Ergonomic Framework to Enhance Sustainable Cost-Effective Process in A Fashion and Designed Industry

Kenneth Ugo Udeze [iD][✉] [1, *], **Gracious Amarachukwu Nwafor** [iD][✉] [2]

[1] Department of Electrical Electronics Engineering, Federal Polytechnic Oko, Oko, Anambra State, Nigeria.
[2] Department of Mechanical Engineering, University of Nigeria, Nsukka, Enugu State, Nigeria.

ABSTRACT

This study presents an integrated solution to the challenges in the global fashion and design industry, prioritizing worker well-being and environmental sustainability. Through an ergonomic framework, it aims to achieve sustainability and cost-effectiveness. The research employs established tools like RULA and REBA and diverse methods, including observations, interviews, and questionnaires, to quantitatively and qualitatively assess ergonomic risks. The study guides the clothing sector towards a more ethical, sustainable, and efficient production paradigm, bridging the gap between ergonomics, sustainability, and cost-effectiveness. It addresses the need for a conscientious transformation, ensuring economic growth aligns with workers' welfare and environmental responsibility.

Keywords: Clothing industry, Ergonomics, Sustainability, Cost-effectiveness, Workers well-being.

1. INTRODUCTION

This study presents an engineering-driven solution to the critical need for sustainability and worker welfare in the clothing industry by developing a cost-effective and practical ergonomic framework. Recognizing the multifaceted role of clothing in society as a fundamental need, a medium of self-expression, and a key driver of economic activity **(Pangesti, 2021).** The research emphasizes the industry's significant global workforce and the necessity of creating safe and efficient working environments **(Ramdass and Mokgokloa, 2020)**. Despite the proven benefits of ergonomics in improving workplace safety and comfort, integrating ergonomic principles with sustainability and cost optimization remains a complex challenge.
The clothing industry's sustainability considerations span environmental, social, and economic dimensions. However, the absence of a comprehensive ergonomic framework has

hindered progress. This study addresses this gap by proposing a tailored ergonomic model that integrates ethical and sustainable practices. Aligned with the United Nations Sustainable Development Goals **(United Nations, 2015)**, the framework specifically targets economic and environmental challenges, with an initial focus on Nigeria.

Nigeria, especially Nsukka Municipality, was chosen for its many small clothing workshops with poor ergonomic conditions. This setting offered a real-life example to study posture-related risks and develop practical, low-cost solutions suited for similar environments in developing countries.

Therefore, the pilot phase of the research is concentrated on clothing workstations in Nsukka municipality, incorporating the flexibility to adapt to other workstations through customizable solutions. The core objectives include identifying ergonomic risks within the clothing sector, engineering safer and more efficient workstations, implementing environmentally friendly practices, and quantitatively assessing worker safety and operational efficiency.

This study distinguishes itself by presenting a practical and adaptable ergonomic framework designed specifically for small and medium-scale clothing industries in developing economies. Unlike prior research focused on theoretical models or large-scale industrial applications, this study addresses real-world limitations such as constrained funding, limited resources, and manual operations. By integrating low-cost ergonomic interventions with lean manufacturing principles, it promotes improved productivity, worker comfort, and cost-efficiency. The framework's foundation in real-time engagement with industry practitioners ensures its relevance and applicability in similar settings.

This ergonomic framework is engineered to transform the clothing industry by balancing sustainability and cost-effectiveness. The result is a more productive and healthier workforce, combined with an industry model that adheres to environmental and social responsibility, setting a global benchmark for sustainable industrial practices.

The proposed framework is versatile and can be applied beyond the clothing sector. Though originally tailored to workshops, its core principles—worker-centered design, cost-efficiency, and lean process integration—are transferable to other labor-intensive sectors such as footwear, furniture, and light manufacturing. Its adaptability to low-resource environments makes it ideal for industries with similar challenges. With slight modifications, it can guide ergonomic improvements and enhance productivity in a broad range of comparable settings.

2. LITERATURE REVIEW

The global clothing industry is a key sector to the economy, but its rapid growth has had adverse effects on the environment and the health of employees. Ergonomics, a discipline that seeks to improve workplace design and conditions, has a significant role in preventing such consequences. In the clothing industry, ergonomics is a significant discipline seeking to optimize human performance and health at the workplace through the optimization of work systems, equipment, and environments **(Jana, 2008).** Workers in the clothing industry often face repetitive tasks and physical strain, leading to work-related musculoskeletal disorders (WRMDs). **(Vihma et al., 1982)** analyzed the relationship between musculoskeletal complaints and work of sewing machine operators. The study determined the prevalence of musculoskeletal disorders, particularly in the back, neck, and shoulders, caused by repetitive work over a long duration and static postures. Their findings emphasized the ergonomic

