar of sustainable development, leading to demands for research and enhancements. While the relationship between ergonomics and social sustainability is recognized, there is limited knowledge regarding how companies understood and incorporate this relationship into their practices.

This study aims to investigate the role of ergonomics and well-being in enhancing the social sustainability of employee in the garment factory. To achieve this objective, a comprehensive literature review will be conducted, providing a descriptive analysis of the topic (Elkhamary et al., 2023). Furthermore, the study recognizes the growing importance of promoting social sustainability within organizations and workplaces. This recognition from the understanding that social sustainability and responsible utilization of natural and physical resources are crucial. It involves considering the sustainable management of human resources and the overall well-being of employees within the organizational context. Human resources encompass the characteristics, behavior, and effectiveness of individuals in the workplace, as well as their interactions with both technology and humans. These aspects are closely intertwined with the field of ergonomics (Gajšek et al., 2022).

The concept of a healthy work environment is often defined by considering the physical, emotional, and organizational issue that influence the well-being of workers, frequently in relation to the current challenges faced by the organization. Creating a safe and supportive workplace environment is essential for long-term growth as it directly influences the potential for social and economic progress (Thomas et al., 2023).

Throughout the world, MSDs are a highly common health issue and a significant contributor to employment injury. The majority of MSDs associated with the workplace are resulted from prolonged exposure to high- or low-intensity repetitive loads (Sain & Meena, 2016).

The literature review on the integration of ergonomic design and material sustainability in garment manufacturing suggests a framework for incorporating these aspects. The study emphasizes the importance of ergonomic and sustainable materials in enhancing various aspects within the garment industry to improving working conditions and reducing environmental impact (Pessoa et al., 2023).

The study reveals that review the importance of promoting quality of life and sustainability in individuals, industries, and organizations. They emphasize the need for systemic changes and structural improvements in sustainability and ergonomics. They propose a new approach to enhancing quality of life based on sustainability and ergonomics principles, aiming to improve living conditions in both developing and developed countries (Sadeghi Naeini, (2020)).

More over the study suggest that sustainable work systems aim to achieve a balance between people's capacity and system demands, rather than the unsustainable consumption of workers' personal resources it is also important for regenerating and enhancing human resources, improving the quality of work life and competitive performance, and establishing sustainable change processes for growth and learning (Meyer et al., (2017).

In general the aim of Sustainable development is essential for addressing the needs of current generations while ensuring that future generations can meet their own needs. Companies recognize the importance of balancing economic, social, and environmental sustainability, and integrating social sustainability principles into ergonomics can help create

work environments that prioritize physical comfort, productivity, well-being, satisfaction, and commitment. However, the social dimension is often considered the weakest pillar of sustainable development, leading to research and enhancements. This study investigates the role of ergonomics and well-being in enhancing sustainability in the garment manufacturing industry. A comprehensive literature review is conducted to provide a descriptive analysis of the topic. The study emphasizes the importance of incorporating ergonomic and sustainable materials in the garment industry to improve working conditions, reduce environmental impact, and enhance product quality. The study also highlights the need for systemic changes and structural improvements in sustainability and ergonomics, proposing a new approach to enhancing quality of life based on sustainability and ergonomics principles, aiming to improve living conditions in both developing and developed countries.

2.8 Ergonomics global study in garment manufacturing

Globally, musculoskeletal complaints are experienced by 1.71 billion people in the world, contributing to disability, pain and reducing work productivity. In Indonesia, the Occurrence of MSDs is 11.9%, and the top position with 65.2% of cases was the garment sector’’. The garment sector generally applies a sitting posture, and standing posture. These cause a risk to health, muscles, skeleton and other body parts (Prima et al., 2022).

The study conducted in India reviewed the literature on individuals working in the garment industry. It identified several common challenges that these workers face, including restricted space for movement, the size and weight of scissors, inadequate lighting, and difficulties in connecting thread and needle. The study also highlighted that repetitive low-load tasks performed in awkward positions for prolonged periods, manual handling of heavy weights and moving items, are potential factors contributing to work-related musculoskeletal disorders (WMSDs) (Karuppiah et al., 2020).

The literature reviewed study in Botswana ,The workstation of sewing machine operators in a textile industry in Botswana as well as their insight of workload and discomfort and also with specific reference to sewing machine operators, this is an occupational group that may experience a high occurrence of MSDs. to identify possible ergonomic deficiencies in the standing workstation of sewing machine operators (Sakthi Nagaraj & Jeyapaul, 2018).

To describe a few major factors that affect the garment manufacturing sector, sewing machine operators experience a variety of health issues, such as shoulder and neck, which have been linked to bad working posture and repetitive hand and arm motions(Chopde & Deshmukh, 2018).

The literature reviewed study in Botswana, Because of the repetitive tasks and uncomfortable work positions in the textile and garment industries, many studies worldwide have identified musculoskeletal risk factors. The aim of this research was to determine whether sewing workers in Botswana's garment manufacturing had workstations that were not ergonomically sound, as well as how they felt about their workload and physical pain (Sealetsa & Thatcher, 2011).

The literature reviewed study in Bangladesh**,** There is a correlation between ergonomics and the working environment, as demonstrated by the wealth of research on ergonomics practices in developing country Garment manufacturing. Poor workstation design, and a lack of adjustable Chairs are examples of poor ergonomics practices that lead to unfavorable working conditions and a higher risk of muscular strain for sewing machine operators (Hoque et al., 2022).

The study in Sri Lankan textile industry evaluated the occurrence of musculoskeletal disorders and associated ergonomic hazards, and the study found that musculoskeletal symptoms are most common in the knee, foot, thigh, lower leg, and lower back and to identify the prevalence of Musculoskeletal Disorders (MSDs) and related ergonomic risk factors among SSMOs in the Sri Lankan textile industry (Nagaraj et al., 2019)

The study conducted in garment industry aims to evaluate the ergonomic risk elements present in the garment industry, with a specific focus on physical workloads and the working environment. The purpose is to identify the risk factors that contribute to work-related musculoskeletal disorders. The outcome of the research mentions that inadequate ergonomic working conditions within the garment industry can result in severe physical ailments, especially in specific departments such as sewing, cutting, packaging, warehouse, and packaging. the research utilizes the Rapid Entire Body Assessment technique to analyze the working conditions and physical workloads experienced by workers (Polat & Kalayci, 2016)

In addition to this the study investigates the influence of ergonomics assessments on the Sustainability Index in a tool manufacturing company. It examines how these assessments indirectly impact the values of Sustainability Index indicators. The study uses the Ergo IA software for the ergonomics assessments, evaluating the workplace using the OWAS and REBA methods, and assessing the impact on the Sustainability Index. The study reveals that ergonomics assessments influence the social, economic, and environmental indicators of the Sustainability Index. the study has limitations, including its experimental setting in a tool making company, its use of OWAS and REBA ergonomics assessment methods, and not considering all risk factors, including duration and frequency of ergonomic risks, which may impact the Sustainability Index (Sinko et al., 2022)

In general, the above study emphasized the need for ergonomic interventions to address the health issues faced by sewing machine operators and improve their working conditions. By identifying and correcting ergonomic deficiencies in workstations, it is possible to reduce the occurrence of MSDs and support the well-being of sewing machine operators in textile and garment industry.

2.9 Ergonomics study in Ethiopia garment manufacturing

In Ethiopia, there are 102 garment industries. Out of these, 79 were located in Addis Ababa, while 22 were found in the Oromia Zone around Addis Ababa. This sector employed over 10,000 workers, with approximately 70% of them being female and used as source of employment.

According to the Ethiopian Ministry of Labor and Social Affairs (MOLSA) report, in the year 2014/2015, a total of 5,135 work-related accidents were reported from 279 establishments. Among these accidents, 5,092 (99.16%) were classified as non-fatal. As a result, the medical expenses for these cases amounted to 2,195,960.74 ETB, and the injured employees absent of 12,612 workdays. According to the MOLSA report of 2014/2015, a total of 2,856 individuals (56.62%) in the manufacturing industries were recorded as victims of work-related accidents and diseases. Among these industries, the garment industry stands out as one of the most hazardous sectors. which is faced to the repetitive nature of the work,

strong visual demand, involve in improper postural position and longtime of either sitting or standing in one position (Abate, 2022) .

The study conducted in Ethiopia Gamoo zone reveals that, musculoskeletal disorders remain a significant global health issue, placing a considerable financial burden on low- and middle-income countries like Ethiopia. This is especially challenging due to the already limited health budgets in Ethiopia, which are primarily focused on addressing life-threatening conditions. According to a systematic review, a significant percentage of Ethiopia's working population, ranging from 35% to 74.5%, experiences musculoskeletal pain (Haftu et al., 2023).

On the other hand the study conducted in Ethiopian manufacturing industry, the increasing presence of ergonomic hazards linked to physical environmental factors is posing a significant challenge in Ethiopian metal and textile factories, affecting both the safety of workers and overall performance. To effectively tackle this issue, it is essential to conduct a scientific evaluation and implement appropriate corrective measures (Kassaneh & Tadesse, 2019).

The study conducted among swing machine operators in Mekele city, the profession of sewing machine operation involves highly repetitive and precise tasks. Operators need to bend forward in order to have a clear view of the operation point. Continuously they use their hands to handle the fabric feed towards the needle while continuously operating the foot and knee pedal. Taking into account the high growth of the garment industry in Ethiopia, it is essential to oversee and address health hazards linked to work related expriance.in addition to this there is no comprehensive studies examining the frequency and contributing factors of neck pain among garment sewing machine operators in the study region (Biadgo et al., 2021) .

Moreover the study carried out in Ethiopian garment industry the study reveals that Ergonomic factors significantly impact workplace productivity in the Ethiopian garment industry. The analysis identified several ergonomic problems, including physical strain on joints, muscles, nerves, tendons, and bones, as well as environmental factors that impact hearing, vision, and overall comfort and health. The study also found that work-related musculoskeletal disorders (WMSDs) are common in the industry, and redesigning the work

environment can decrease MSDs problems and improve productivity (Abebe & Hasegawa, 2018).

The study conducted among sewing machine workers in Galan City's garment industry aims to evaluate the prevalence and risk factors of work-related musculoskeletal disorders. The study revealed a 40% prevalence of work-related elbow and wrist MS disorders among sewing machine operators, significantly influenced by personal and environmental factors. The methodology utilized an institution-based cross-sectional design and standardized Nordic questionnaire, to collect data on sociodemographic characteristics, personal factors, organizational factors, and working environment factors (Deyyas & Tafese, 2014).

The conceptual framework structure explains the set of workstation factors supposed to impact worker outcomes. These ergonomic factors, such as noise, temperature, extended periods of sitting, rapid work pace, static and uncomfortable positions, and highly repetitive actions, are basically independent variables that affect the wellbeing of workers performance. According to Rahmat et al. (2023) dependent variables, the lack of ergonomic workstation design and input factors, have a major negative impact on worker performance.

2.10 Ergonomics tools and techniques

Regarding For ergonomics, tools and techniques Different literature is conducted and has used different tools and techniques for their study in garment manufacturing industries.

The study in Sri Lanka textile industry the methodology the study use is work associated factors and (CMDQ) Cornell Musculoskeletal Discomfort Questionnaire along with the use of confirmed ergonomic tools such as the (REBA) Rapid Entire Body Assessment and the Strain Index (SI), to evaluate ergonomic risks (Nagaraj et al., 2019).

On the other hand the study conducted by Gajšek et al. (2022) He demonstrates how the use of a specific innovative Ergo IA ergonomics tool, Ergo IA, along with selected methods for ergonomic risk hazard assessment such as the (OWAS) Ovako Working Posture Assessment System and the (REBA) Rapid Entire Body Assessment, can and should be linked and interconnected with Social Sustainability. The study has limitations, including its experimental setting in a tool making company, its use of OWAS and REBA ergonomics

assessment methods, and not considering all risk factors, including duration and frequency of ergonomic risks, which may impact the Sustainability Index.

According to the current study conducted by Kiritkumar and Pothiraj (2023) Prevalence of work-related musculoskeletal disorders and analysis of working posture for sewing machine operators in a garment industry method used is Örebro Musculoskeletal pain questionnaire (ÖMPQ), Rapid Entire Body Assessment tool (REBA), Quick Exposure Check tool (QEC) and International Physical Activity Questionnaire (IPAQ) and data was analyzed using SPSS 24 software.

- REBA is an approach employed to assess the risk levels associated with different postures to assess the existing workplace ergonomic MSD & to identify the factors that affects in garment manufacturing using Statistical software SPSS for analyzing survey responses and quantitative data.
- Root cause analysis techniques fishbone diagram, to identify and analyze root causes of workstation ergonomic factors that affect Employee in the garment industry using Qualitative analysis methods and visualization tools and (MAXQDA) software.
- Medical records and incident reports related to MSDs to assess and identify areas that are exposed to the prevalence of musculoskeletal Disorders (MSDs) in garment manufacturing firms using tools SPSS and data visualization tools (Tableau)
- Benchmarking and Best practice review and literature review on ergonomic interventions, to develop a preventive mechanism strategy that improves workstations in garment manufacturing using survey questioner.

The below table 2.2 shows that the final score characterized by according to the risk level that an individual exposed to musculoskeletal disorder. The risk level and priority of corrective posture action classified in to five categories: Negligible the risk value very low with final score 1, the risk level low group with final score 2-3, the risk level medium group with final score 4-7, the risk level high group with final score 8-10, the risk level very high group with final score 11-15.

Table 2.2 Final score REBA by (Jambarsang & Anoosheh, 2020)

Evaluation and final Actions	The value of Risk	Final score of risk
Is no necessary	very low	1
It may be necessary	low	2-3
Necessary	medium	4-7
It will be necessary soon	high	8-10
It is necessary now	very high	11-15

According to the study conducted by Kee (2021) the study compared three commonly used observational techniques OWAS (Ovako Working Posture Analyzing System), RULA (Rapid Upper Limb Assessment), and REBA (Rapid Entire Body Assessment) by assessing the relationship between the work-related musculoskeletal loadings determined using these methods and actual musculoskeletal disorder (MSD) data.

REBA: the REBA (Rapid Entire Body Assessment) considers the position of the upper arms, lower arms, wrists, trunk, neck, and legs. The REBA method evaluates the extent of external loads or forces, the muscle activity caused by static, dynamic, rapidly changing or unstable postures, as well as the coupling (connection) between the body parts.

OWAS: the OWAS (Ovako Working Posture Analysing System) identifies four different work postures for the back, three for the arms, and seven for the lower limbs. It also has three categories for the weight of the load handled or the amount of force used.

RULA: the RULA (Rapid Upper Limb Assessment), provides a rapid assessment of upper body posture and loading, and then classifies the results into four levels that guide the need for ergonomic improvements to reduce the risk of musculoskeletal disorders.

