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Development of an Ergonomic Framework for a Sustainable Cost-Effective Process in Nigeria Clothing Industries

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Abstract

This study presents an integrated solution to the challenges in the global clothing 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. The results show that a conscientious transformation that emphasizes economic growth and workers' welfare is still lacking. Hence, result-oriented measures that can improve the profitability and environmental responsibility of stake holders and workers in the clothing industry were recommended.

Keywords

Clothing industry, Ergonomic, Sustainability, cost-effectiveness, workers well-being.

1. Introduction

There has been an ever-increasing need for sustainability and worker well-being in almost every industry, such as can guarantee the pressing desire for increased productivity and profitability. Since industries are varied in design and

structure, it will be difficult to present a one-stop methodology for keeping the mural and health of workers to an acceptable level of maximum performance. The most reasonable recourse is to isolate specific industries and study the peculiarities of the job description, and attempt a framework of best practices that will be most suited for the workers. This study addresses the pressing need for enhanced physical fitness and sustainability in the clothing industry through the development of a cost-effective ergonomic framework. The project is motivated by the diverse roles clothing plays in society, from a necessity to a form of self-expression and economic activity (Yohana, 2021). With a substantial global workforce in the clothing industry, ensuring safe and comfortable working conditions is paramount (Ramdass and Mokgokloa, 2020). While ergonomics can contribute to the overall output, integrating it into sustainability and cost-effectiveness has proven challenging. Sustainable practices in the clothing industry involve environmental, social, and economic considerations; yet the lack of comprehensive ergonomic frameworks hampers progress. Another important thrust of this work is to bridge this gap by creating a tailored ergonomic framework to promote ethical and sustainable practices, potentially improving economic sustainability and environmental impact, and aligning with United Nations sustainability development goals in Nigeria (United Nation, 2015). The project's initial scope will focus on clothing workstations in Nsukka municipality, offering adaptability to other clothing workstations with some customization. The research identifies clothing industry ergonomic risks, designs safer workstations, implements eco-friendly practices, and assesses worker safety and efficiency. The need for an ergonomic framework in the clothing industry is fundamental for achieving sustainability and cost-effectiveness, ultimately resulting in a healthier, more efficient, and environmentally responsible industry.

2. Literature Review

The global clothing industry is a significant contributor to the economy, but its rapid expansion has had adverse effects on the environment and worker well-being, especially in developing countries which Nigeria is a typical example. Ergonomics, which focuses on improving workplace design and conditions, plays a vital role in addressing these issues. Workers in the clothing industry often face repetitive tasks and physical strain, leading to work-related musculoskeletal disorders (WRMDs). Ergonomics draws from various disciplines and aims to tailor tasks, equipment, and the work environment to suit each worker, ultimately enhancing productivity and reducing accidents (Stanton et al., 2005). Research has highlighted the importance of ergonomic interventions. For example, Mgbemena et al. (2020) showed that timely ergonomic interventions increase worker satisfaction and productivity. Similarly, Kim et al. (2019) improved sewing workstations, reducing musculoskeletal disorders. The clothing industry has a significant environmental impact, including water and air pollution and resource depletion. Integrating sustainability practices, such as eco-friendly materials and energy-efficient processes, has gained traction to mitigate 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). Sustainable practices, like using organic cotton and renewable energy, can significantly reduce environmental impacts. Combining ergonomics and sustainability in the clothing industry is essential to address economic challenges and enhance worker well-being. The benefits of integrating ergonomics and sustainability, including reduced costs, improved safety and productivity, as well as enhanced worker health is well documented (Ramdass, 2013; Aakanksha and Visha, 2023). Cost-effective ergonomic interventions in the clothing industry aim to reduce expenses while maintaining productivity and worker well-being. Minor adjustments like changing workstation heights and providing ergonomic tools can yield substantial improvements in both employee well-being and output (Ramdass, 2013). Additionally, creating a secure working environment through ergonomic interventions can enhance workplace productivity. While the literature is vast with ergonomic sustainability applications to certain industries, the authors are not aware of any work dedicated to the clothing industry in Nigeria. This sector provides direct and indirect employment to a good percentage of the populace due to the ease of starting the business. Therefore, this work has become necessary to up the deliverables of the clothing industry in the studied location and similar concerns elsewhere.