issues associated with sewing workstations and recommended reworking the workstation and task adjustment to minimize discomfort and improve occupational health among sewing machine operators. **(Öztürk and Esin, 2011)** showed musculoskeletal symptoms and ergonomic risks between 283 Turkish sewing machine workers were examined utilizing Rapid Upper Limb Assessment (RULA) and the Nordic Musculoskeletal Questionnaire. High rates of musculoskeletal symptoms and higher ergonomic risks on the trunk, neck, and shoulders were obtained. The authors emphasized the applicability of reducing workplace ergonomics in terms of reducing the risk as well as enhancing workers' health in the textile industry manufacturing. Similarly, **(Sealetsa and Thatcher, 2011)** examined ergonomics issues among Botswana's textile factory sewing machine operators. From their 157-women operator survey, they found rampant musculoskeletal disorders, mainly of the shoulders, neck, and back, due to repetition and poorly designed workstations. Using a body map questionnaire and NASA TLX, they stressed the importance of workstation redesigning, improved chairs, and ergonomics instruction to enhance the well-being and productivity of the operators. **(Gunning et al., 2001)** provides an Ergonomic Handbook for the Garment Industry, which outlines solutions to ergonomic problems. Through the design of workstations, reorganization of tasks, and training of workers, the handbook promotes healthier, more productive textile production workplaces, developed in collaboration by unions and health organizations to make workplaces healthier and more productive. Ergonomics is the use of knowledge from a variety of disciplines to adapt tasks, tools, and the working environment to each individual worker, leading to higher productivity and fewer accidents **(Stanton et al., 2000)**. this multidisciplinary profession is indeed capable of enhancing the productivity of workers by lessening fatigue, a healthier working atmosphere with fewer accidents, along with less absenteeism and employee turnover **(Priya, 2022)**. Research has highlighted the importance of ergonomic interventions. For example, **(Mgbemena et al., 2020)** showed that timely ergonomic interventions increase worker satisfaction and productivity. **(Oborne, 1991)** provides an overarching review of workplace ergonomics and its role as a tool for improved worker performance, safety, and health. The second edition expounds more on the practice-oriented application of ergonomic ideas in creating safer, more productive workplace design. Oborne's book remains an excellent book in unraveling how workplace ergonomics can be applied in various industry applications to provide improved productivity as well as minimized workplace accident frequencies. Similarly, **(Kim et al., 2019)** improved sewing workstations, reducing musculoskeletal disorders. The fashion industry has grave environmental impacts on water and air pollution and the use of resources. The inclusion of sustainable strategies such as green materials and energy-saving processes has gained momentum to reverse these effects **(Bocken et al., 2016)**. Incorporating sustainability into business strategies is crucial for minimizing environmental impact and supporting Sustainable Development Goals **(Shen et al., 2017)**. The study by **(Richa et al., 2024**) assesses the financial aspects of adopting sustainable development strategies in the textile industry, specifically for India's periphery. The study in the International Journal of Research Publications and Reviews critically discusses the financial influence of sustainable strategies on financial performance, operational efficiency, and profitability over the long term. Adopting a paradigmatic stance, the authors apply qualitative and quantitative methods to assess production cost, resource utilization, and waste management strategies. The findings highlight that while initial investment in sustainable strategies incurs financial expenses, long-term benefits are resource optimization savings, improved brand equity, and regulatory compliance. The

study provides pragmatic guidance on reconciling economic and environmental goals, emphasizing inter-stakeholder cooperation. Its focus on the Indian periphery, however, may decrease generalizability to other contexts. This document is a useful guide for industry leaders and policymakers interested in sustainable development in the textile industry. Sustainable methods, such as incorporating organic cotton and renewable energy, are capable of lessening environmental footprint significantly. **(Hasanain, 2024)** reviews the central role of ergonomics and human factors in advancing sustainable manufacturing systems. Published in Machines, the article explores how the application of ergonomic principles leads to increased productivity, safety, and overall system efficiency of workers. The paper describes the interplay between human-centered design and sustainability goals, with a focus on energy consumption minimization, waste reduction, and better resource allocation. Also underscored in the paper is the game-changing role digital technologies such as AI and simulation software have in optimizing manufacturing processes in the face of human limitations. Through combining human factors engineering and sustainability, the review presents a holistic vision of creating resilient and effective manufacturing systems. The detailed analysis provides valuable insight to practitioners and researchers in the field of sustainable manufacturing strategies. It is necessary to combine ergonomics and sustainability in the fashion industry in order to offset economic challenges and enhance employees' well-being. **(Gehrold, 2020)** research develops a sustainable product design model for the fashion and textile industry through balancing Ted's 10 design approaches and UN Sustainable Development Goals (SDGs). Grounded in systematic literature review and expert interviews, the research puts in the spotlight gaps in environmentally sustainable design aesthetics guidelines. The promoted framework emphasizes reduction of consumption, chemical footprint, and use, bringing with it the potential for textile designers to lead sustainability aligned with SDGs. Studies, such as those **(Ramdass, 2013; Visha, 2023)**, emphasize the benefits of integrated ergonomics and sustainability, including reduced costs, increased productivity, and improved worker health and safety. Cost-effective ergonomic interventions in apparel industries are conceived with the objective to reduce cost without losing productivity and worker welfare.

Minor adjustments like changing workstation height and providing ergonomic tools can yield substantial improvement in both worker welfare and productivity **(Ramdass, 2013)**. The study by **(de Oliveira et al., 2022)** examines consumer attitudes towards sustainability in slow fashion and fast fashion stores. Using a comparative approach, the study reveals how customers value sustainability initiatives, such as ethical sourcing and green packaging, within their purchases. There is evidence to show a need for transparency and sustainability in slow fashion, where fast fashion is attacked for shallow "greenwashing." The research underscores the role of open communication of sustainable endeavors in building trust and loyalty. The research yields insights that will be helpful for brands that intend to harmonize practice with shifting consumer expectations. Similarly, **(Bano, 2019)** highlights the critical significance of job satisfaction and a secure working atmosphere in influencing workplace efficiency. Additionally, creating a secure working environment through ergonomic interventions can enhance workplace productivity. **(Wickens et al., 2013)** provide a comprehensive review of human factors engineering, with emphasis on the integration of psychological principles in system design. The book discusses human abilities, limitations, and interaction with systems, giving insight into design and evaluation, sensory systems, cognition, and decision-making. It effectively bridges theories of human performance to practice, as evidenced through real-life examples. This interdisciplinary treatment provides

an even-handed approach, addressing ergonomics, safety, automation, and human-computer interaction, and is therefore a requirement for human factors studies. **(Khan et al., 2024)** examine the critical impediments to adopting green manufacturing in medium-sized ready-made garment companies and suggest mitigation measures. The main challenges of financial limitations, technical competence, resistance to change, and regulatory mechanisms were determined by the study. The adoption of green materials, energy-efficient technologies, and waste reduction strategies is hindered by these challenges. To address these challenges, the authors propose programs such as capacity-building initiatives, incentives by the government, stakeholder collaboration, and investment in emerging technology. The study emphasizes the need for policy support and leadership to take sustainability endeavors forward. Based on an in-depth analysis of problems and solutions, the paper serves as a great guide to industry practitioners and policymakers seeking to enhance sustainability in garment production. **(Tareque, 2021)** job satisfaction study among Needle Drop Limited garment workers investigates matters relating to worker joy in an increasingly competitive manufacturing business. The study is concerned with key variables such as work environment, pay, workload, supervisor attitude, and career growth. The research demonstrates that inadequate remuneration, excessive workload, and bad career opportunities have a great influence on worker satisfaction and result in massive turnover rates as well as decreased productivity. Conversely, affirmative workplace practices and positive work climate trigger motivation and employee retention. Organizational policy alignment with employee demands is emphasized as the key to enabling greater satisfaction and overall effectiveness. By offering targeted recommendations, such as fair wage structures and skill development programs, this research provides valuable insights for improving workplace conditions in the garment industry and fostering sustainable workforce management.