In general The REBA (Rapid Entire Body Assessment) evaluates external loads, muscle activity, and coupling between entire body parts. This method is more preferable for

garment industry work activity considering dynamic movements with assessment of overall body parts then other methods. The OWAS (Ovako Working Posture Analyzing System) identifies different work postures and weights. The RULA (Rapid Upper Limb Assessment) assesses upper body posture and loading, classifying results into four levels for ergonomic improvements.

2.11 Gaps in the literature reviews

Social sustainability has been often neglected in recent years. In literature there are no methodologies and tools to objectively evaluate processes' impacts on human. Similarly, there are not objective correlations between the well-being of the operator and company performance. These evaluations become essential if we become aware that human continues to play a key role for company growth (Scafà et al., 2019). This study stated that the need of social sustainability in the wellbeing in correlation between operator and company. However in the case company there is no assessment is done in social sustainability in employee wellbeing

According to Kaya (2023) studied that by integrating ergonomics, knowledge, and methodology, human-centered design with an interactive approach is the best method for user pleasure, sustainability, human health, safety, and performance, and increasing efficacy and productivity.

On the other hand in recent literature review, Industry 4.0 has a new requirement for garment manufacturing sector, which emphasize the importance of conducting new research. This research should encompass various aspects such as production "coordination, management, and control, in particular emphasis in well-being of employee and the value of their work.

The gap identified from the recent studies, the research carried out by (Gomes et al., 2023) Suggested additional research is required Improving communication, exploring innovative monitoring technologies that can effectively measure essential factors like the intensity of work,

- Duration of work,

- Social and environmental conditions,
- Skill levels,
- Career prospects and wages. To enhance productivity and employee well-being for the long-term sustainability of employees in the garment industry.

The study conducted by (Kiritkumar & Pothiraj, 2023), the research focus on investigating the occurrence of (WMSDs) work-related musculoskeletal disorders among sewing machine operators in garment industry. The study successfully recognized various risk factors that contribute to the development of workplace musculoskeletal disorder among these operators, particularly emphasizing the impact of poor working posture.

However, a literature gap identified, highlighting the need for future research to concentrate on evaluating the success of workplace involvement designed to minimize the prevalence of WMSDs. These interventions include

- Ergonomic training,
- Adjustable workstations, and
- Regular breaks for the sewing machine operators.

The literature review reveals a gap in knowledge regarding the relationship between ergonomic design and material sustainability in the fashion industry. While previous research has examined sustainable materials and ergonomics separately, this shows that there is absence of comprehensive studies that integrate both aspects (Sadeghi Naeini, 2020).

2.12 Literature review conceptual frame work

The conceptual framework structure explains the set of workstation factors supposed to impact worker outcomes. These ergonomic factors, such as noise, temperature, prolonged sitting position, fast-paced work, static and awkward postures, and highly repetitive movements, are basically independent variables that affect the wellbeing of workers performance. According to Rahmat et al. (2023) dependent variables, the lack of ergonomic workstation design and input factors, have a major negative impact on worker performance. In addition to this most researchers agree that job stress arises from work design and the workplace environment. These can impact employee in various ways, including reducing

their illnesses resistance, causing sleep deprivation, and weakening their concentration, which can lead to more injuries and accidents. Indicators of distress can be psychological such as anxiety, depression, or irritability, high blood pressure or increased muscle tension, and behavioral change including poor work performance, accidents, sleep disturbances, and substance abuse (Rahmat et al., 2023) .

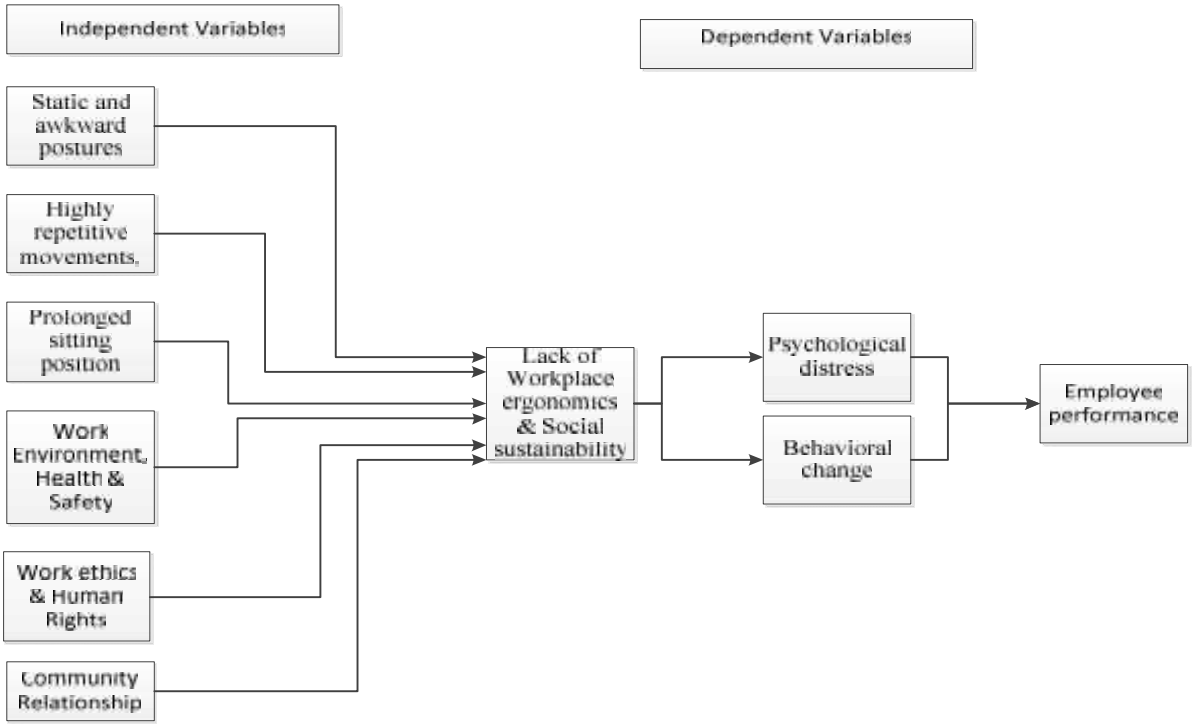


Figure 2.3 Literature conceptual frame work source (Rahmat et al., 2023)

Chapter Three

3. Research Methodology

3.1 Introduction

This chapter outlines the methodologies and design that have been used in the study to workplace ergonomics and its impacts on social sustainability in Senmul garment manufacturing and the research is needed to solve the challenges by Assess, analyze and improve Workplace ergonomics at Senmul garment manufacturing which will enhance the Productivity and quality and it helps to increase the overall performance of the case company.

3.2 Research Design

Descriptive research is used in order to identify the ergonomic risk factors that may potentially contribute to musculoskeletal disorders on the sewing line of the company known as Senmul Garment Manufacturing. Different methods have been proposed by researchers to Assess and evaluate work place ergonomics and its impact on social sustainability. There are different research designs and for this study a descriptive case study design has been used. The study design took into account the reliability and applicability of data identify, and assessment of workplace ergonomics in garment manufacturing. The purpose of the research design is to answer predetermined research questions by methods such as site visit, data gathering, questioning, data analysis, and result discussion.

3.3 Research methodology frameworks

A methodology flow diagram is a visual tool that helps to illustrate the Phases within a research methodology framework. In addition to this it helps researchers in understanding the sequential process of conducting research, from the initial idea conception to the final end analysis. Below figure 3.1 is a brief overview of the research flow diagram.

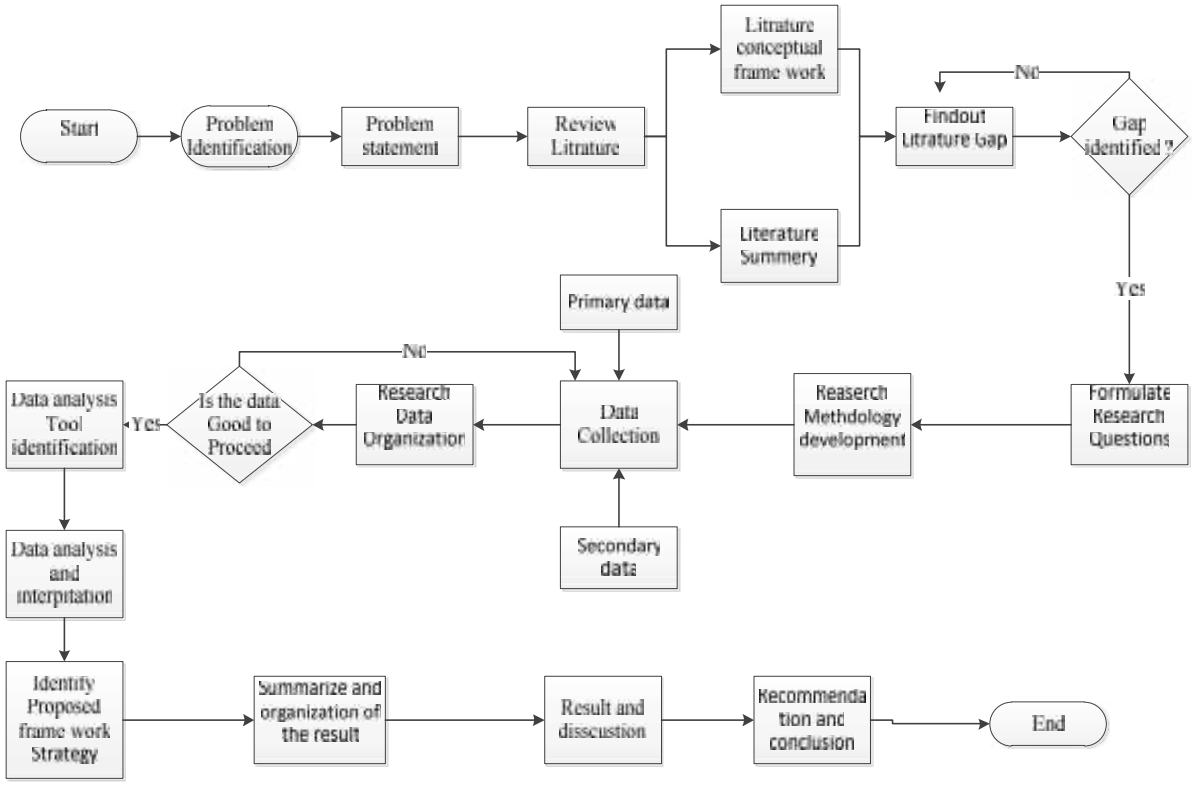


Figure 3.1 Research methodology frame work

3.4 Data sources

Primary data source and collection

Primary data that are gathered through in-person interviews and site observations, discussion with groups of members, managers, senior technician & Questionnaire to review. In this research method activity, the interview is conducted to gather the general and detail information with open ended questionnaire for the selected groups of the company Senmul

garment manufacturing. In addition to this observation activity method the information is conducted through own direct observation without soliciting input from the respondent. These primary collection data will help to address research question number one in the research questions. The primary benefit of this method is that it is subjective is eliminated and the observer made observation in Senmul Garment manufacturing**.**

Secondary data source and collection

The data collection is done through the following methods: examination of recorded secondary data. The secondary data which consists of data that the

The research utilized journals, articles, senior theses, different relevant books, and available papers review and best bench marks which are recent practice in the world. Reviewing and consider the existing workplace ergonomics also used to give the best possible solution and create a good workplace in Senmul Garment manufacturing. These secondary data collection will help to address research question number three in the research questions.

The major source consists of data, from company sick leave history records, industrial safety records, logbooks, checklist & other relevant records. in addition, planned to get relevant data from related works studies, books, articles, brochures, case company manuals.

3.5 Questionnaires Sample Size Determination

A sample size is a part of the population involved to represent the whole population in a study, different factors will be considered in determining the suitable sample size, such as the purpose of the study, population size, the risk of wrongly taken samples, and acceptable sampling errors (Muyembe Asenahabi & Anselemo Ikoha, 2023).

According to the study conducted by (Avinante et al., 2021) **t**he study uses the formula to determine accurate number of samples and assumes that 90% with 10% margin error used.

However the study uses to determine accurate number of samples and assumes that 95% confidence level and acceptable error level (5%) with margin of error 0.05:

Formula: n = N / (1+Ne 2)

Whereas: n = number of samples

N= total population

e= margin of error.

Total population in the company N=100, e=0.1 0.05

n = N / (1+Ne 2)

n= 100/(1+100*0.05*0.05)

n= **80 number of samples**

3.6 Data collection methods

A descriptive research method has been used in order to determine the ergonomic risk factors that may potentially contribute to musculoskeletal disorders in Senmul garment manufacturing. In addition to this using secondary collection method reviewing and analyzing different journals, questionnaire, site observation, observation tools, Articles, senior thesis work, different relevant books, available documents and best bench marks which are recent practice in the world are things consider in data collection method in the study.

3.6.1 Questionnaire

Questionnaire**:** survey questionaries' are utilized and distributed to 80 employees and collect their feedback on their workstation activities, working conditions, and the level of pain they experience (WMSD) in different parts of their bodies. However from the distributed 80 questionnaires 11 questionnaires are not responded. Therefore analysis is done for 69 responded questionnaires. In addition to this reliability test is done for the collected data's to analyze the impact of workplace ergonomics and social sustainability in Senmul garment manufacturing.

3.6.2 Site observation

Observing operators in their current working conditions in site is one of the most valuable methods of collecting data. The researcher employed observation of activity performed, duration work, frequency of activities performed by the employee, movement of their bodies and working postures. Moreover observation is used to create a process flow and mapping the workflow.

3.6.3 Observation tools

Video or photo camera has been used to capture images or record videos of operators' working postures for ergonomic analysis. This allowed for a detailed examination of their body positions and movements to identify potential ergonomic and social sustainability issues. Additionally, the camera was used to document the work and working activities involved in order to analyze the process flow.

Measuring tape is one of the tools which are used to estimate the size and take measurements of different working positions in the workplace heights, lengths and other any necessary measurements in their working stations for the analysis.

Interview: is one of the data collection methods, and an interview is carried out to gather detailed information about the case company garment manufacturing through face-to-face interview, site observation, discussion with groups of members, managers, senior technician and selected groups.

3.7 Data Analysis tools

Different methods have been proposed by researchers to Assess and evaluate work place ergonomics and its impact on social sustainability. For this study REBA rapid entire body assessment approach is used to determine the risk of musculoskeletal disorders occurring in occupation (Jambarsang & Anoosheh, 2020). REBA is a methodology used to investigate risk levels of various postures by using aggregate position of the body factors that affects the workplace ergonomics in garment manufacturing and is the most widely used and proposed method to enhance workstation ergonomics in garment manufacturing.

Moreover interconnected to social sustainability the research carried out by Gajšek et al. (2022) methods employed for ergonomic risk assessment, including the (OWAS) Ovako Working Posture Assessment System and the (REBA) Rapid Entire Body Assessment, can be linked and interconnected with Social Sustainability. The limitation of this study not considering all risk factors, including duration and frequency of ergonomic risks, which may impact the Sustainability Index.