3. Materials and Methods

The research methodology used for the study were primarily qualitative and exploratory in nature. Primary and secondary data were relied upon to develop the framework. In execution, a cross-sectional analytical study was conducted using results of scientific evaluations from various clothing industries. Some of the clothing outfits visited include Floxy fashion designers, KS Kanyira stitches, Nuel's culture, Ifetex tailoring shop, GF interiors, Palkels gentle clothing, Ken stitches, Teflon tailors, Ogetex fashion home and Caje's perfect wears. There were others visited but could not meet the metrics used to filter the data for the entire work. For example, data from industries where the Staff were not willing to answer all the questions contained in the interview document were later discarded. Others declined

the interview citing non-familiarity with such study and its implications to its business. These industries produce a range of clothing and textile products.

During site visits, 50 questionnaires were distributed, categorized into ten sections aligning with the study's objectives. These sections encompassed 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.

4. Data collections

The data collection encompassed direct observation, interviews with Staff with more than five years experience, excluding the years spent in apprenticeship, structured questionnaires and the utilization of established ergonomic assessment tools. These were used to evaluate and categorize musculoskeletal risks. A sample size of around 50 respondents was determined statistically, and data analysis was performed using Statistical Package for the Social Sciences (SPSS) to align with the study's procedural framework. 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 workshops' experienced representatives provided experiential context for the study. The comprehensive approach aimed to uncover and address ergonomic issues in the clothing industry in Nigeria effectively.

5. Results and discussion

Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA) are ergonomic assessment tools used in evaluating body postures in clothing industry tasks. The time-tested assessment procedure can act as an effective guide to development of sustainability and cost-effective ergonomic framework. Plate 1 shows the posture of some selected workers during sewing in the clothing industry. Each worker was subjected to detailed assessment using the REBA and RULA procedure. The results are presented in Table 1.

Plate 1. Selected workers carrying out sewing activities

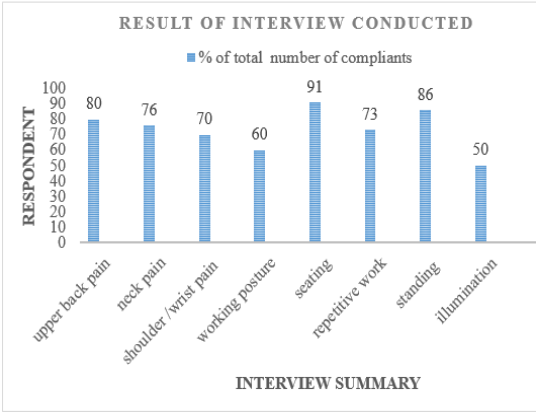
Table 1. Summary of the results from the sewing sections using the REBA and RULA assessment worksheets

Reba Score	Number of Photo	% Score	Rula Score	Number of Photo	% 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	

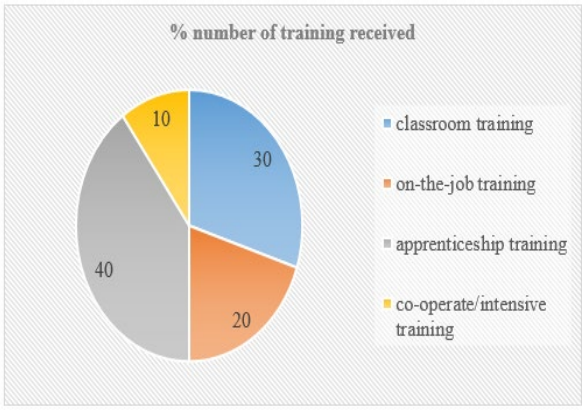
As can be observed from Plate 1, operators engage in repetitive tasks without ergonomic workstations. This leads to physical discomfort and comfortably explains upper back pain reported by some workers. In addition, chairs lack adjustability, forcing uncomfortable postures on the workers. Limited space necessitated product stacking, leading to hunched positions. Elbow support is absent, causing arm fatigue. Inadequate lighting requires body bending to maintain intricate decorations. Research findings 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 (see Table 1**).**