3. MATERIALS AND METHODS

This research is a cross-sectional analytical study conducted across multiple clothing workshops; the clothing workshops studied are located within Nsukka Municipality, Enugu State, Nigeria. The specific areas were selected due to the high density of informal garment production activities, where tailors and fashion designers work under small- to medium-scale operations. It involved various clothing industries, including Floxy fashion designers, KS Kanyira stitches, Nuel's culture, Ifetex tailoring shop, GF interiors, Palkels gentle clothing, Ken stitches, Teflon tailors, Ogetex fashion home, Caje's perfect wears, and others. These industries produce a range of clothing and textile products. They were selected based on their active operations, accessibility, and relevance to the study's focus on ergonomic conditions in small- to medium-scale garment production settings. These shops are located in the Ogige Market clothesline in Nsuka, Enugu State, Nigeria.

From **Fig. 1**, it shows the simplest flow method of materials in the various clothing shops visited. Fabric is either provided by customers or delivered in rolls, as seen at GF Interiors. It's first cut into patterns, then sewn, washed, and dried. After drying, the items move to the finishing department for final touches. Lastly, they are ironed, inspected, and neatly packed for delivery.
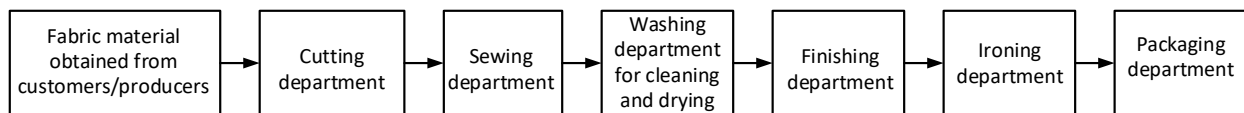
Figure 1. The flow method of materials in the various clothing shops visited.

The research adopted a qualitative approach, as shown in **Fig. 2**, that was both exploratory and descriptive in nature. The descriptive exploratory approach was selected to understand and map ergonomic challenges and inefficiencies within small to medium-scale clothing industries, especially in developing economies where such data and models were scarce. This approach enabled in-depth observations and worker engagement, capturing context-specific variables that quantitative methods might miss. It allowed for rich, qualitative insights to inform the development of a practical framework, setting the stage for future targeted quantitative studies based on these findings.

The initial stage of the study involved visiting several clothing workshops as part of the first phase. In the subsequent phase, a structured questionnaire was administered to delve deeper into the ergonomic challenges prevailing in the work settings within the clothing industry.
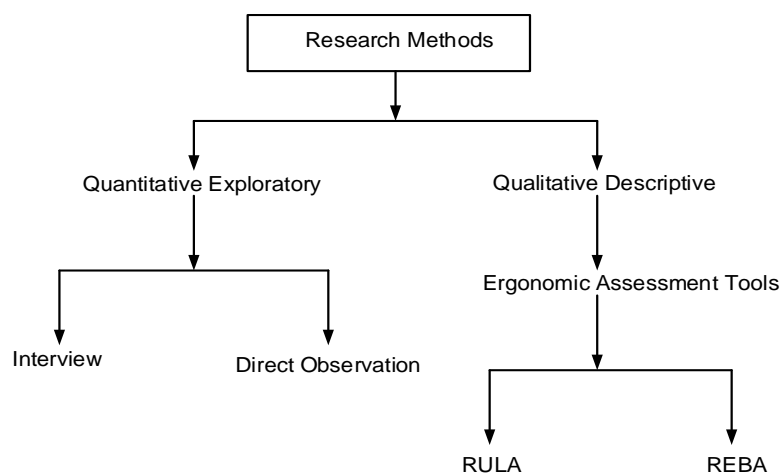

Figure 2. The method used for the research data collection.

3.1 Data Collections

The data collection encompassed direct observation, interviews, structured questionnaires, a literature review, and the utilization of established ergonomic assessment tools (RULA and REBA) to evaluate and categorize musculoskeletal risks. The study focused on selected small to medium-sized clothing workshops within a busy urban textile cluster. These workshops were purposively chosen based on accessibility, willingness to participate, number of workers, and the presence of manual tasks relevant to ergonomic observation. Activities like sewing, cutting, ironing, and packaging were assessed. Each visit lasted 3–4 hours, covering different times of the day—morning, midday, and afternoon—to capture task and posture variations. Tools like RULA and REBA were used during these sessions to evaluate ergonomic risks and gain a comprehensive view of working conditions throughout the day

A sample size of around 50 respondents was determined statistically, and data analysis was performed using SPSS to align with the study's theoretical framework. The sample size of 50 was chosen based on study scope, access to participants, and the need for detailed ergonomic observation within a realistic timeframe. Workers were selected from various departments across different small to medium garment shops to capture a range of tasks. Though not nationally representative, the sample was suitable for exploring key ergonomic risks and inefficiencies. The findings offer a strong basis for future, larger-scale studies.

Literature sources, including printed and online materials, were utilized to gain insights into ergonomic challenges in the clothing industry, while visits and interviews with clothing workshop representatives provided experiential context for the study. The comprehensive approach aimed to uncover and address ergonomic issues in the clothing industry effectively.

The concept of "sample size" in research pertains to determining the number of individuals selected for inclusion in a research investigation to stand as representatives of a larger population. The sample size indicates the overall count of participants encompassed in a study, and it is frequently divided into subgroups based on demographic factors like age, gender, and location to ensure that the entire sample effectively mirrors the characteristics of the entire population **(Kibuacha, 2021)**. Choosing of sample size of the respondents followed a systematic approach. Andrew Fisher's method of sample sizing was used to develop the questionnaire size of approximately 50 respondents.