In general, the above statement summarizes that researchers use the observational technique, the REBA and OWAS method approaches to assess workplace ergonomics and their impact on sustainability. This method investigates risk levels of postures and body factors affecting workplace ergonomics and how they are interconnected with social sustainability in garment manufacturing.

3.8 Data analysis method

The study utilized descriptive data analysis techniques, using both quantitative and qualitative approaches, to gather information onsite observation, a survey questionnaire, and interviews with selected groups, and company past injury data. According to the data type, the observational technique the (REBA) Rapid Entire Body Assessment method has been to analyze task performed. The REBA method evaluates the extent of external loads or forces, the muscle activity caused by static, dynamic, rapidly changing or unstable postures, as well as the connection between the body parts. In addition, the study used Microsoft Excel and SPSS 27 software for data analysis.

3.9 Reliability and validity

Reliability analysis (RA) is a crucial statistical process for evaluating the dependability, consistency, and stability of datasets and measurement methods. Determine whether the measurements or data are reliable enough to support conclusions or decisions made with confidence is the main use of reliability analysis (RA). Test-retest reliability is important to asses' consistency measurements over time. This could involve giving people the same questionnaire at various periods, then figuring out how well their answers the correlation between their responses correlated (Izah et al., 2023).

Cronbach's alpha is a statistic that the tests and scales developed or adopted for their research projects are suitable for the intended purpose and the recommended value (Taber, 2018).

Table 3.1 Cronbach‟s alpha results for each Questionnaire

Workplace ergonomics assessment measurements	Reliability Statics	
	Cronbach's alpha	No of items
For ergonomics condition	0.711	6
For work place condition	0.765	7
For ergonomics trainings	0.799	5
Pain in different body parts	0.738	9

3.10 Research ethical consideration

The preliminary phase of the study began with approval obtained from Addis Ababa University Institute of Technology School of Mechanical and Industrial Engineering. The data has been gathered from the company, consent has been conducted, and the company manager has receive the official letter from Addis Ababa Institute of Technology and give awareness information about the purpose of the study and It is mentioned on the official letter that it is only used for educational research purposes and that it protects the confidentiality of the company.

3.11 Dissemination of Research findings

Findings of the research will be delivered and shared to Addis Ababa University School of Graduate Mechanical and Industrial Engineering. An effort will be conducted to present the findings for publication in an international journal as a contribution to research.

Chapter Four

4. Result and Data discussion

4.1 Introduction

This section outlines the current workplace ergonomics of the company. It analyzes and identifies data gathered from observations, past injury reports, questionnaires, and workplace measurements. Using this collected information, the factors that put workers at risk for significant ergonomic health issues are identified. Additionally, it evaluates the methods and tasks that employees carry out in relation to workplace ergonomics and their impact on social sustainability in senmul garment manufacturing and identify strategies and mechanisms to enhance social sustainability and improve workstations in garment manufacturing.

4.2 Data analysis

4.2.1 Industry record data analysis

Senmul Garment Manufacturing Company has five main departments, under the general manager, which are production and technical departments, administrative and finance departments, and marketing and sales departments with sub-sections, which have a total of 100 employees. Among this from production and technical departments, more than 50% of the total is working on sewing machine operators.

4.2.2. Questionnaires Data Analysis

4.2.2.1 General information of respondents

The general information's helps to get and identify the respondent general information regarding age category, Educational status, gender and work experience based on this to prepare and provide health and safety and different ergonomics concept trainings. The Respondent age category 4.3% less than 20years ,82.6% age in between 20 – 30years ,8.7% age in between 31 – 40 years, 4.3% age in between 41 – 50 years, 11.6% of the respondent has less than one year work experience ,55.1% of the respondent have 1 – 5 year work experience ,30.4% of the respondent have 6 – 10 year work experience ,the rest have 11

years and above work experience and 14.5% of the respondent grade 1 – 8 educational level,62.3% of them grade 9 – 12 educational level,14.5% of them Diploma and 8.7% of them Degree and above. Among the respondent gender identification 89.9% of the respondent female and 10.10% of the respondent male and employment status of the respondents 85.5% permanent and 14.5% temporary. The objective of these data is to know about the respondent's general information regarding age, educational level, and work experience in order to prepare and provide ergonomics trainings based on their educational level and age category to the respondents.

Table 4.1 Socio demographic characteristics

	Catagaroy	Frequency	Percentage
Age	Lessthan 20 year	3	4.30%
	20 - 30	57	82.60%
	31 - 40	6	8.70%
	41 - 50	3	4.30%
	51 and above	0	0
Education Level	Elementary 1-8	10	14.50%
	Grade 9-12	43	62.30%
	Diploma	10	14.50%
	Degree & above	6	8.70%
sex	Male	7	10.10%
	Female	62	89.90%
Work expriance	Lessthan 1 year	8	11.60%
	1 - 5 years	38	55.10%
	6 - 10 years	21	30.40%
	11 years & above	2	2.90%
Employeement stutus	Permanent	59	85.50%
	Temporary	10	14.50%

4.2.2.2 Workplace Ergonomics conditions Questionnaire

Ergonomics condition is one of the critical ergonomic factors that affects workstation ergonomics and also is a prevalence of musculoskeletal disorders (MSDs) among workers. It has a high effect on workers safety and ergonomics, moreover when we keep the workplace safe and comfortable for employees it will increase productivity and reduce injury and discomfort of workers in garment manufacturing.

The below table shows that for the questionnaire, ER1 the workstation equipment has movable and adjustable heights, Among the respondents, 49.3% respond strongly disagree, 39.1% respond disagree, 10.1% said neutral, and 1.4 % said agrees. For the questionnaire, ER3 on ergonomic conditions, the respondent replied that the current workplace chair provides adequate lumbar support. The respondents reply that, 52.2% strongly disagreed, 33.3% disagreed, 10.1% were neutral, and 4.3% agreed. For the questionnaire, ER5,The workstation have a possibility staying at stationary position for long time, the respondents response 21.7% and 49.3% strongly agree and agree respectively,18.8% reply neutral and 10.1% disagree. For the questionnaire, ER7 The workstation have work stress, among the respondents 40.6% and 40.6% strongly agree and agree respectively,18.6% reply neutral. For the questionnaire, ER9 the workplaces are free from dust & high noise, the respondent replies 49.3% and 39.1% strongly disagree and disagree respectively, 11.6% reply neutral. For the questionnaire ER10 the workplaces have job rotation per shift, the respondent replies 49.3% and 42% strongly disagree and disagree respectively, and 8.7% reply neutral.

Table 4.2 Workplace Ergonomics conditions(ER)

Workplace Ergonomics conditions												
	ER 1		ER 3		ER 5		ER 7		ER 9		ER 10	
	N	%	N	%	N	%	N	%	N	%	N	%
Strongly disagree	34	49.30%	36	52.20%					34	49.30%	34	49.30%
Disagree	27	39.10%	23	33.30%	7	10.10%			27	39.10%	29	42.00%
Neutal	7	10.10%	7	10.10%	13	18.80%	13	18.80%	8	11.60%	6	8.70%
Agree	1	1.40%	3	4.30%	34	49.30%	28	40.60%				
Strongly agree					15	21.70%	28	40.60%				

In summary, for the questionnaire workplace ergonomics conditions the employee responses indicate significant dissatisfaction with different ergonomic condition aspects of the workstations, such as adjustability of equipment, lack of lumbar support in chairs, inability to remain stationary for long periods, high work stress, and poor dust and noise control and a lack of job rotation opportunities. These findings from the questionnaire response are indications for the improvement of workplace ergonomic conditions.

4.2.2.3 Workplace Ergonomics environment Questionnaire (WE)

Investigating ergonomics for the work environment is important and is one of the factor that affects the employee health and ergonomics condition, improving workplace in garment manufacturing that can result in enhanced productivity, reduced injuries, better employee wellbeing, significant cost savings and it is important aspect of creating a safe, efficient, and supportive work environment.

The below table show that the respondent response for the questionnaire, WE2.1 the lighting in the workplace area sufficient and does not cause eye strain, the respondent replies 56.5% and 30.4% strongly disagree and disagree respectively, 13% reply neutral. For the questionnaire, WE2.2 the overall layout of the work area minimizes the need for excessive reaching or bending, the respondent replies 47.8% and 40.6% strongly disagree and disagree respectively, and 11.6% reply neutral. The respondent for the questionnaire WE2.4 I have enough space at my workstation to comfortably perform my tasks, the respondent replies 40.6% and 39.1% strongly disagree and disagree respectively, and 20.3 % reply neutral. For the questionnaire, WE2.5 I am able to take adequate breaks to stretch and relieve muscle fatigue, the respondent replies that 37.7% and 52.2% strongly disagree and disagree respectively, 10.1% reply neutral. For the questionnaire, WE2.6 Is the temperature at the working station always the same, 52.2% responds strongly disagree, 37.7% responds Disagree and 10.1% responds neutral. For the questionnaire, WE2.7 I feel the current ergonomic conditions in the facility allow me to work safely and comfortably, 47.8% reply strongly disagree, 37.7% disagree, 8.7% neutral and 5.8% responds Agree. For the questionnaire, WE2.8 Overall, my current ergonomic conditions allow me to work comfortably, 20.3% responds strongly disagree, 43.5% disagree ,27.5% responds neutral and 8.7% responds agree.

Table 4.3 Workplace Ergonomics environment

Ergonomics Workplace environment														
	WE 2.1		WE 2.2		WE 2.4		WE 2.5		WE 2.6		WE 2.7		WE 2.8	
	N	%	N	%	N	%	N	%	N	%	N	%		
Strongly disagree	39	56.50%	33	47.80%	28	40.60%	26	37.70%	36	52.20%	33	47.80%	14	20.30%
Disagree	21	30.40%	28	40.60%	27	39.10%	36	52.20%	26	37.70%	26	37.70%	30	43.50%
Neutal	9	13.00%	8	11.60%	14	20.30%	7	10.10%	7	10.10%	6	8.70%	19	27.50%
Agree											4	5.80%	6	8.70%
Strongly agree														

In summary, for the questionnaire ergonomics workplace environment the employee response result shown that the employee are dissatisfy in different workplace ergonomics factors such as, in workplace lighting issue, workstation layout, workplace space, break time, workplace temperature, and overall comfort and ergonomics conditions. These findings indicate the need for workplace improvement to improve employee health and wellbeing.

4.2.2.4 Ergonomics trainings in the company

This section of the questionnaire aims to evaluate the workers knowledge and awareness of how to safeguard themselves from ergonomic injuries. They were asked to respond whether they have received training or have knowledge on workplace safety and protecting themselves from musculoskeletal disorders (MSDs).

By providing comprehensive ergonomics training, garment manufacturing companies can create a safer, more comfortable work environment, improve worker health and productivity, and enhance the overall efficiency and profitability of their operations. It's very essential for garment manufacturing industry.

The below table 4.4 show that the respondent response for the questionnaire, TR 1 Are you familiar with the concepts of ergonomics? The respondent replies that 40.6% and 40.6% strongly disagree and disagree respectively, 13% reply neutral and 5.8% respondents reply Agree. For the questionnaire TR 2 How important do you consider ergonomics in your workplace? The respondent replies that 36.2% and 42% strongly agree and agree respectively, 21.7% reply neutral. for the questionnaire, TR 3 Have you received any training on how to protect yourself from musculoskeletal disorders (MSDs)? The respondent

replies that 50.7% and 39.1% strongly disagree and disagree respectively, 10% reply neutral. TR 4 Does the company facilitate safety and ergonomics training for employee? The respondent replies that 55.1 % and 37.7% strongly disagree and disagree respectively,7.2% reply neutral. for the questionnaire, TR 5 Does the culture in your workplace encourage cross-training as a means to reduce the frequency of employees engaging in repetitive motion tasks? The respondent replies that 36.2% and 37.7% strongly disagree and disagree respectively, 26.1% reply neutral.

Table 4.4 Ergonomics Training

Ergonomics Trainings										
	TR1		TR2		TR3		TR4		TR5	
	N	%	N	%	N	%	N	%	N	%
Strongly disagree	28	40.60%			35	50.70%	38	55.10%	25	36.20%
Disagree	28	40.60%			27	39.10%	26	37.70%	26	37.70%
Neutal	9	13.00%	15	21.70%	7	10.00%	5	7.20%	18	26.10%
Agree	4	5.80%	29	42.00%						
Strongly agree			25	36.20%						

In general the questionnaire on ergonomics trainings in the company the employee response shown that there is a severe lack of ergonomics awareness, knowledge, and training among the respondents. The workplace culture also appears to be unsupportive of ergonomics and safety practices. These findings show a need for significant improvement in educating workers on ergonomics and fostering a more positive safety culture within the organization.

4.2.2.5 Pain in different body parts

Injuries can occur in different human body parts, and understanding the types of injuries that can affect specific body parts is important for effective prevention, treatment, and recovery. In this introduction, we will explore some common injuries that can occur in different body parts.

The below table shown that among the respondents , understanding the common types of injuries in different body parts can help individuals take preventive measures, recognize the

symptoms, and seek appropriate medical attention when necessary. Proper treatment and recovery are important for ensuring preventing long-term complications.

Among the respondents of body parts pain in Neck 37.7% very painful, 20.3% painfully, 20.3% moderate pain & 21.7% have no pain. Pain in shoulder 47.8% very painful, 15.9% painfully, 21.7% moderate pain% 14.5% have no pain. Pain in upper back 52.2% very painful, 15.9% painfully, 13 % moderate pain% 18.8% have no pain. Pain in Elbow body part 29% very painful, 30.4% painfully, 20.3 % moderate pain% 20.3% have no pain. Pain in wrist/hands of body part 17.4% very painful, 31.9% painfully, 20.3 % moderate pain% 30.4% have no pain. Pain in Low back body part 20.3% very painful, 36.2% painfully, 20.3 % moderate pain% 23.2% have no pain. Pain in Hip/Thigh body part 8.7% very painful, 31.9% painfully, 24.6 % moderate pain & 34.8 % have no pain. Pain in Knee body part 5.8% very painful, 14.5% painfully, 23.2 % moderate pain & 56.5% have no pain. Pain in Ankle/Foot body part 2.9% very painful, 14.5% painfully, 39.1 % moderate pain & 43.5% have no pain.

Table 4.5 Different body parts pain

Frequency of pain in different body Parts																		
	Neck		Shoulder		Upper back		Elbow		wrist/hands		low back		Hip/Thigh		Knees		Ankle/ Foot	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
No pain	15	21.70%	10	14.50%	13	18.80%	14	20.30%	21	30.40%	16	23.20%	24	34.80%	39	56.50%	30	43.50%
Moderate pain	14	20.30%	15	21.70%	9	13.00%	14	20.30%	14	20.30%	14	20.30%	17	24.60%	16	23.20%	27	39.10%
Painfully	14	20.30%	11	15.90%	11	15.90%	21	30.40%	22	31.90%	25	36.20%	22	31.90%	10	14.50%	10	14.50%
Very Painfull	26	37.70%	33	47.80%	36	52.20%	20	29.00%	12	17.40%	12	20.30%	6	8.70%	4	5.80%	2	2.90%

In general, for the questionnaire pain in different body parts the employee response results show that the employee feeling pain with varying levels of pain in different body parts and

the results indicate that neck, shoulder, and upper back were the body parts with the highest proportion of very painful responses, suggesting these may be the most problematic areas for workers.