5.1. Knowledge and integration of ergonomic principles

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, environmental assessments, including evaluations of lighting, temperature, and noise levels, were conducted at selected workstations. Figure 1 (a) displays the complaints of the sampled workers while Figure 1(b) present the training level of the selected workers.



A: Workers complaints



B: Percentage of Training

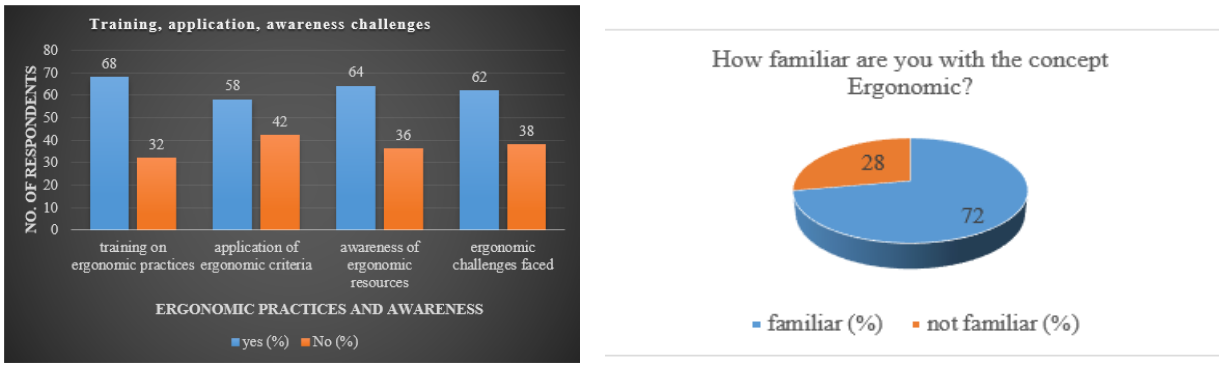
Figure 1. Complaints and Percentage of training received by workers in the studied clothing industry

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. 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 observed. This highlights 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.

5.1.2. 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. Figure 2 captures what was obtained in the places visited (Figure 2)



A B

Figure 2: A and B: Ergonomic practices, awareness, applicability and challenges of ergonomics in the studied workplaces

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.

5.2. Proposed improvement

Proposed improvements for the ergonomic framework enhancement in the clothing industry include adjustable workstation, ergonomic tools, focused and enhanced employees training, optimized workspace layouts, comfortable seating, regular break and a feedback loop. These measures can reduce strain, prevent injuries, and foster a healthier and more productive work environment.

5.3.Validation

To validate the proposed project of creating an ergonomic framework for the clothing industry's sustainability and cost-effectiveness, a comprehensive plan was outlined. This includes ergonomic interventions, worker feedback integration, performance monitoring, comparative analysis, and expert review, all aimed at validating the framework's practicality and alignment with industry standards. These steps were essential to ensuring the project's success and industry-wide applicability. As this study marks the initial exploration within this particular industry and location, further inquiry is necessary to validate these findings. Nonetheless, it’s evident that the workstation exhibits inadequate design, prompting an immediate need for broader -scale interventions.