Steps in calculating sample size include:

Identify the population size (if it's known).

- Establish the confidence interval or margin of error.
- Specify the confidence level.
- Determine the standard deviation (opting for 0.5 is a prudent choice when the exact figure is unknown).
- Let the sample size, n= $\left(\frac{Z^2*P(1-P)}{e^2}\right)$
- Where Z is the Z-score
- P is the standard deviation and e is the margin of error
- (P=0.5 and e =0.05)
- Convert the confidence level into a Z-score.

3.2 Analysis of Data

The data collection and analysis are based on the theoretical framework that was developed initially. According to **(Saunders, 2007)**, there would be a recurring theme emerging from the analysis in seeking to satisfy the postulations developed in the theoretical framework. When a theoretical framework is established early in the research, data should be examined in a way that allows key themes to emerge naturally. These recurring themes help validate or refine the framework's assumptions. In this study, the approach ensured that observations and questionnaire responses from garment workers were systematically analyzed to uncover common ergonomic issues. This method supported the development of a practical, evidence-based framework for improving workplace ergonomics.

The Statistical Product and Service Solutions (SPSS) software package was used to analyze the data and to provide descriptive statistics. The survey required the respondents to indicate their opinion on how strongly they agreed or disagreed with the statements in the questionnaires.

4. RESULTS AND DISCUSSION

The researcher showcases the outcomes of the survey conducted by Amarachukwu Nwafor, who followed the analytical approach of **(Geldenhuys, 2008).** According to Geldenhuys, effective research goes beyond data collection by identifying underlying patterns and drawing meaningful insights through both qualitative and quantitative analysis. Guided by this mechanism, the researcher examined interviews and questionnaire responses to uncover deeper ergonomic issues and support evidence-based conclusions

4.1 Interview

Over a sequence of visits, interviews were carried out with willing participants who represented the specific roles within the plants. These interviews encompassed the following areas: Physical discomfort related to the musculoskeletal system, attributes of the working environment, attributes of the workstation, seating, and job role, training, including on-the-job training, classroom instruction, conference participation, and apprenticeship program **(Nwanya, 2023)**, as well as environmental assessments, including evaluations of lighting, temperature, and noise levels, were conducted at selected workstations. These areas of interviews were identified by Amarachukwu Nwafor using the Nwanya approach, which provided a comprehensive framework for evaluating workplace training, which emphasizes on-the-job learning, classroom instruction, and specialized programs like conferences and apprenticeships to improve worker skills and safety. His mechanism supports the holistic approach to ergonomic assessments by combining both physical and environmental factors with worker training. The researcher identified these interview areas to ensure a thorough understanding of the ergonomic risks and to align findings with Nwanya's framework on training and environmental assessments.
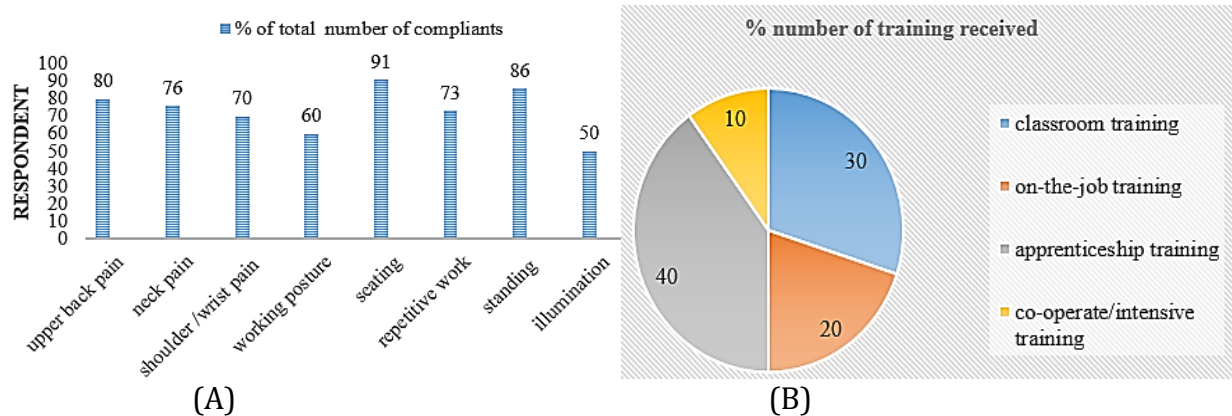

Figure 3. The interview summary (A) the results of the conducted interview, and (B) the number of training received

Fig. 3 displays the outcomes of the total interviews conducted, providing an overview of the data collected. The interviews revealed valuable information about various aspects of ergonomic challenges in the clothing industry. The interview results revealed a high prevalence of musculoskeletal discomfort in the upper back (80%), shoulders/wrists (70%), and neck (76%) among participants, consistent with questionnaire responses. Participants often adopted stooped working postures (60%) due to factors like task demands and workstation design, leading to muscle fatigue and discomfort. Issues related to illumination

(50%), particularly suboptimal eyesight, were noted, highlighting the importance of good vision for workplace safety. The research also identified a mismatch between workstation design and operator dimensions, necessitating adjustments to seating, which often led to a forward-leaning posture. The use of non-ergonomic chairs and stools was common, with homemade cushions added for comfort. Repetitive manual manipulation was associated with increased physical discomfort, especially in the neck, upper and middle back, right shoulder, and hands. Training methods varied, with room for improvement in ongoing training and performance feedback, particularly for younger workers. These findings emphasize the need for ergonomic interventions in the clothing industry to enhance worker well-being and reduce discomfort and injury.

4.2 Ergonomic Assessment Tool

REBA **(Hignett and McAtamney, 2000)** and RULA **(McAtamney and Corlett, 1993)** are ergonomic assessment tools used in evaluating body postures in clothing industry tasks, aiding in ergonomic framework development for sustainability and cost-effectiveness. **Fig. 4** is a collection of pictures from various sewing shops during visits to individual shops for questionnaires. They were taken at the shop after much interaction with the shop owners.