4.3 Interview data analysis

The data collected from the company through the interview method for selected grouped managers have been conducted for five employees in management positions, and the management requested in the interview questions a response in involvement in the concept of ergonomics introducing in the factory, how the current workstation is safe for the employee, the impacts of ergonomics on the health and well-being of employees, in addition to any additional comment regarding the design of workstations in your factory.

The below response from the respondent from selected group managers of the company for the first interview question that introducing the concept of ergonomics in the company, the respondent reply that not yet introduced and very important for the company, for the second interview question about how the current work station is save for the employee ,the respondent reply that not save and it needs improvement, for the interview question the impact of ergonomics in workplace and about the workplace design the respondents reply that it affects the employee health and safety and decrease production and about the workplace design they reply that it needs improvement.

In summary, the company's selected group managers responded to the interviews about the introduction of ergonomics, the current workstation's benefits for employees, and the impact of ergonomics on workplace design. They acknowledged that ergonomics affects employee health and safety, and the design needs improvement.

4.4 REBA Analysis

REBA (Rapid Entire Body Assessment) serves as an ergonomic assessment tool that is commonly used to assess the physical demands and postural risks associated with various tasks. In the context of garment manufacturing, REBA analysis is particularly valuable for evaluating the ergonomics of different workplaces in Senmul garment manufacturing:

- For sewing workstations: the Reba tool evaluating the posture and positioning of workers operating sewing machines and identifying risk factors such as awkward neck/trunk bending, repetitive arm movements, and lack of back/leg support.
- For cutting/pattern making stations: the Reba tool analyzing the posture and body mechanics of workers engaged in cutting fabric and developing patterns and assessing risks like excessive reaching, bending over cutting tables, and prolonged standing.
- For finished garments handling activities: evaluating the ergonomics tasks like lifting, carrying and moving heavy fabric and finished garments for this reason identifying potential musculoskeletal risks from heavy manual handing.
- For finish garments and inspection tasks: For finishing garments, to assess the posture and movements of workers doing complete finishing work, pressing, and quality inspection. For this working posture, to asses and identify ergonomic issues such as repetitive wrist motions, extended reaching, and static postures.

The purpose of the Rapid Entire Body Assessment (REBA) is to assess the risk of musculoskeletal disorders (MSDs) in a timely manner in relation to certain job tasks. In addition to this the tool uses a systematic methodical approach to analyze the biomechanical and musculoskeletal disorder (MSD) risks associated with the job task being assessed. This technique makes use of a one-page worksheet to assess the type of movement or action, forceful exertions, coupling, repetition, and required or chosen body position related to the job task.

4.4.1 Work break down activity in sewing line

The observation is done on the case company Senmul Garment Manufacturing to track the employee movement on the sewing operator line working position; this helps to know the working position of the employee doing their task.

The primary purpose of the observation has been to track the workers' movements as they carried out the task. The workers' entire body of movement has been directly observed, and it has been logged on the REBA worksheet (Appendix2) together with the angle of movement of the entire body. In order to complete these tasks, workers were observed

across their entire body, including their neck, trunk, and wrist positions and twists. The result of observation outcome is helpful in identifying the employee is at risk or not.

The Rapid Entire Body Assessment (REBA) tool produces a final REBA Score, which is a single numeric value that represents the level of musculoskeletal disorder (MSD) risk associated with the job task being evaluated. The REBA Score can range from a minimum of 1 to a maximum of 15. The REBA level of MSD risk descriptions and corresponding score are outlined in a chart (Hignett & McAtamney, 2000).

REBA Score 1-4: Negligible Risk

REBA Score 5-7: Low Risk

REBA Score 8-10: Medium Risk

REBA Score 11-15: High Risk

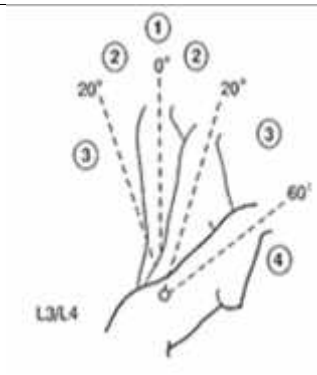
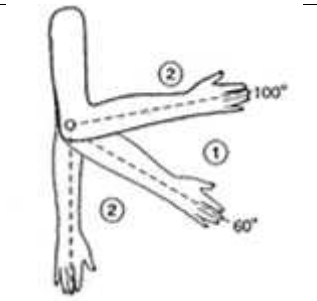
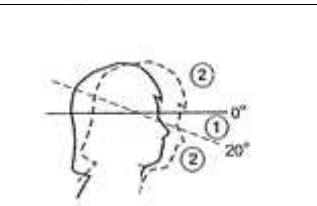
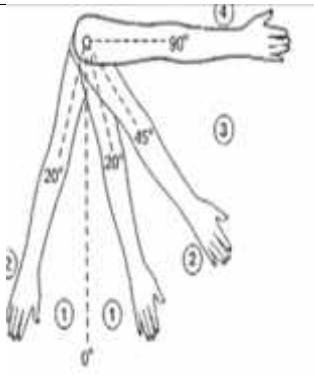
The REBA method is used to analyze body posture by measuring joint angles, observing the force exerted, assessing the repetitiveness of movements, and monitoring the frequency how often postural changes occur. Each range of motion for the assessed functional areas is assigned a score that increases as the distance from the segment's neutral position grows. Table A and Table B scores are combined in Table C, in Addition to this an activity score is added to determine the final REBA score (Al Madani & Dababneh, 2016).

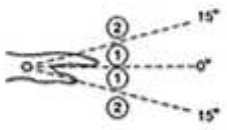
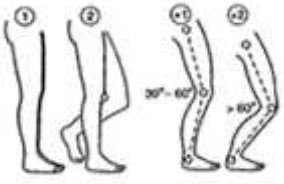
This REBA scoring system provides a concise, quantitative assessment of the MSD risk level for the evaluated job task, with higher scores indicating greater risk that requires attention (Hignett & McAtamney, 2000).

Figure 4.1 current working positions

By completing the REBA (Rapid Entire Body Assessment) employee assessment worksheet in Appendix 2, the below figure shows that the existing work position of the employees and the working position measurement taken by considering ethical consideration on employee to find out the REBA analysis in assessment work sheet the value shows high risk level based on the risk scoring table. This indicated that some improvement and work method changes to be implemented in order to reduce or eliminate the risk of musculoskeletal disorders (MSDs).

Table 4.6 REBA Analysis Measurements score

	Current Activity Located	Angle	Score According to REBA work sheet
Trunk	The current trunk working position is between 20 and 60 degree		4
Lower Arm	The current Lower Arm working position is Between< 60 degree		1
Neck	The working Neck position > 20 Degree		2
Upper Arm	The working position is Between< 45 degree		3

Wrist	The wrist working position is Between 0 to 15 degree		2
Leg	The working Leg position > 60 Degree		3
Load /force	Load /force is between 0 to 5 kg		0

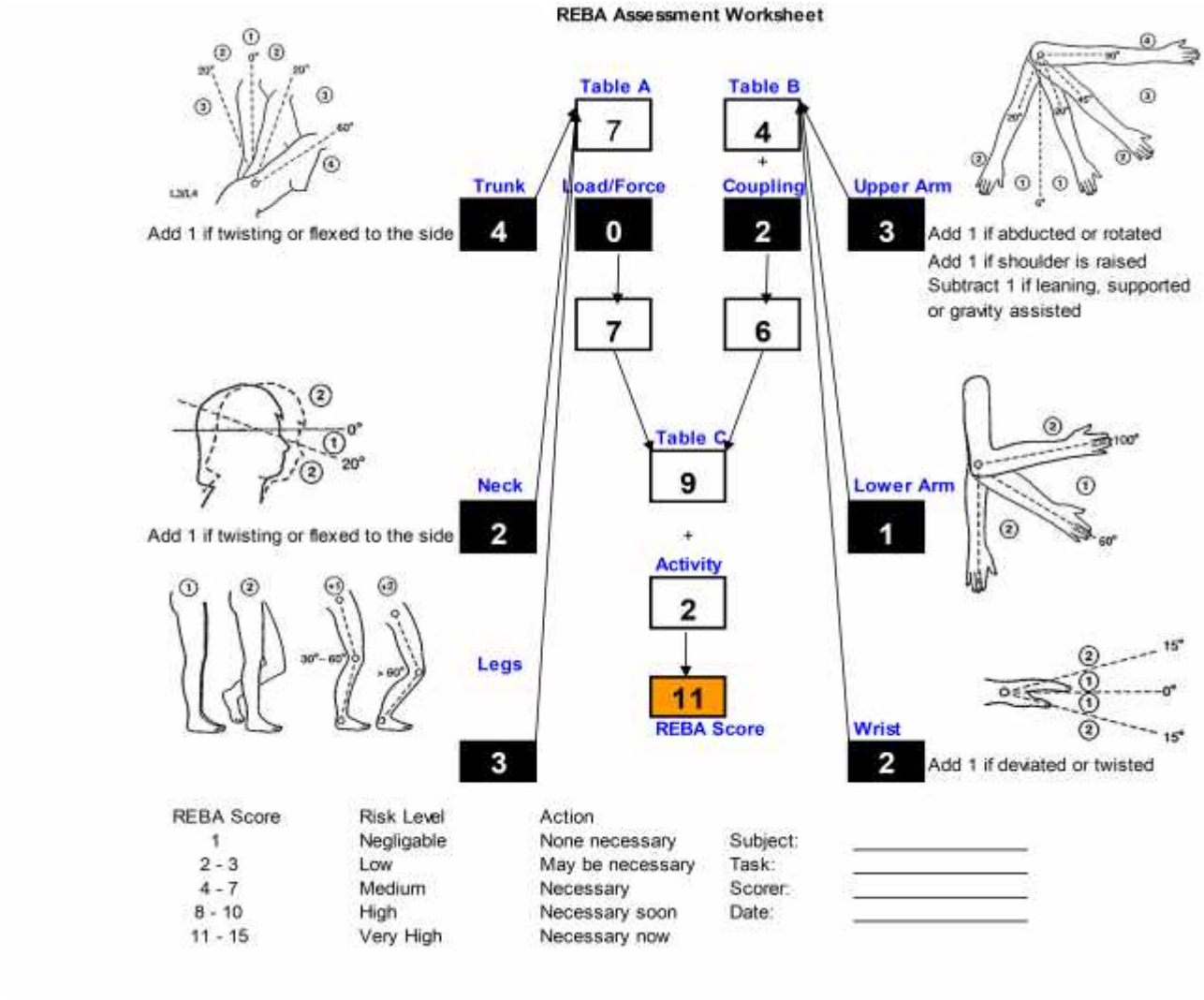


Figure 4.2 Sewing workplace REBA Analysis Result (Hignett & McAtamney, 2000)

4.5 Measurements of workplace

4.5.1 Workplace temperature measurements

The workplace temperature measurements evaluate the thermal environment and its impact on worker comfort and productivity. The workstation measurements analyze the design and dimensions of the work areas to optimize employee posture, reach, and overall workspace efficiency. The workplace temperature measurements have been taken for four days in the morning and afternoon by using temperature measuring tool thermometer at Senmul

Garment Manufacturing Company. Table 4.7 shown below that cold in the morning and hot in the afternoon and the temperature varies.

Table 4.7 Existing workplace temperature measurements

Temperature in degree Celsius		
	Morning	Afternoon
Date 1	19	26
Date 2	16	27
Date 3	18	26
Date 4	17	28

.

Heat stress affects workers' health and productivity and is a worldwide issue that affects many different sectors of the economy, regions, and businesses. In comparison to more temperate settings, heat experience lowers the physiological capability of the human body to accomplish tasks and raises the risk of health , the recommended temperature range (OSHA) recommends is typically between 20-24°C (68-77°F) (Bach et al., 2023).

4.5.2 Workplace lightings

The lighting measurements assess the ambient and task-specific illumination levels to ensure adequate visibility and ergonomics. Insufficient lighting can raise the amount of visual fatigue. General strain, and lead to bad posture as workers bend to improve their visualization of workers in the garment manufacturing. To determine these first to know about the room length, width and Height of the workplace

The existing workplace has with Length 25 meters, width 10 meters, and height 5 meters, the existing suspended workplace lighting fixture mounting height 3.2 meters with in a total number of 135 bulbs. But the recommended suspended mounting height is 2.5–3.0 meters (8–10 feet) above the floor. As per international and European recommendations (Iluminance Levels) indoor artificial lighting levels without any daylight contribution typically range from 100 to 500 lux.

Lux = Lumens / total Area

Lux = 134500lm / 250m2

Lux = 538 Lux

As per the existing workplace dimensions it required 538 lux ,required lumens 134500 lumes,light bulb type 60 w equivalent to 800 lm/bulbs. finally it needs a total of 169 bulbs These lighting levels are often determined by industry standards or recommendations (Preto & Gomes, 2019).

4.5.3 Workplace Chair and tables

In Senmul garment manufacturing industry, the design of chairs and tables is essential for worker comfort and wellbeing, productivity, and overall workplace ergonomics. Assessing the current designs it against the industry standards.

The current chair at Senmul garment manufacturing not completely adhere to ergonomic best practices industry standards highlight the importance of adjustable features, such as seat height, backrest angle and lumbar support, due to this employees may face discomfort, which could result in lower productivity and a higher risk of musculoskeletal disorders.

Assessing Senmul's garment manufacturing current designs against safety standards the material that the chair has been manufactured with low quality, not ergonomically recommended for garment manufacturing operators and against the standard. These will help to classify any needed improvements to create a safer working environment.

The workstations, including tables and chairs, at Senmul garment manufacturing are uncomfortable and are one of the prevalence of MSDs. They are made up of wooden plywood seats. Seat chairs have different heights, seat width and lengths for each workplace and are not uniform, as we can see in the picture shown in the below figure 7. The working table and chairs are not adjustable as required and no footrest. In general as we can see and understand from the below picture the employee are seated and working on sewing workstation with uncomfortable chair and poor posture. In addition to this the area is equipped with different fabric and that may cause of pain for sewing operators.

Figure 4.3 Seat positions that may cause pain in the current workplace

The recommended standard chair and table sizes for garment sewing machine operators are carefully designed to provide a comfortable and ergonomic working environment. The objective is to allow the operator to easily reach the controls of the sewing machine while maintaining proper posture and body positioning in their workplace. Moreover the chair and table should be adjustable, work station lay out these contribute ease of access to reach out the tools and materials, foot rests these can help to reduce pressure on leg and improve circulation and tool placement sewing tool and equipment can minimize repetitive motion and help to maintain neutral wrist position (Vandyck et al.).