6. Conclusion

This project successfully developed an ergonomic framework that balances sustainability and cost-effectiveness in the clothing industry in Nigeria. By employing diverse methodologies, including quantitative tools (RULA and REBA)

and qualitative approaches (observation, interviews, and surveys), it identified ergonomic risks and contextual intricacies in clothing production. The resulting framework prioritizes high-risk task interventions, improving workspace design and training programs, and embracing reduced-waste principles to optimize processes. Stakeholder commitment and ongoing adherence are vital for successful implementation in this evolving industry. This study underscores ergonomics' role in enhancing worker well-being, reducing absenteeism, and boosting productivity. It highlights the need for a trans-formative organizational culture shift and continual ergonomic attention, making it a potent catalyst for industry transformation.

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Biographies

Ms. Gracious Amarachukwu Nwafor graduated from the department of Mechanical Engineering, faculty of Engineering, university of Nigeria, Nsukka, Enugu state, Nigeria in 2023, with second class honours, upper division. She was a student member of Nigeria Society of Engineers (NSE) and Association of Professional Women Engineers of Nigeria (APWEN), where she is currently pursuing full registration as a graduate member. Ms. Nwafor bagged an Ordinary National Diploma (OND) degree from Federal Polytechnic Oko, Anambra state, Nigeria. She had her earlier studies at Iheorji Secondary School, Aba, Abia state where she obtained her west Africa examination council (WAEC) certificate with flying colours. Her hobby includes reading, tourism and research. Ms Nwafor's immediate focus is to advance her career in the area of energy systems and sustainability.

Paul Amaechi Ako (formerly Ozor) is currently an Associate Professor and Head, Department of Mechanical Engineering, University of Nigeria, Nsukka. He obtained a bachelor's degree in Mechanical/Production Engineering at Enugu State University of Science and Technology. He later specialized in Industrial Engineering and Management, and obtained both Masters and PhD in the field during 2008 and 2015 respectively from the University of Nigeria. Dr Ako had been a project manager of a reputable Engineering and Services company in Nigeria for over five years. He ventured into University Teaching and research career since 2009 and have published over eighty (80) research articles in peer reviewed local and international Journals and conference proceedings. Dr Ako is a scholar of the Association of Commonwealth Universities. He has won and completed the prestigious TWAS-NRF-DST postdoctoral fellowship to the University of Johannesburg, where he is currently a Senior Research Associate. He has visited several countries including Washington DC, USA, Lisbon, Portugal, Shanghai, China, Bangkok, Thailand, Agadir, Morocco, South Africa, etc, on research grounds. Furthermore, He has supervised significant national and international graduates and undergraduate students to successful study completion, and is still supervising local and international students. His research interests include Operations modelling, Quality management, Project Management, Systems Analysis, Asset Management, Environmental influence and Sustainability.

Professor Charles Mbohwa was a Pro Vice Chancellor of the University of Zimbabwe, Harare, Zimbabwe. He obtained B. Sc. Honours in Mechanical Engineering in 1986 from Department of Mechanical Engineering of the same University. He later bagged M. Sc. in Operations Management and Manufacturing Systems with a distinction in 1992, from Department of Manufacturing Systems Engineering, University of Nottingham, UK. He obtained PhD in Engineering (Production Systems focusing on Energy and life cycle assessment) from Tokyo Metropolitan Institute of Technology, Tokyo, Japan in 2004. Professor Mbohwa is an NRF-rated established researcher. In January 2012 he was confirmed as an established researcher making significant contribution to the developing fields of sustainability and life cycle assessment. In addition, he has produced high quality body of research work on Southern Africa. He is an active member of the United Nations Environment Programme/Society of Environmental, Toxicology and Chemistry Life Cycle Initiative, where he has served on many task-force teams. He has published over 1000 research articles in leading international Journals and Conference Proceedings. Prof Mbohwa had been keynote speaker in many international conferences and has supervised many local and international postgraduate students while playing host to several international postdoctoral fellows. He is a visiting Professor to the University of Johannesburg, South Africa, where he had served in various capacities; including Dean of Postgraduate Studies and Executive Dean of Faculty of Engineering and the Built Environment.