Figure 4. The pictures of workers carrying out sewing activities

In the sewing department from **Fig. 4**, operators engage in repetitive tasks without ergonomic workstations, leading to physical discomfort. Chairs lack adjustability, forcing uncomfortable postures. Limited space necessitates product stacking, leading to hunched positions. Elbow support is absent, causing arm fatigue. Inadequate lighting requires body bending. Research findings after due calculation using the REBA and RULA employee assessment worksheet reveal that approximately 56.97% of sewing operators' postures may need ergonomic improvements, with a REBA score of 2-3, and 63.64% may require further investigation, corresponding to a RULA score of 3-4 **(Table 1)**

The researcher also found out that workers with the highest RULA scores (6–7) were mainly sewing machine operators and hand finishers, since they were exposed to sustained awkward postures and repetitive movements. Key contributing factors to it included: prolonged forward head and neck bending, unsupported arms during fine motor tasks, non-adjustable workstations, poor seating without backrests, and high task repetition with limited breaks. These conditions led to significant upper body strain and increased musculoskeletal risk.

Table 1. The Summary of the results of the REBA and RULA scores in the sewing sections using the REBA and RULA assessment worksheets.

Reba Score	Number of Photos	% Score	Rula Score	Number of Photos	% Score
1	20	12.12	1-2	40	24.24
2-3	94	56.97	3-4	105	63.64
4-7	35	21.21	5-6	20	12.12
8-10	16	9.70	7	0	0
11-15	0	0			
TOTAL	165			165	

4.3 Questionnaire

Paper questionnaires were used due to limited digital access and literacy among clothing workshop employees. This method allowed for direct, in-person engagement, clearer communication, and immediate support from the researcher. The questionnaires, available upon request, focused on ergonomic factors like workstation design, posture discomfort, task frequency, workload, and worker feedback, and were based on standard ergonomic guidelines tailored to the local garment industry context.
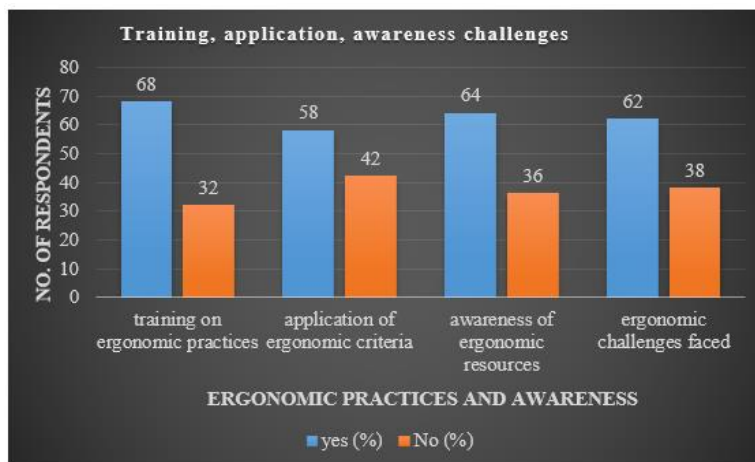
During site visits, 50 questionnaires were distributed and categorized into ten sections, aligning with the study's objectives. These sections encompass demographics, ergonomic framework, ergonomic practices and awareness, physical demands, work environment, job satisfaction, sustainability, mitigation, and management support. The research questionnaire was carefully organized and categorized into ten sections, with the independent variables under examination being linked to the dependent variable. **Table 2** shows a sample of the questionnaire section (ergonomic practices and awareness) that was distributed during the site visits.

Table 2. Ergonomic practices and awareness

Criteria		
How familiar are you with the concept Ergonomic?	Familiar	Not familiar
Have you received any Training on ergonomic practices, lifting techniques or injury prevention?	Yes	No
Do you Apply ergonomic principles in your daily work task?	Yes	No
Do you face any Ergonomic challenges in your work environment?	yes	No
Are you aware of ergonomic resources available in your workplace?	Yes	No

4.3.1   Ergonomic Practices and Awareness.

This study tried to establish the extent of knowledge of ergonomic practices and awareness among the clothing industries in the study stretch **(Firmansyah, 2020)**. **Fig. 5** captures what was obtained in the places visited. From **Fig. 5**, training in ergonomic practices is essential for workers' safety and health, with 68% having received training. Integrating ergonomic criteria into workstation design and tools is crucial for promoting user comfort and reducing awkward postures, as 58% of employees apply ergonomic principles. Creating awareness about available ergonomic resources, known by 64%, empowers workers to report discomfort and access assistance. The clothing industry faces ergonomic challenges, with 62% of workers encountering them stemming from repetitive tasks, prolonged standing, and awkward postures. Familiarity with ergonomic concepts, reported by 72%, is vital for recognizing and addressing potential issues in the garment production process.

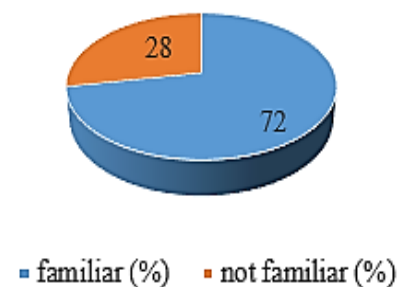**(A)**   **(B)**

Figure 5. The ergonomic practices and awareness (A) the training and awareness that the respondent received. (B) the applicability and challenges of ergonomics in their workplace.

4.3.2   Perception of Management Support

This study referred to how employees view their superiors' commitment to ergonomic practices and safety measures, impacting worker confidence, well-being, and overall job satisfaction.

Fig. 6 illustrates how management support impacts employees in various aspects. The data shows that while a significant portion of respondents have opportunities to provide feedback (54%) and feel supported (38%) in ergonomic practices, workers safety (48%), and work-life balance (48%), there is room for improvement in ensuring a safe, ergonomic, and balanced work environment. Addressing these aspects can boost employee morale, comfort, and overall well-being.