Table 4.8 *Recommended seat chair measurements, Source (Vandyck et al.)

Seat Height (cm)	%	Seat Width (cm)	%	Seat Depth (cm)	%
< 38	6	< 40	13	<33	52
38 - 50*	37	40 - 45*	51	33 - 40*	37
> 50	57	> 45	36	>40	11
Totals	**100**		**100**		**100**

The below figure 4.4 shows , the proposed sit position and sewing chair allows the operators to adjust the height to outfit with their sewing tables; lumber support helps the spine to maintain natural curve keeping comfort in long sewing operation the swivel helps to access on different work places. In addition to this the adjustable seat depth are helps for different body sizes of operators to fit for comfortable position and it helps to minimize the risk of injury of sewing operators.

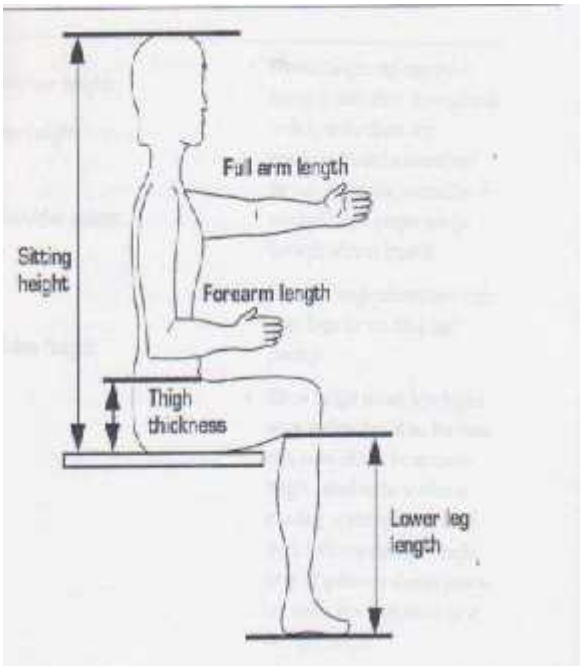


Figure 4.4 Seat Position comfortable for operators source (Vandyck et al.)

4.6 Chapter discussion summary

Workplace ergonomics in garment manufacturing is influenced by repetitive motions, awkward posture, manual material handling, insufficient work-rest cycles, and lack of breaks, excessive overtime, and poor ergonomics. These factors contribute to the development of musculoskeletal disorders (MSDs), such as carpal tunnel syndrome, tendinitis, and lower back pain. Factors such as inadequate leg room, high temperatures, poor ventilation, noise, vibrations, high production targets, and lack of worker independence are also key ergonomic risk factors. Addressing these risk factors through ergonomic interventions is crucial for improving worker wellbeing in the garment manufacturing.

REBA employee assessment worksheet yielded a final score of 11, indicating a high risk level for musculoskeletal disorders, necessitating improvements and work method changes.

Workplace heat stress, is a global issue, negatively impacts workers' health and wellbeing and affecting various sectors of the economy, The average workplace temperature is 17°C in the morning and 26°C in the afternoon, the recommended workplace temperatures ranging from 20-24°C (68-77°F),

Lighting measurements are important for ensuring adequate visibility and ergonomics in garment manufacturing. Inadequate lighting can lead to visual fatigue, strain, and poor posture. The recommended suspended mounting height is 2.5-3.0 meters (8-10 feet) above the floor. According to international and European advice on illuminance levels, indoor artificial lighting generally ranges from 100 to 500 lux. (Peña-García & Salata, 2020).

Workplace design plays a significant role in ergonomics risk factors. Adjustable workbench heights, seat positions, and furniture should match worker anthropometry. Proper lighting and ergonomic materials handling can reduce eye strain. Senmul garment manufacturing aims to educate workers on ergonomics principles, train supervisors, and encourage participation in addressing issues. Work organization and job design should reduce repetitive strain, rotate workers, schedule breaks, and limit overtime. Regular ergonomic assessments and observations are essential for continuous improvement.

4.7 Ergonomics risk factors identifications

In workplace ergonomics, the key ergonomic risk factors commonly found in garment manufacturing operations that cause the prevalence of MSDs are repetitive motions activities in garment manufacturing, such as repetitive sewing, trimming, pressing, and other manual tasks. In addition to these frequent, constant, and high-velocity hand and finger movements that are identified as ergonomic risk factors awkward posture is one of the key ergonomic factors in garment manufacturing, with activities like prolonged sitting or standing in fixed positions, reaching, bending, twisting, and overhead work, and improper neck, back, and shoulder positioning. Manual material handling of finished products and

fabrics frequent lifting, lowering, pushing, and a heavy load for an extended period of time is also one of the key ergonomic risk factors in garment manufacturing. Insufficient Work-Rest Cycles, lack of adequate breaks, excessive overtime and extended work hours are also the key ergonomics factors that caused of prevalence of MSDs poorly adjusted or non-ergonomic sewing machines, tables, and chairs, inadequate leg room, reach distances, and work surface heights in related to workplace design issues, extreme temperatures, high humidity, and poor ventilation, excessive noise from sewing machines and other equipment in related to environmental factors, vibrations from sewing machines, trimmers, and other power tools in noise and vibration exposure in workplace, high production targets, time pressures, and job demands, lack of worker independence and control over work processes in related to psychosocial factors

Psychosocial risk factors: Psychosocial factors in the workplace include the interactions among the work environment, job responsibilities, organizational conditions, and the employees' abilities, needs, cultural background, and personal factors outside of work. These elements can impact their health, job performance, and overall job satisfaction.in addition to these others factors related to psychological factors lack of co-workers and immediate supervisor support in workplace (Krishnan et al., 2021).

Physical risk factors: awkward posture is one of the key ergonomic factors in garment manufacturing, with activities like prolonged sitting or standing in fixed positions, reaching, bending, twisting, and overhead work, and improper neck, back, and shoulder positioning. Manual material handling of finished products and fabrics frequent lifting, lowering, pushing, and a heavy load for an extended period of time is also one of the key ergonomic risk factors in garment manufacturing**.** These physical demands enlarge the risk in various parts of the body (Krishnan et al., 2021).

Environmental risk factors: key ergonomics factors that caused of prevalence of MSDs poorly adjusted or non-ergonomic sewing machines, tables, and chairs, inadequate leg room, reach distances, and work surface heights in related to workplace design issues, extreme temperatures, high humidity, and poor ventilation, excessive noise from sewing machines and other equipment in related to environmental factors, vibrations from sewing machines,

trimmers, and other power tools in noise and vibration exposure in workplace, high production targets, time pressures, and job demands, lack of worker independence.(Krishnan et al., 2021).

These risk factors can contribute to the development of musculoskeletal disorders (MSDs), such as carpal tunnel syndrome, tendinitis, and lower back pain, among garment manufacturing workers. identifying and addressing these risk factors through appropriate ergonomic interventions is crucial for improving worker health and safety in the garment manufacturing industry (Odebiyi & Okafor, 2023).

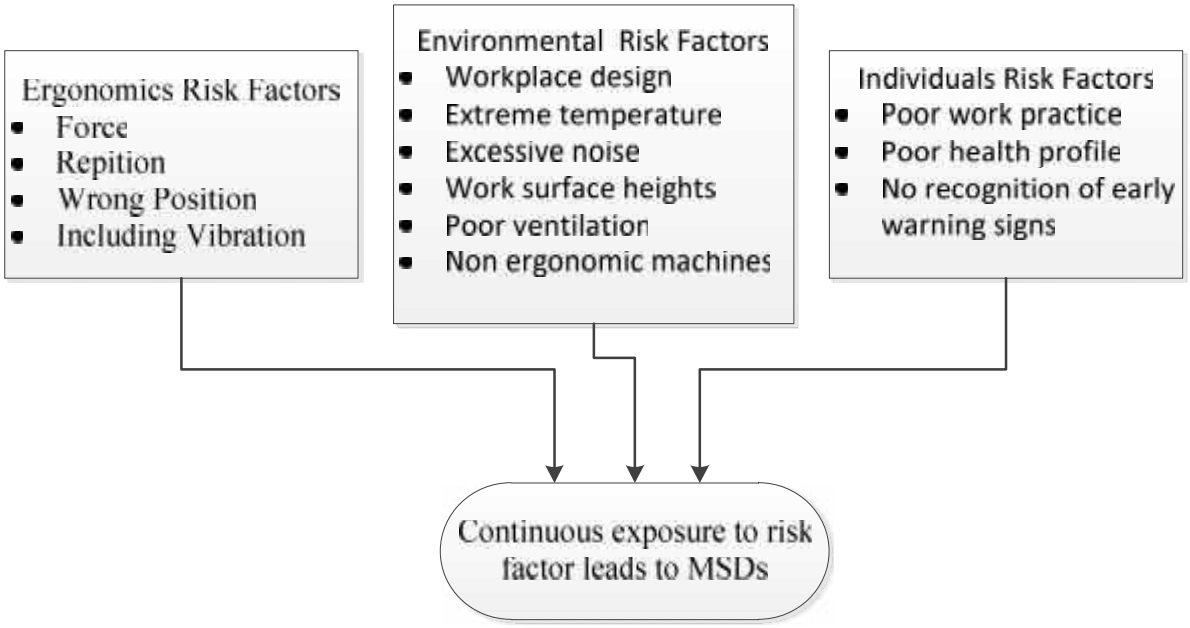


Figure 4.5 work related MSDs risk Factors, Source (Odebiyi & Okafor, 2023)

4.8 Proposed Suggested mechanism and strategies to enhance workplace Ergonomics

Workplace ergonomic risk can indicate that impact of employee health and safety due to awkward postures and poor design of tools and equipment can lead to unnecessary motions. The proposed strategies workplace design, material handling, tool and equipment

ergonomics, Training and education, work organization and job design are some suggested strategies and mechanisms to improve workplace ergonomics in garment manufacturing:

Workplace Design one of the most causes of ergonomics risk factor, by changing Adjustable workbench heights, seat positions and other furniture to match worker anthropometry, by Providing adjustable and ergonomic chairs with good back lumber support, ensure adequate legroom, knee/foot clearance, and reach distances and Implement adjustable lighting and task lighting to reduce eye strain. For proposed garment manufacturing material handling activities using carts, trolleys and any material handling reduces manual lifting, using hoists for bulk items and height adjustable conveyers. Concerning tool and equipment ergonomics select ergonomic sewing machines, trimmers, irons, and hand tools with proper grip sizes and shapes, and ensure frequently used items are easily accessible for the operator. With-respect-to training and education the Senmul garment manufacturing aims to educate workers on ergonomics principles, train supervisors and managers, and encourage worker participation in identifying and resolving ergonomic issues. With-regard-to work organization and job design in workplace to reduce repetitive strain rotate workers between different stations, schedule regular breaks, and limit overtime to prevent fatigue. Keeping workplace environment more convenient and comfort in garment manufacturing to manage stress, ensure proper temperature, humidity, air circulation, proper lighting, and manage noise levels and vibrations. These strategies needs continuous improvement in garment manufacturing by doing Regular ergonomic assessments and workplace observations are essential for identifying improvement opportunities and analyzing injury/illness data to target high-risk areas (Odebiyi & Okafor, 2023).

To achieve satisfactory results, a three hierarchy of controls comprising Engineering, Administrative measures, and Personal Protective Equipment (PPE) is commonly recognized as an effective strategy for reducing, eliminating, or managing workplace hazards, including ergonomic risks.

Engineering control: With-regard-to work organization and job design in workplace ,Rearrange ,modifying and replacing work processes and changing workstation lay out tool and equipment select ergonomic sewing machines, providing adjustable and ergonomic chairs with good back lumber support, ensure adequate legroom, knee/foot clearance

Administrative measures: job design in workplace to reduce repetitive strain rotate workers between different stations, schedule regular breaks, provide muscle relaxation time ,changing job rules and procedures and limit overtime to prevent fatigue.

Personal protective equipment (PPE): personal protective equipment (PPE) generally serves as a barrier between workers and hazards. Additionally, there are other devices like braces, wrist splints, and back belts that can help reduce the duration, frequency, and intensity of exposure to risk factors for musculoskeletal disorders (MSDs).

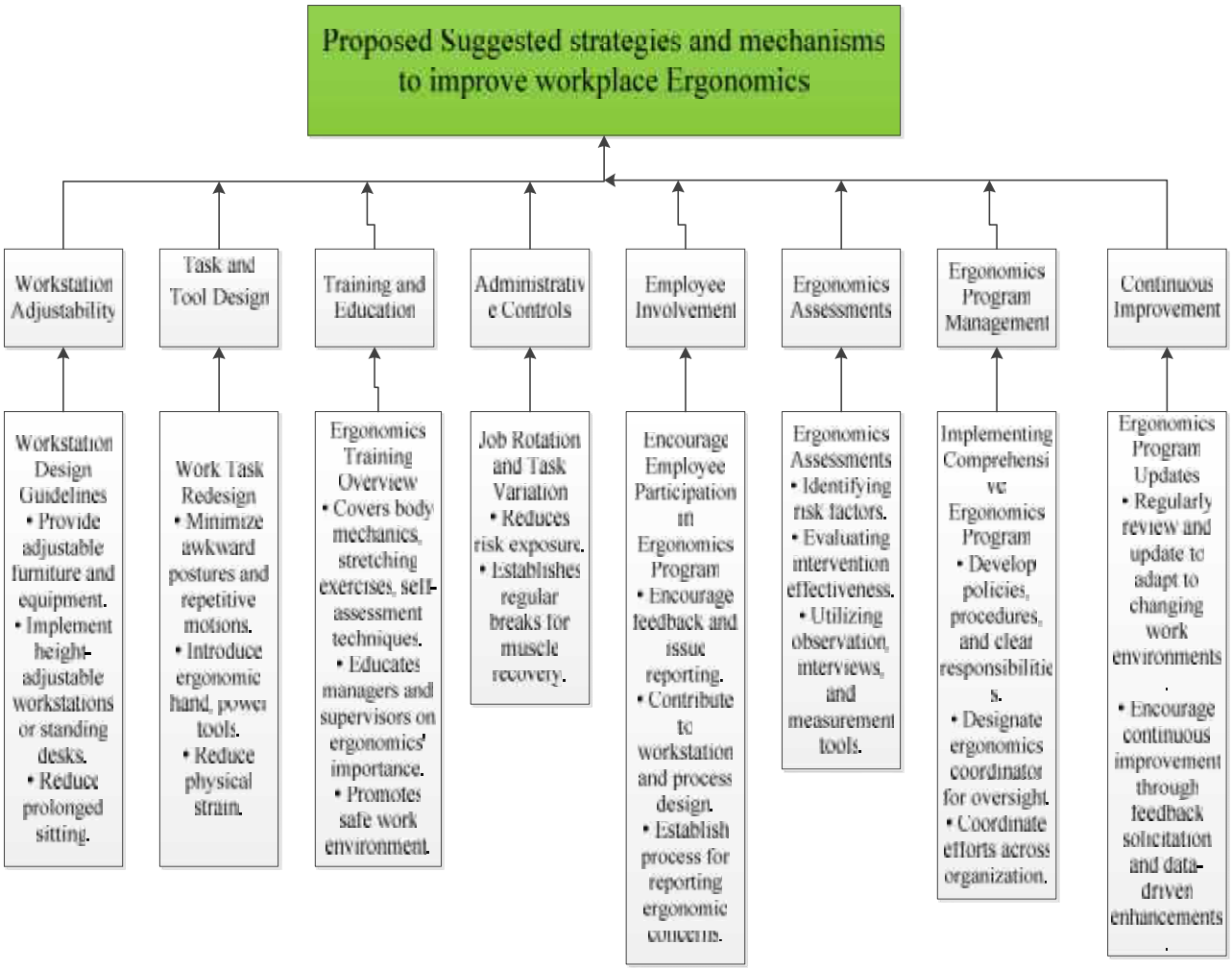


Figure 4.6 Proposed frame work and suggested strategies

The below figure 4.7 shows mechanism development of MSD's, the level of risk is influenced by the intensity, frequency, and duration of exposure to workplace hazards. Additionally, the impact of these risks can be increased by organizational factors, including

shift work, work pace, imbalanced work-rest schedules, high work standards, and a lack of task variety. In addition to this forcing a worker to operate beyond their physical capabilities can put their musculoskeletal system at risk. This may lead to fatigue that exceeds their ability to recover, resulting in musculoskeletal imbalances and potentially leading to the development of musculoskeletal disorders (MSDs). Therefore, exposure to workplace risk factors increases the risk of workers developing MSDs (Odebiyi & Okafor, 2023).

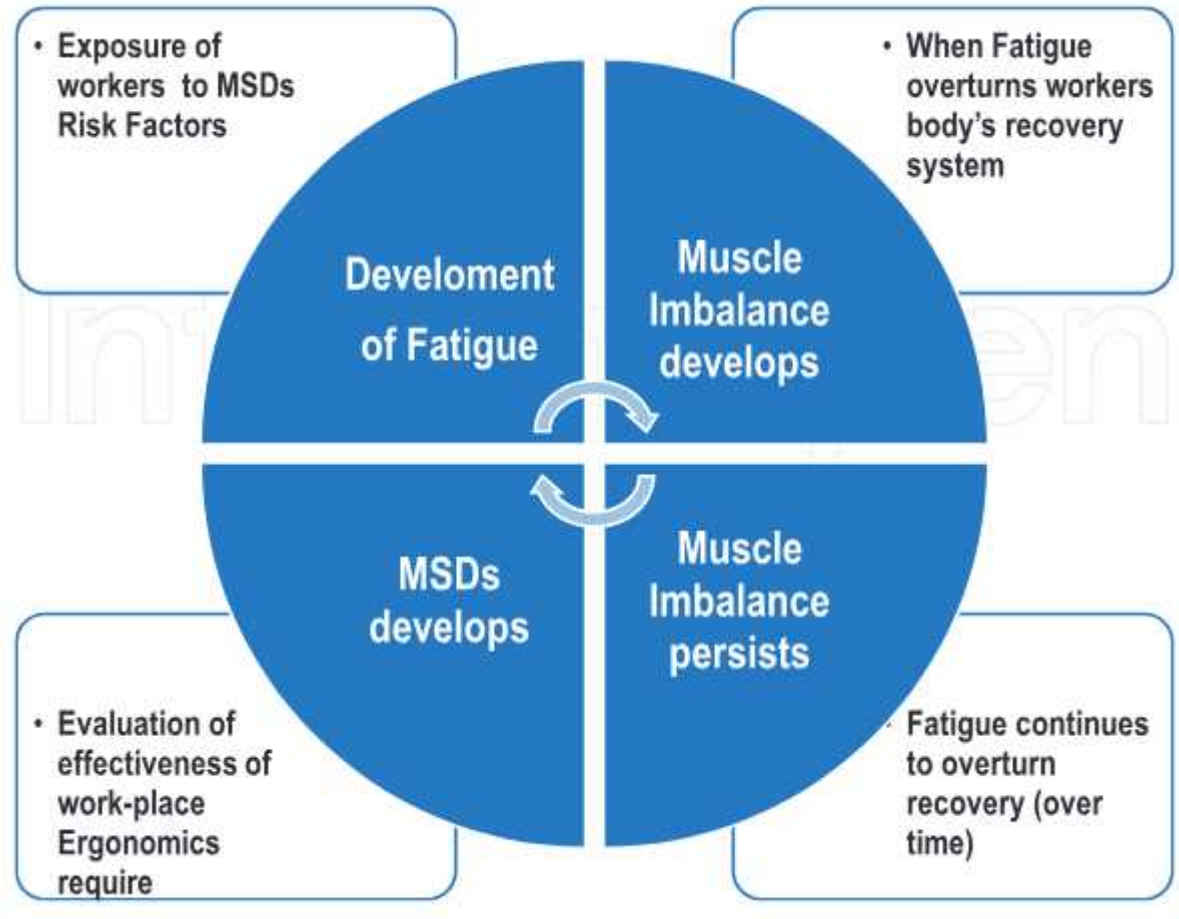


Figure 4.7 Mechanism development of MSDs. Source (Odebiyi & Okafor, 2023)

The below figure 4.8 Proposed correct working position REBA Analysis Result shows that, Table a assembly (trunk, neck, legs), with these three positions values it projects the table A values as 3. To table A values the load acting values 1 is added. Final values equal to 4

Table B assembly (upper arm, lower arm, wrist), with these three positions values it projects the table B values as 2. To table A values the coupling value 1 is added. Final values
Equal to 3. Value A and B combine forms table C. That is table A and B values are arrived into table C to produce value C. The generated value is 4. Finally, value 2 is added for the activity of work. Unexpected large change in the working position. The value is combined to the value C and the final result with value 6 as shown in Figure 4.8 REBA value risk calculations. The identified risk is classified as medium, indicating that some action is needed now to reduce the risk of injury. The recommended posture is associated with a medium risk level. If the task is not performed continuously, the risk is considered low. However, if the work is done for extended periods, it is advisable to take breaks. the recommended posture is classified as having a medium risk level (Hignett & McAtamney, 2000).

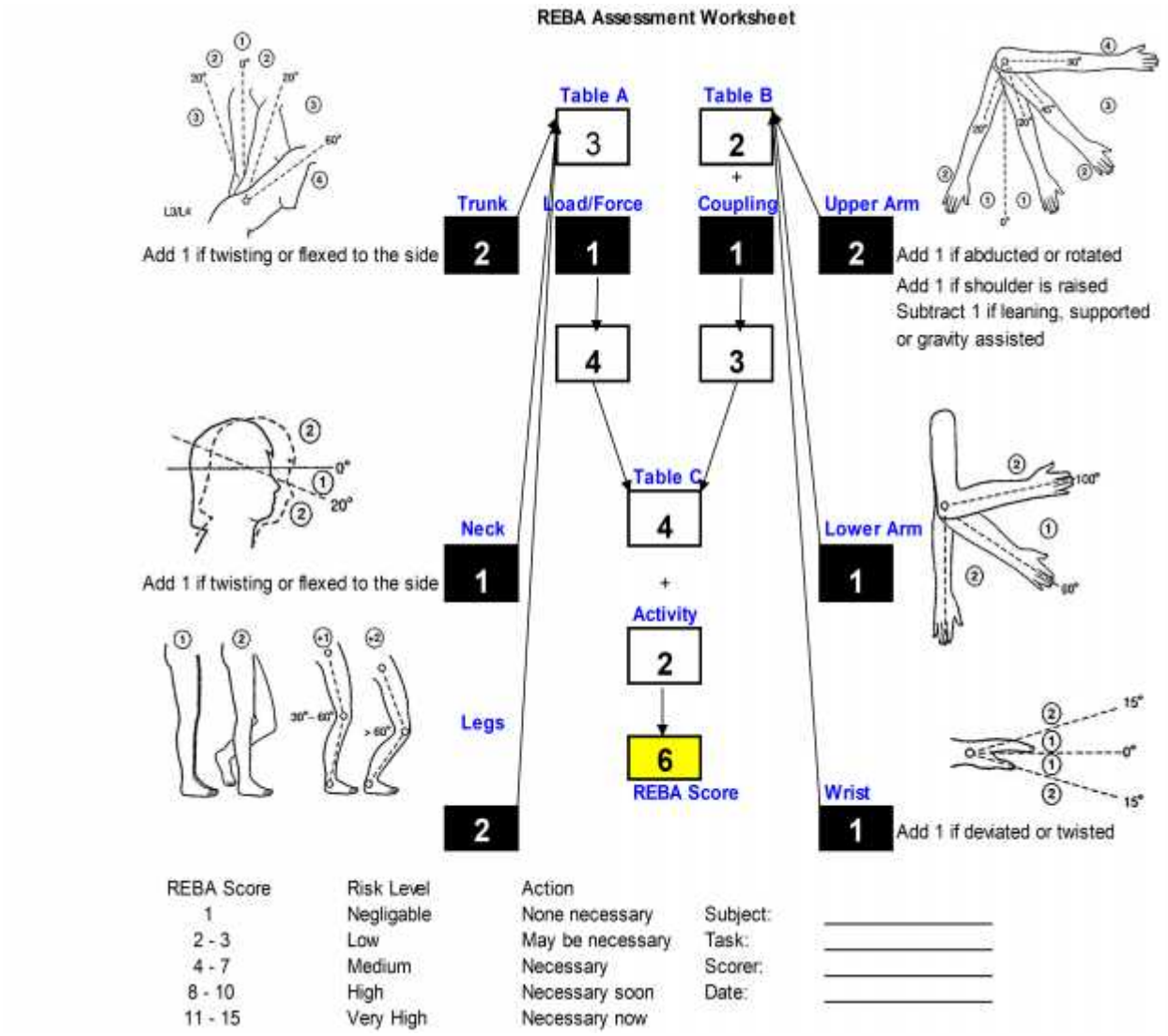


Figure 4.8 Proposed correct working position REBA Analysis Result, Source (Hignett & McAtamney, 2000).

In general workplace ergonomic risk in garment manufacturing can be mitigated through strategies such as workplace design, material handling, tool and equipment ergonomics, training and education, work organization, and job design. Workplace design should match worker anthropometry, provide adjustable furniture, and ensure adequate legroom and reach distances. Material handling should use carts, trolleys, hoists, and height adjustable conveyers to reduce manual lifting. Tool and equipment ergonomics should be selected with proper grip sizes and shapes, and frequently used items easily accessible. Training and

education should involve worker participation in identifying and resolving ergonomic issues. Continuous improvement is essential through regular assessments and observations.

By implementing these strategies and mechanisms, Senmul garment manufacturing company can create ergonomically fit workplace for employee and worker-friendly workplace environment, this will also to improved productivity, quality, and also helps to improve employee well-being.

Chapter Five

5.1 conclusion

This study has provided valuable understanding into the importance of workplace ergonomics assessments for enhancing social sustainability in the garment manufacturing industry. The results show that thorough ergonomic assessments can significantly enhance the health, safety, and well-being of employees. Manufacturers may develop work environments that reduce the incidence of musculoskeletal disorder, increase worker productivity, and encourage engaged and satisfied workforce by recognizing and treating ergonomic risk factors.

By implementing ergonomic interventions such as job rotation schedules, adjustable workstations, material handling, task & tool changing, establish comprehensive ergonomics programs, involving routine evaluations, interventions, and continuous monitoring, integrated into their overall health and safety management framework. Invest in ergonomic training courses for managers and employees to understand workplace concepts identify risk factors, and use ergonomic tools effectively, enhancing their ability to identify and address ergonomic issues and the company focuses its main priority on ergonomics risk factor identification and assessments and offering adjustable and adaptable workplaces to meet individual worker needs. These aids can improve worker comfort and minimize fatigue and absence. These outcomes directly support the social sustainability objectives of the industry that include employee rights, encouraging ethical labor practices, crate standard working hours and enhancing the employee quality of life.

Senmul Garment manufacturing industries should be committed to social responsibility and help create a more sustainable and equitable industry by making workplace ergonomics a priority issue. It is advised that more study be done in order to better understand the relation between ergonomics and social sustainability and to determine the most efficient ways to implement ergonomic programs in settings related to garment manufacturing.

5.2 Recommendation

As per the findings of this study, the following recommendations are proposed to further improve the integration of workplace ergonomics assessments in garment manufacturing operations to support social sustainability:

- Comprehensive ergonomics programs should be established by garment manufactures these programs should involve routine evaluations, the application of ergonomic interventions, and continuous monitoring and assessment of the interventions' efficacy. These programs must be integrated into the company's overall health and safety management framework.
- Ethical Considerations: Integrating ethical considerations into ergonomic design and implementation can contribute to the social sustainability of the work environment. These practices should consider ethical principles, such as respecting human dignity, promoting social justice, and avoiding exploitation or discrimination.
- Giving Ergonomics Training for Managers and Workers: Invest in training courses that instruct managers and employees on ergonomic workplace concepts, how to identify ergonomic risk factors, and how to utilize ergonomic tools and equipment correctly. As a result, workers will be more equipped to recognize and address ergonomic problems in their daily work activity.
- Ergonomics Standards: Together with, policy makers and groups representing the garment business should create and execute thorough ergonomic standards and recommendations that are applicable to garment manufacturing. As a result, these creates accountability and provide safe and ergonomically fit work environments for all garment manufactures
- Inclusive design: encourages equity, accessibility, and social inclusion, promoting more varied and inclusive workforce. these principles can be applied to create compressive work environments that accommodate the needs of various workers, including those with disabilities or varying physical capabilities.

By implementing these recommendations, Senmul garment manufacturing integrates workplace ergonomics assessments into their operations and contributes to the improvement of social sustainability within the industry, finally improving the safety, health, and well-being of garment employees.

5.3 Future study area

This study has been provides valuable insights into workplace ergonomics and its impact on social sustainability within the Senmul garment manufacturing industries. However, further research is needed to understand the relationship between workplace ergonomics and social sustainability with other aspects of sustainability, such as economic sustainability more research is needed to identify additional areas for improvement.