The analysis encompassed binary logistic regression, correlation, and chi-square tests to explore factors affecting the clothing industry's ergonomics, revealing significant relationships and insights. The Binary Logistic Regression helped in the investigation of factors influencing clothing industry ergonomics. Dependent variables included satisfaction with seat height, table height, discomfort due to tools or equipment, and more while the model explained 58.5% to 79.2% of variances in ergonomic conditions. The table height was found to be significant, indicating its impact on ergonomic improvements. Spearman rank correlation was employed due to nominal variables and the positive and negative relationships between variables were examined. Significant relationships were identified, such as seat height and table height's positive correlation. Cross-tabulations explored job satisfaction across job positions and workers comfort in the work environment had a significant relationship with job positions. Workers were found to be more comfortable than bosses in their work environments. Chi-square tests assessed sustainability practices based on gender. No significant differences were found between male and female respondents in waste management, recycling, minimizing waste generation, or cost-effective ergonomic designs.
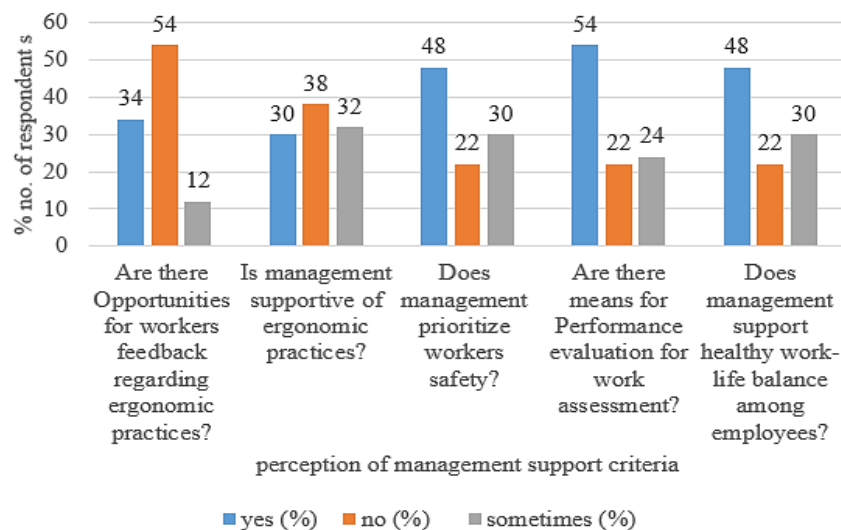

Figure 6. The respondent perception of management support criteria.

4.3.3   Ergonomic Framework

Creating an effective ergonomic framework in the clothing industry is essential to ensure the well-being and productivity of employees. An ergonomic framework considers various factors, such as seat height, table working height, adjustability, discomfort and pain management, ergonomic tools and equipment design, and the overall working space.
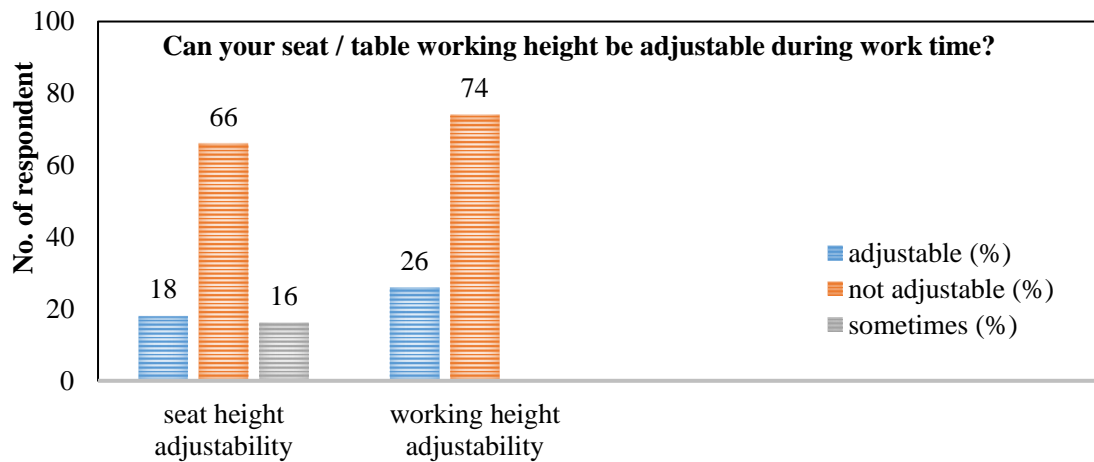
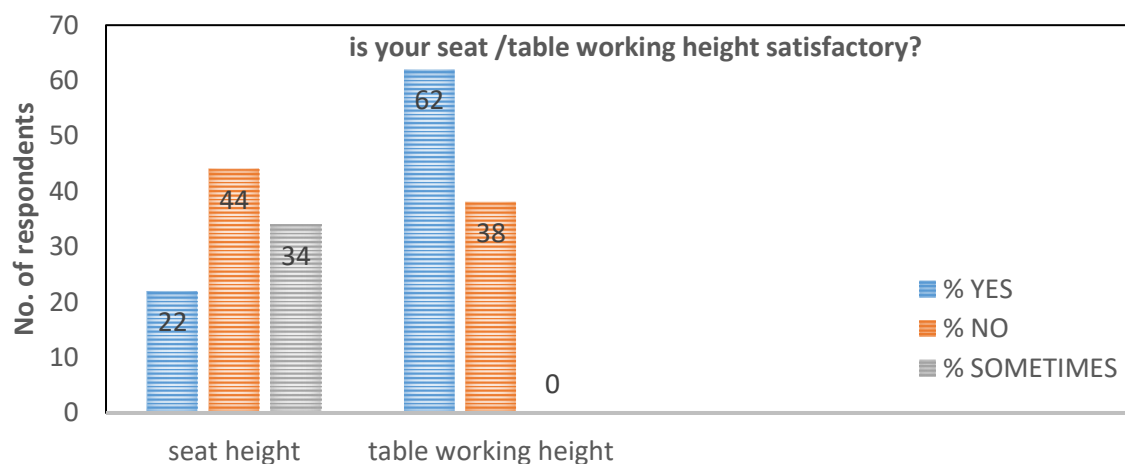**Figure 7.** The adjustability of the seat height or working height

Figure 8. The results showing how satisfactory a respondent is with his/her seat or working height

From **Fig. 7**, seat height and adjustability; 66% of the seat heights were not adjustable, 18% were adjustable and 16% were adjustable sometimes also from **Fig. 8**, 44% of the seat heights were not satisfactory to the respondent during work time, 22% of the seat height were satisfactory and 34% of the seat height were satisfactory sometimes to the respondent during work time. The seat heights that were adjustable and satisfactory sometimes were due to the respondent's effort to improve his/her working posture and output. Proper seat height is critical to maintain a comfortable posture while working. Chairs should be adjustable to accommodate different employee heights. An ergonomic chair should allow the feet to rest flat on the floor while maintaining a 90-degree angle at the hips and knees. Adjustable seat depth and lumbar support are also important for ensuring optimal back comfort.

Some plants offer marginally improved chairs that possess limited height or back adjustment features, but these adjustments are not easily and quickly made, and they fail to provide adequate back support. In certain cases, plants procure chairs that they believe to be ergonomically suitable, but these chairs do not cater to the needs of most or all operators. Common issues encountered when procuring ergonomic chairs include situations where a single chair is selected without consideration for the diverse requirements of various operators as well as the chair's compatibility with different tasks. For instance, the chair

might come equipped with casters or swivel features when such features are unsuitable for the specific job. Frequently, the seat pan is excessively large, resulting in the backrest not making contact with the operator's back. Additionally, the seat pan may have an uncomfortable protrusion at the front, leading the operator to perch on the front edge of the seat and neglect the backrest. Operators often lack proper guidance on how to use these chairs effectively. Without appropriate training, many of the advantages offered by ergonomic chairs go unrealized.

When the researcher tries to find out from the respondents why wooden/ metal stools are mostly used around the project scope of the study, one of the respondents, "we mostly don't use that type of seat you are asking about here to avoid laziness of worker especially that one with backrest."

Working height and adjustability; from **Fig. 7**, 4% of the respondents' table working height is not adjustable, and 26% of their table working height is adjustable. Also from **Fig. 8**, 62% of the respondent are satisfied with their working height, 38% are not satisfied. The working table heights were not easily adjustable as seen in **Fig. 9** with 74% number of respondents. Tables that are positioned at excessive heights lead to elevated shoulder postures as well as non-neutral elbow and wrist postures. Conversely, tables that are too low compel the operator to lean forward and flex their neck. Some tables lack the necessary size to adequately support the weight of the garment, and many are not well-suited in terms of shape for their intended tasks. The majority of sewing tables are flat in design. Sewing tables that are flat fail to optimize visibility and can negatively affect the posture of the upper extremities and neck. The height of tables or workstations plays a critical role in preventing strain on the neck, shoulders, and arms. Work surfaces should be positioned at a height that enables employees to work comfortably without the need to hunch or overreach. The use of adjustable tables or workstations can cater to employees of varying heights and accommodate different tasks, promoting a neutral working posture.
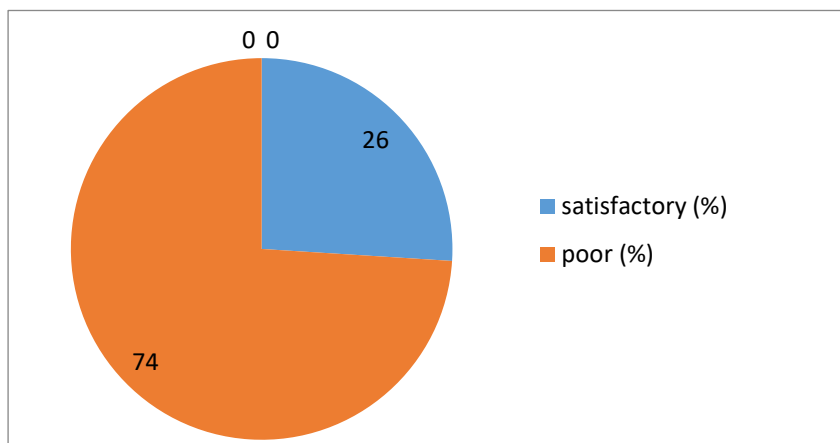

Figure 9. The results showing if a respondent experiences discomfort/pain due to working tools/equipment used.

From **Fig. 10**, 62% of the respondents experienced no pain/discomfort, and 38% experienced pain/discomfort while using the working tool and equipment. Discomfort and pain could arise from prolonged periods of repetitive tasks or poor posture. An effective ergonomic framework should include strategies to identify and address discomfort early on.

Regular breaks, stretch, and ergonomic training can help employees manage discomfort and reduce the risk of developing chronic pain.
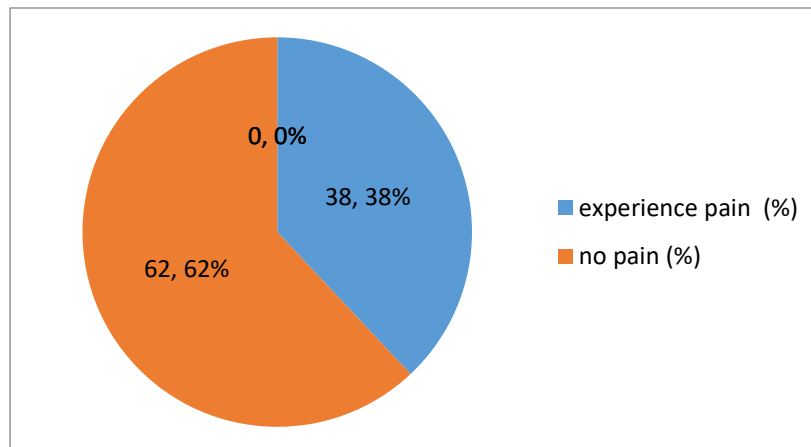

Figure 10. The results showing if the ergonomic design of the tools/equipment is satisfactory.