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Appendices

Appendix A

Ergonomics global study in garment manufacturing

Authors	Title	Objective	Methods	Findings	Limitations/ Future study
(Kiritkumar & Pothiraj, 2023)	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: a cross sectional study	Assessing employee positions, identifying risk factors, and evaluating physical activity among different occupations is important for determining the prevalence of work-related musculoskeletal disorders..	Örebro Musculoskeletal pain questionnaire (ÖMPQ), Rapid Entire Body Assessment tool (REBA), Quick Exposure Check tool (QEC) and International Physical Activity Questionnaire (IPAQ) was administered to all the participants. Data was analyzed using SPSS 24 software.	The study found no significant link between physical activity and work-related musculoskeletal disorders (WMSDs) in sewing machine operators, but highlighted the impact of poor working posture.	Limitation in recruitment of an unequal number of participants on different machines and not identifying new and old machines. For future study structured physical activity amongst the sewing machine operators helps in reducing the risk of WMSDs.
(Scafà et al., 2019)	How to improve worker's well-being and company performance: a method to identify effective corrective actions	To evaluate workers' experience and identify the optimal solution to improve workers' well-being and company performance	Methodical analysis of risks, corrective actions, and KPIs to enhance worker well-being and company performance in manufacturing	Strong correlations were observed between certain risk factors (e.g., awkward posture) and specific corrective actions (e.g., ergonomic equipment).The study highlighted the importance of management actions in addressing work-related risks and	Future works will focus on the empirical validation of correlations, involving a significant sample, and the development of a tool that automatically suggest the most proper actions and allow simulating achievable

				improving worker well-being.	results based on machine learning algorithms
(Karuppiah et al., 2020)	Role of Ergonomic Factors Affecting Production of Leather Garment-Based SMEs of India: Implications for Social Sustainability	focusing on ergonomics and sustainability in the apparel manufacturing industry	The fuzzy AHP method employed to rank the recognized ergonomic factors.	The findings of this study will help industrial managers improve production rates and advance social sustainability in Indian SMEs.	In this study were Collected from the Indian context and not taking these factors into account in other developing countries, this study focuses solely on assessing the significance of ergonomic factors.
(Aquino Rojas et al., 2023)	Ergonomic Redesign Model to reduce musculoskeletal disorders in a cluster of SMEs in the clothing accessories sector	Ergonomic redesign model aimed at minimizing musculoskeletal disorders in a group of SMEs within the clothing accessories industry.	The study uses a combination of ergonomic tools like RULA, REBA, NIOSH, and Lean manufacturing tools to address musculoskeletal disorders and absenteeism rates in the textile sector .	The garment industry sector faces high occupational accidents due to repetitive tasks and material handling processes, causing (WMSD) in workers.	the limitations of the body that could be affected, being an important factor to consider the maximum load weight together with the environmental characteristics for the worker

(Gomes et al., 2023)	Ergonomics and Worker Well-Being: Contributions to Sustainability in the Apparel Manufacturing Industry	The main objective of this paper is to expand the discussion about the contributions of ergonomics and well-being to the sustainability of the worker, in the clothing manufacturing industry.	Method used in this paper is known as PRISMA, a research method divided in four phases: Identification, Screening, Eligibility and Inclusion	Impact of improving workstations on productivity and worker well-being, as well as the importance of defining work methods to enhance worker performance and quality standards in the garment industry	Further studies are needed to enhance productivity and worker well-being in garment manufacturing by promoting better workplace observation, standardizing work methods, improving communication, and exploring new monitoring technologies.
(M. A. Hasan et al., 2023)	Prevalence of Musculoskeletal Disorders among Garment Workers: A Cross-Sectional Study in Bangladesh	The study investigated the prevalence of musculoskeletal disorders (MSDs) among textile workers in Bangladesh and their correlation with various demographic factors..	Conducted a cross-sectional study to determine the prevalence of musculoskeletal disorders (MSDs) among garment workers in Bangladesh.	The findings revealed that lower back pain was the most common form of pain experienced by the workers, with the lower back, upper back, and knees being the most affected body regions.	The prevalence estimate was precise; however, the contributing elements were not carefully evaluated. Other limitations of this study include that it is cross-sectional, the possibility of recollection bias, and the dependence on self-report of MSDs.

(Rahman et al., 2023)	Review of Emerging Technologies for Reducing Ergonomic Hazards in Construction Workplaces	The study analyzed the correlation between publications, keywords, and citations related to wearable sensors, XR, exoskeletons, and robotics technologies in occupational safety and health.	Bibliometric Analysis Scientometric Analysis:	Offering valuable insights into the evolving landscape of emerging technologies that are designed to address and minimize ergonomic hazards in construction work environments.	The study's limitations include potential biases in database selection, keyword search terms, and data processing methods, and its focus on specific technologies or regions may limit its generalizability.
(Eugenia et al., 2023)	Reducing Ergonomic Hazards and Challenges in Clothing Laboratories in Tertiary Institutions in Anambra State.	The primary objective of the study was to examine the ergonomic risks and difficulties present in clothing laboratories within tertiary institutions in Anambra State.	the study is a survey design	The study reveals ergonomic hazards in clothing laboratories, including repetitive movements, forceful movements, awkward postures, heavy loads, and improper lifting techniques, which can be mitigated by using appropriate tools.	The study did not investigate the effectiveness of the recommended strategies for reducing ergonomic hazards and challenges in clothing laboratories Which may not represent the entire population of clothing laboratories in Nigeria or other countries.

(Sadeghi Naeini, 2020)	Ergonomics on the Context of Sustainability: A New Approach on Quality of Life	The main objective is to create a synergetic paradigm between ergonomics and sustainability to enhance the quality of life for individuals.	using PubMed and EBSCO databases	findings underscored the importance of integrating ergonomics and sustainability to enhance work efficiency, productivity, safety, health, and quality of life	Future research should explore the integration of ergonomic design and sustainable materials in fashion manufacturing, examining challenges faced by designers and manufacturers, and their impact on consumer behavior and satisfaction.
(Nagaraj et al., 2019)	Evaluation of ergonomic working conditions among standing sewing machine operators in Sri Lanka	Evaluate the prevalence of Musculoskeletal Disorders (MSDs) and related ergonomic risk factors among small-scale manufacturing organizations in the Sri Lankan textile sector.	job-related factors and Cornell Musculoskeletal Discomfort Questionnaire (CMDQ), combined with validated ergonomic tools such as the Rapid Entire Body Assessment (REBA) and Strain Index (SI), to evaluate ergonomic risks among them.	The study found that musculoskeletal symptoms are most common in knee, foot, thigh, lower leg, and lower back. Risk factors encompass age, BMI, marital status, experience, job satisfaction, job stress, and daily walking distance.	The study only focused on female sewing machine operators & did not include a comparison group of sewing machine operators in other countries or industries

(Polat & Kalayci, 2016)	Ergonomic Risk Assessment Of Workers In Garment Industry	The study aims to assess ergonomic risk factors within the garment manufacturing, focusing on physical workloads and working environment, to pinpoint the risk factors that contribute to work-related musculoskeletal disorders.	This study uses the Rapid Entire Body Assessment (REBA) method to analyze the working conditions and physical workloads of workers in a baby towel manufacturing factory, focusing on postures and repetitive motions.	The study reveals that insufficient ergonomic working conditions in the garment industry can lead to serious physical disorders, particularly in certain departments like sewing, cutting, packaging, warehouse, and packaging, causing musculoskeletal disorders.	The study's limitations include focusing on a single factory and not considering psychosocial factors like job strain and work-related stress, suggesting future research should include multiple factories and incorporate these factors.
(Meyer et al., (2017)	Ergonomics as a tool to improve the sustainability of the workforce	The research explores the link between sustainability, ergonomics, and occupational health issues, focusing on workforce sustainability and identifying work-related imbalances	The methodology is not mentioned in the study, however the authors conducted a literature search using keywords such as sustainability, ergonomics, occupational health, and workforce sustainability.	The study emphasizes the importance of sustainable work systems, balancing workers' capacity with system demands, and the role of ergonomics in optimizing the employee-work environment interface. It emphasizes the need for revitalizing and enhancing	The study acknowledges the growing concept of sustainability, particularly workforce sustainability, but still faces issues related to OH. It suggests organizations improve strategies and consider an ergonomics approach for workforce sustainability.

				human resources, fostering a quality work life, and implementing sustainable change processes	

Appendix B

Ergonomics in Ethiopia literatures Summery

Authors	Title	Objectives	Method	Findings	Limitations/ Future study
(Abebe & Hasegawa, 2018)	Application of Ethiopian Garment Industry: Improvement of Workplace Productivity through Ergonomics Management System	This study investigates the impact of ergonomics management on workplace productivity, analyzing human-job interaction and factory state using statistical analysis tools.	The Kano model was utilized to prioritize design requirements and assess the quality of work environment and employee.	Findings from the study on workplace ergonomics in the Ethiopian garment industry aimed on identifying the effect of ergonomics management on workplace productivity improvement.	The study had limitations in terms of the correlation analysis results. While some dependent variables showed significant correlations with specific independent variables, others did not have significant correlations.
(TAFESE et al., 2018)	Work-related Low Back Pain among Garment Industry Workers in Eastern Oromia Region, Ethiopia	The objective is to determine the magnitude and associated factors of work-related (LBP) low back pain between garment industry employees in ethiopia Eastern Oromia,	The study used bivariate logistic regression analysis to determine variables' associations, with variables with a P-value below 0.15 being exported to multiple logistic regressions to control for confounding factors.	The study revealed a high magnitude of self-reported LBP among garment industry workers in Eastern Oromia, with a prevalence of 64.9%.	The study focused on a specific region and industry, so generalizing the results to other populations or sectors should be done.
(Biadgo et al., 2021)	Burden of Neck Pain and Associated Factors Among Sewing Machine Operators of Garment Factories	The study aimed to identify the prevalence and factors contributing to neck pain among sewing	The study utilized an institutional-based cross-sectional design and included 297 sewing machine operators from garment factories in	The 12-month occurrence rate of neck pain among sewing machine operators was 42.3%.	The study focused on sewing machine operators in garment factories in Mekelle city, limiting generalizability to

	in Mekelle City, Northern Part of Ethiopia, 2018, A Cross-Sectional Study	machine operators in Mekelle city's garment factories.	Mekelle city		other populations.
(Abebe & Hasegawa, 2018)	Application of Ethiopian Garment Industry: Improvement of Workplace Productivity through Ergonomics Management System	The research objective is to identify the ergonomics management impact on workplace productivity improvement in the Ethiopian garment industry	The study utilized a Likert scale questionnaire & using Spearman correlation coefficient for data analysis and Kano model to identify and prioritize key independent variables.	Research found, the Ethiopian garment industry's productivity is significantly impacted by ergonomic factors, including physical stress, environmental factors, and work-related musculoskeletal disorders. Redesigning the work environment can reduce these issues.	The study also focused on the sewing department of the Akaki garment factory, which may not be representative of the entire Ethiopian garment industry.
(Deyyas & Tafese, 2014)	Environmental and Organizational Factors Associated with Elbow/Forearm and Hand/Wrist	The study aims to evaluate the prevalence and risk factors of work-related musculoskeletal disorders among sewing	The study utilized an institution-based cross-sectional design and standardized Nordic questionnaire, to collect data on sociodemographic	The study revealed a 40% prevalence of work-related musculoskeletal disorders of the elbow and wrist among sewing	The study has limitations, including the use of a self-reported questionnaire, potential recall bias, and its focus on two garment

	Disorder among Sewing Machine Operators of Garment Industry in Ethiopia	machine workers in Galan City's garment industries.	characteristics, personal factors, organizational factors, and working environment factors.	machine operators. Significantly influenced by personal and environmental factors.	industries, potentially excluding all industries.

Appendix C

Data analysis methods and tool selection

Author	**Research Title**	**Method and data analysis tools used**	**Data Analysis Tools**	**Method gap & limitations**
(Nagaraj et al., 2019)	Evaluation of ergonomic working conditions among standing sewing machine operators in Sri Lanka	job-related factors and the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ), along with the use of the Rapid Entire Body Assessment (REBA) and the Strain Index (SI).	Analyzing Statistical software SPSS 24.	Lack of statistical analysis to understand risk factors in previous studies, and limitations in the dependability and accuracy data collection in the research
(Sakthi Nagaraj & Jeyapaul, 2018)	Ergonomic Study on Work Postures of Sewing Machine	using the Cornell Musculoskeletal Discomfort Questionnaire	using chi-square test	Methodology gaps such as potential biases, inadequate data

	Operators in Government Industry	(CMDQ) and the Rapid Entire Body Assessment (REBA)		collection techniques, or insufficient analysis methods
(Gajšek et al., 2022)	Linking the Use of Ergonomics Methods to Workplace Social Sustainability: The Ovako Working Posture Assessment System and Rapid Entire Body Assessment Method	Selected methods Ovako Working Posture Assessment System (OWAS) and the Rapid Entire Body Assessment (REBA),	Data analysis tool utilized, ErgoIA software tool	Method limitations: The assessment does not include the neck, elbows, and wrists. The method does not take into account repetitive movements. Furthermore, it is only accessible to specialists who have been trained in the use of OWAS.
(Gomes et al., 2023)	Ergonomics and Worker Well-Being: Contributions to Sustainability in the Apparel Manufacturing	The study utilized a bibliographic research methodology with a qualitative approach, using the PRISMA research method,		Further studies needed on focus key areas, including workplace observations, standardizing workplace methods,

	Industry			improving communications, seeking new monitoring technologies
(Sinko et al., 2022)	Raising workplace sustainability with ergonomics assessment methods	The study utilized OWAS and REBA assessment method	Selected software tool ErgoIA	It does not consider some parts of body neck, elbows and wrists.
(Kiritkumar & Pothiraj, 2023)	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: a cross sectional study	Örebro Musculoskeletal pain questionnaire (ÖMPQ), Rapid Entire Body Assessment tool (REBA), Quick Exposure Check tool (QEC) and International Physical Activity Questionnaire (IPAQ)	Data was analyzed using SPSS 24 software.	Unequal number of participants on different machines and not identifying new and old machines.

Appendix D

Questionnaire

ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY (AAIT)

School of Mechanical and Industrial Engineering

Msc in Industrial Engineering

Survey Questionnaire on senmul garment manufacturing

Dear respondents i am a student at AAIT in industrial engineering. I am conducting research on workplace ergonomics assessment and its impact on sustainability in garment manufacturing. The university would like to assure you that the data collected will be used for only educational purposes, and your response data will be kept confidential and will only be used for research and analysis purposes. The response to the research is based on your demand, and it will only take a few minutes to fill out the questionnaire.

- To answer the questionnaire please mark on the check box
- If you have any questions or suggestion please call on +251913046694 or +251944109046

Thank you for your participation.

Tagesse Amtachew

Part 1 General Information

1. Employment Condition: a) permanent employee ☐ b) Temporary employee ☐

2. Educational Level: a) Elementary Grade 1-8 ☐ c) Grade 9-12 ☐

   D) Diploma ☐ f) Degree & above ☐

3. Gender : Male : ☐ Female: ☐

4. Age: a) less than 20 years ☐ b) 20-30 years ☐ c) 31-40 years ☐

   d) 41- 50 years ☐ e) 51 & above ☐

5. Your work experience in the company : a) less than 1 Year ☐ b) 1-5 Years ☐ c) 6-10 year ☐ d) 11 years & above ☐

	Part 2 Ergonomics conditions	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
1	The workstation equipment have movable and adjustable heights የመስሪያ ቦታ መሳሪያዎቹ ተንቀሳቃሽ እና የሚስተካከሉ ቁመቶች አሏቸው					

2	The current workplace chair provides adequate lumbar support አሁን ያለው የሥራ ቦታ ወንበር በቂ የሆነ የወገብ ድጋፍ ይሰጣል					
3	The workstation have a possibility staying at stationary position for long time የሥራ ቦታው በቋሚ ቦታ ላይ ለረጅም ጊዜ የመቆየት እድል አለው					
4	The workstation have work stress የሥራ ቦታው የሥራ ጫና አለው					
5	The workplaces are free from dust & high noise የስራ ቦታዎቹ ከአቧራ እና ከፍተኛ ጫጫታ ነፃ ናቸው					
6	The workplace have job rotation per shift የስራ ቦታው በፈረቃ የስራ መዞር አለው					
	Part 3 Work environment	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
1	The lighting in the workplace area sufficient and does not cause eye strain በልብስ ስፌት ቦታ ላይ ያለው መብራት በቂ እና የዓይንን ጭንቀት አያስከትልም					
2	The overall layout of the work area minimizes the need for excessive reaching or bending. የሥራው ቦታ አጠቃላይ አቀማመጥ ከመጠን በላይ የመድረስ ወይም የመታጠፍ ፍላጎትን ይቀንሳል.					

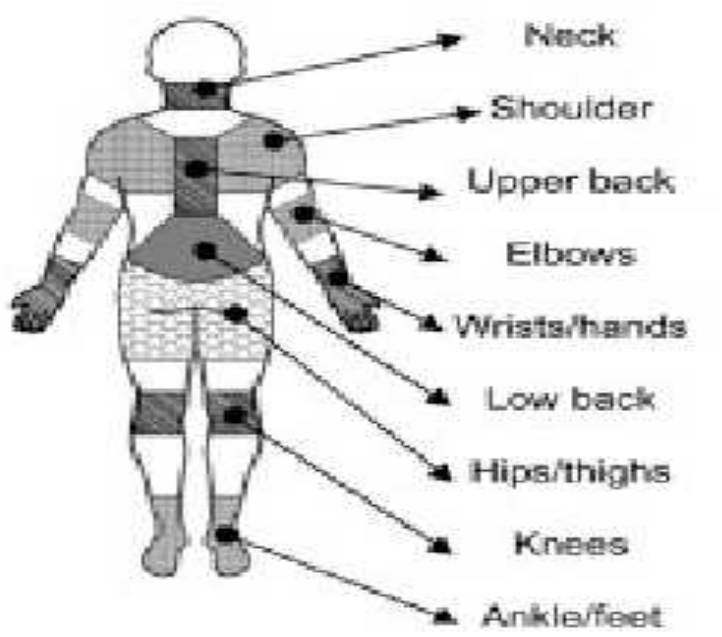
3	I have enough space at my workstation to comfortably perform my tasks. ተግባሮቼን በምቾት ለማከናወን በስራ ቦታዬ በቂ ቦታ አለኝ					
4	I am able to take adequate breaks to stretch and relieve muscle fatigue የጡንቻን ድካም ለመዘርጋት እና ለማስታገስ በቂ እረፍት ማድረግ እችላለሁ					
5	I feel the current ergonomic conditions in the facility allow me to work safely and comfortably በተቋሙ ውስጥ ያሉት አሁን ያሉት ኢርጎኖሚክሰ ሁኔታዎች በአስተማማኝ እና በምቾት እንድሰራ እንደሚረዱኝ ይሰማኛል					
6	Overall, my current ergonomic conditions allow me to work comfortably. በአጠቃላይ፣ አሁን ያለኝ ኢርጎኖሚክሰ ሁኔታዎች በምቾት እንድሰራ ያስችሉኛል					
	Part 4 Ergonomics Training	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
1	Your knowledge about ergonomics concept is better ስለ ኢርጎኖሚክሰ ጽንሰ-ሀሳቦች ምን ያህል ያውቃሉ?					
2	In your company how important do you consider workplace ergonomics					

	በድርጅትዎ ውስጥ የስራ ቦታ ኢርጎኖሚክሰን ምን ያህል አስፈላጊ እንደሆኑ ያስባሉ					
3	The company provide any training on how to protect yourself from musculoskeletal disorders (MSDs) ኩባንያው እራስዎን musculoskeletal disorders (MSDs) እንዴት እንደሚጠብቁ ማንኛውንም ስልጠና ይሰጣል.					
4	The company gives safety and ergonomics training for employee ኩባንያው ለሠራተኛ ደህንነት እና ኢርጎኖሚክሰ ስልጠና ይሰጣል					
5	The culture in your workplace encourage cross-training as a means to reduce the frequency of employees engaging in repetitive motion tasks በስራ ቦታዎ ውስጥ ያለው ባህል የሰራተኞችን ተደጋጋሚ እንቅስቃሴዎችን ድግግሞሽ ለመቀነስ ስልጠናን ያበረታታል					

Appendix E

Part 5 Body parts

Do you feel excessive tiredness or discomfort in any part of your body due to your regular work activities? For any body parts affected, please choose, **1= No pain, 2 = Moderate pain, 3 = Painfully, 4 = Very painful**



Body parts	**1 = No pain**	**2=moderate pain**	**3= painfully**	**4= Very painful**

1- Neck
2- Shoulder
3- Upper back
4- Elbow
5- Wrists/hands
6- Low back
7- Hips/thighs
8- Knees
9- Ankle/feet

Part 6 for Selected groups (Managers)

1) What are the impacts of ergonomics on the health and well-being of employees?
   የ ኢርጎኖሚክሰ በሠራተኛ ጤና እና ደህንነት ላይ የሚያሳድረው ተጽዕኖ ምንድን ነው?

---

2) Is the current design of the work environment safe for employees?
አሁን ያለው የስራ ጣቢያ ዲዛይን ለሰራተኞች ደህንነቱ የተጠበቀ ነው?

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3) What is your opinion on introducing ergonomic workstations in your factory?
በፋብሪካዎ ውስጥ ኢርጎኖሚክሰን በማስተዋወቅ ላይ ምን አስተያየት አለዎት?

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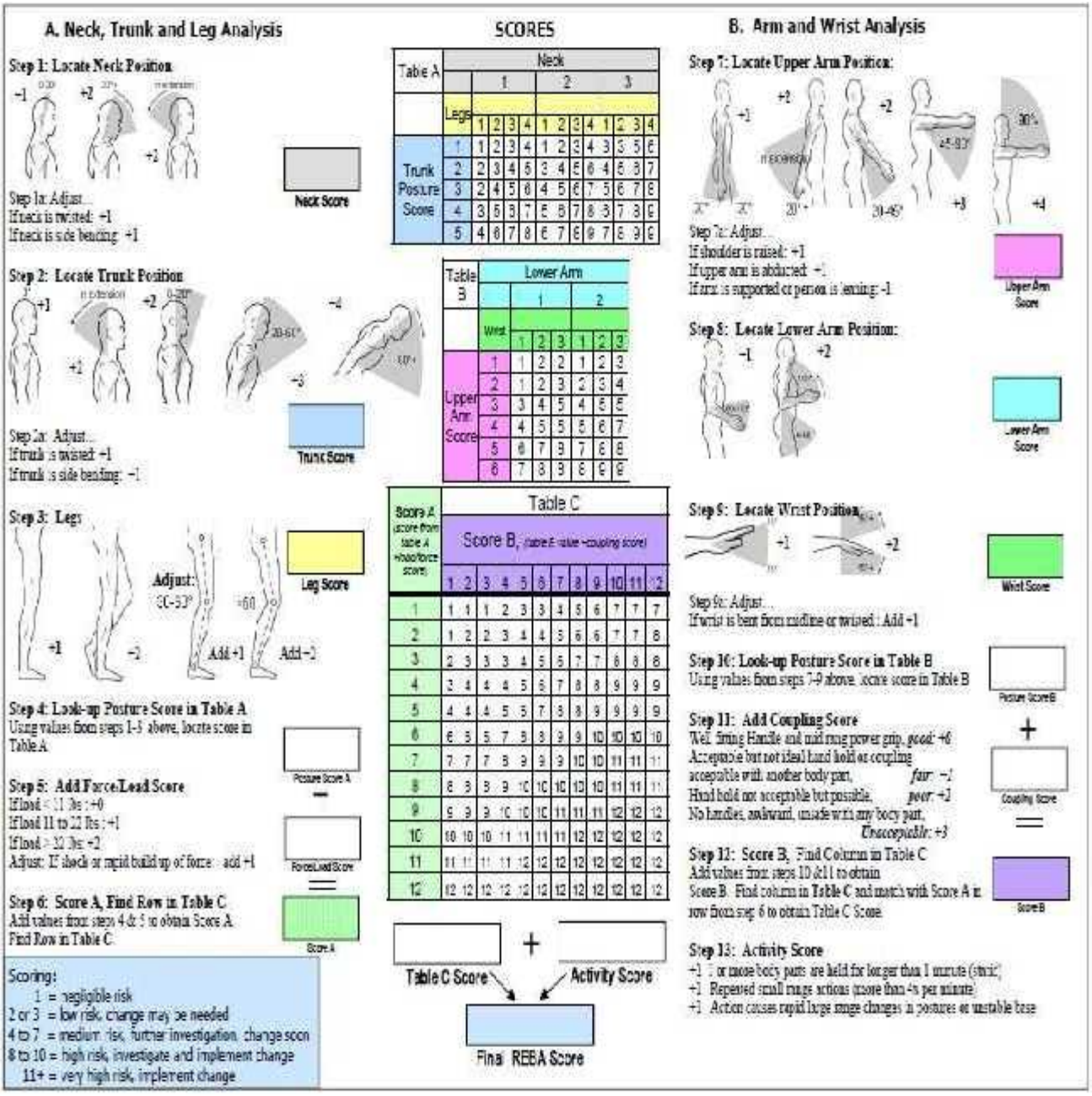
4) Is there anything else you would like to mention regarding the design of workstations in your factory?
በፋብሪካዎ ውስጥ ያሉትን የሥራ ቦታዎች ዲዛይን በተመለከተ ሌላ መጥቀስ የሚፈልጉት ነገር አለ?

Appendix F

REBA Assessment Worksheet

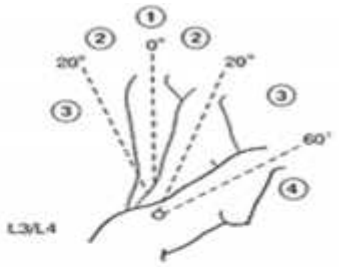

A. Neck, Trunk and Leg Analysis
SCORES
B. Arm and Wrist Analysis
Step 1: Locate Neck Position
Step 1a: Adjust...
If neck is twisted: +1
If neck is side bending: +1
Neck Score
Step 2: Locate Trunk Position
Step 2a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1
Trunk Score
Step 3: Legs
Adjust:
Add +1
Add +2
Leg Score
Step 4: Look-up Posture Score in Table A
Using values from steps 1-3 above, locate score in Table A
Posture Score A
Step 5: Add Force/Load Score
If load < 11 lbs : +0
If load 11 to 22 lbs : +1
If load > 22 lbs: +2
Adjust: If shock or rapid build up of force add +1
Force/Load Score
Step 6: Score A, Find Row in Table C
Add values from steps 4 & 5 to obtain Score A
Find Row in Table C
Score A
Scoring:
1 = negligible risk
2 or 3 = low risk, change may be needed
4 to 7 = medium risk, further investigation, change soon
8 to 10 = high risk, investigate and implement change
11+ = very high risk, implement change
Table A
Neck
Legs
Trunk Posture Score
Table B
Lower Arm
Wrist
Upper Arm Score
Table C
Score A (score from table A +load/force score)
Score B, (table B value +coupling score)
Table C Score
Activity Score
Final REBA Score
Step 7: Locate Upper Arm Position:
Step 7a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1
Upper Arm Score
Step 8: Locate Lower Arm Position:
Lower Arm Score
Step 9: Locate Wrist Position
Step 9a: Adjust...
If wrist is bent from midline or twisted: Add +1
Wrist Score
Step 10: Look-up Posture Score in Table B
Using values from steps 7-9 above, locate score in Table B
Posture Score B
Step 11: Add Coupling Score
Well fitting Handle and mid 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

Appendix G

Body Part REBA Result

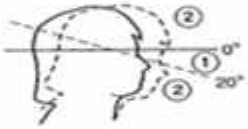
Trunk

Movement	Score	Change score:
Upright	1	+1 if twisting or side flexed
0°–20° flexion 0°–20° extension	2	
20°–60° flexion >20° extension	3	
>60° flexion	4	



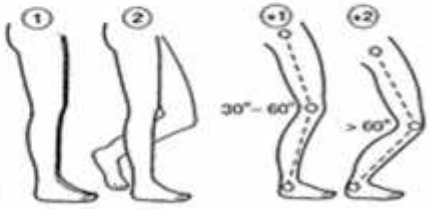
Neck

Movement	Score	Change score:
0°–20° flexion	1	+1 if twisting or side flexed
>20° flexion or in extension	2	



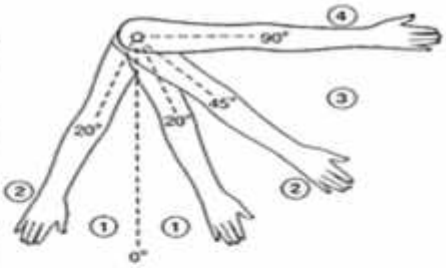
Legs

Position	Score	Change score:
Bilateral weight bearing, walking or sitting	1	+1 if knee(s) between 30° and 60° flexion
Unilateral weight bearing Feather weight bearing or an unstable posture	2	+2 if knee(s) are >60° flexion (n.b. Not for sitting)



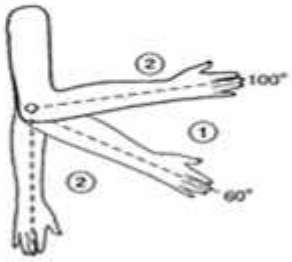
Upper arms

Position	Score	Change score:
20° extension to 20° flexion	1	+1 if arm is: • abducted • rotated
>20° extension 20°–45° flexion	2	+1 if shoulder is raised
45°–90° flexion	3	–1 if leaning, supporting weight of arm or if posture is gravity assisted
>90° flexion	4	



Lower arms

Movement	Score
60°–100° flexion	1
<60° flexion or >100° flexion	2



Wrists

Movement	Score	Change score:
0°–15° flexion/ extension	1	+1 if wrist is deviated or twisted
>15° flexion/ extension	2	

Appendix H

Proper sewing operator seat position and seat chair