From **Fig. 11**, 74% of the respondents were satisfied with the ergonomic designs of the working tools/equipment, and 26% were not satisfied with the ergonomic design of the working tools/equipment. Tools and equipment used in the clothing industry, such as sewing machines, cutting tools, and ironing stations, should be designed with ergonomics in mind. Controls and buttons should be easily accessible and operable without straining. Handles should have a comfortable grip to reduce hand and wrist fatigue. Well-designed tools can significantly improve work efficiency and reduce the risk of injuries.
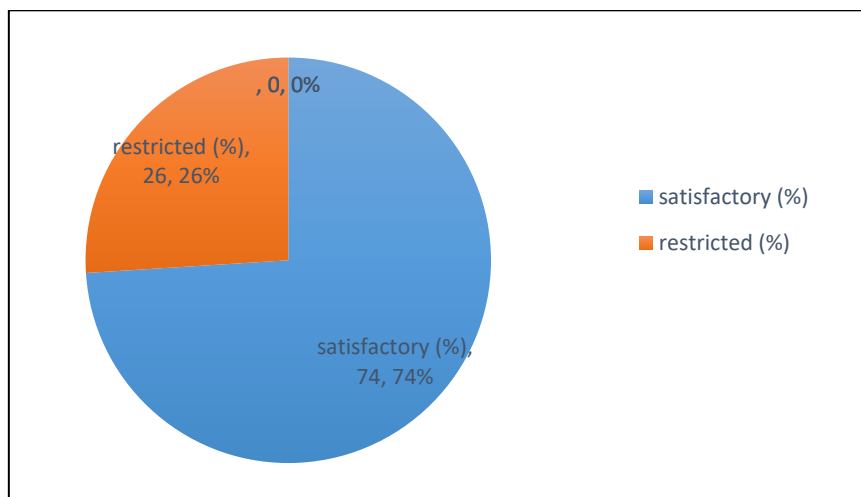

Figure 11. The results showing a satisfactory respondent working space

From **Fig. 11**, 74% of the respondents were satisfied with their working space, while 26% of the respondents agreed that their working space is restricted. Adequate workstation space was crucial to prevent overcrowding and facilitate comfortable movement. Workstations should have enough room for employees to perform tasks without feeling

cramped or restricted. Arrangement of the individual working space should ensure free movement and not cause undue straining. Work stations should be positioned to prevent overreaching or twisting. Sufficient room for equipment, tools, and materials should be provided to prevent congestion and allow easy workflow.

5. THE PROPOSED IMPROVEMENT AND VALIDATION

In order to confirm the suggested project of developing an ergonomic framework for the cost-effectiveness and sustainability of the clothing industry, a detailed plan is presented. This involves ergonomic interventions, incorporation of worker feedback, monitoring of performance, comparative analysis, and expert evaluation, all with the purpose of confirming the practicality and conformity of the framework with industry standards. These are critical to the success of the project and its applicability across the industry.

6. CONCLUSIONS

In conclusion, this project has successfully developed an engineering-based ergonomic framework that effectively integrates sustainability with cost-efficiency in the clothing industry. By applying quantitative measurement instruments such as RULA and REBA, and qualitative approaches such as observation, interviews, and questionnaires, the research extensively elicited ergonomic risks and operational problems in clothing production operations. The system prioritizes the reduction of the high-risk tasks by workstation designs tailored to their requirements, prioritized in training programs, and the implementation of lean manufacturing principles to enhance efficiency and reduce waste of resources. Achieving successful implementation of this framework hinges on active stakeholder collaboration and a commitment to continuous adaptation in response to the industry's evolving demands. The study focused on identifying ergonomic challenges and recommending low-cost or no-cost improvements to enhance productivity and worker comfort, such as adjusting workstations and training workers on better posture. Although it did not include a direct cost comparison before and after implementation, the framework promotes using affordable, locally sourced materials. While the financial return was not calculated, benefits like reduced injuries, improved efficiency, and fewer absences are expected to yield indirect cost savings. Future research is encouraged to quantify these benefits through measurable indicators like lower healthcare costs and increased worker output. The present study therefore concentrates on the significant impact of ergonomics in improving the health and well-being of workers, minimizing absenteeism, and improving overall performance productivity. It also emphasizes the significance of the development of a culture of continuous improvement in which ergonomic practices are incorporated in day-to-day business, providing the framework for supporting sustainable, effective, and transformative change in the clothing industry.

Nomenclature

Symbol	Description
n	Sample size
P	standard deviation
e	Exponential

Credit Authorship Contribution Statement

Gracious Amarachukwu Nwafor: Writing–original draft, Validation, Methodology and data collection. K.U. Udeze: Writing–review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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إطار عمل مريح لتعزيز العمليات المستدامة والفعالة من حيث التكلفة في صناعة الأزياء والتصميم

كينيث أوغو أوديزي [*, 1]، **غراشيوس أماراتشوكوو نوافور** [2]

[1] قسم هندسة الكهرباء والإلكترونيات، المعهد الفدرالي للفنون التطبيقية، أوكو، ولاية أنامبرا، نيجيريا

[2] قسم الهندسة الميكانيكية، جامعة نيجيريا، نسوكا، ولاية إينوغو، نيجيريا

الخلاصة

تقترح هذه الدراسة إطارًا مريحًا يهدف إلى تعزيز الاستدامة والفعالية من حيث التكلفة في صناعة الأزياء والتصميم، مع إعطاء الأولوية لرفاهية العاملين. ومن خلال دمج الاعتبارات البيئية والاقتصادية مع التصميم الذي يركز على الإنسان، تتناول الدراسة التحديات الرئيسية التي تواجه هذا القطاع. باستخدام أدوات تقييم مريحة معروفة مثل RULA و REBA، إلى جانب بيانات تم جمعها من خلال الملاحظات والمقابلات والاستبيانات، تقوم الدراسة بتقييم المخاطر المريحة بشكل نوعي وكمي. يوفر هذا الإطار إرشادات عملية للانتقال نحو ممارسات إنتاج أكثر أخلاقية واستدامة وكفاءة. وفي نهاية المطاف، تؤكد الدراسة على أهمية التوفيق بين التقدم الاقتصادي ورفاهية العاملين والحفاظ على البيئة في صناعة الأزياء.

الكلمات المفتاحية: صناعة الملابس، علم المريحيات (الأرغونوميا)، الاستدامة، الكفاءة من حيث التكلفة، رفاهية العاملين.