Grenze International Journal of Engineering and Technology, June Issue

Work-Related Musculoskeletal Disorders in the Packaging Industry: A Case Study on Corrugated Carton Box Workers

Bhavanapravanthika S[1], Gayathri P[2], Susvinth S[3], Srithar A[4], S. Yamuna Devi[5] and Dr. Dhipa [6]
[1-4, 6]Department of Biomedical Engineering, Nandha Engineering College, Erode, India
Email: srithar@nandhaengg.org
[5]Department of Biomedical Engineering, Velalar College of Engineering and Technology, Erode

***Abstract*—The corrugated carton box manufacturing sector is associated with musculoskeletal disorders (MSDs). This study examined the prevalence of MSDs in employees within the cardboard industry and pinpointed associated risk factors. It recommends that companies offer ergonomic equipment, train employees on correct lifting methods, and enhance workstation layouts to minimize MSD hazards. The research indicated that MSDs were prevalent, particularly impacting the neck, shoulders, back, and wrists. Factors that contributed included repetitive tasks, manual lifting, and inadequate workstation designs. A study involving 60 workers in Erode examined musculoskeletal symptoms and related factors. The analysis indicated that employees with MSDs suffered from fatigue, discomfort, and decreased productivity. The study emphasizes the importance of efficient management and ergonomic strategies to reduce MSD risks, suggesting these actions to improve employee safety and welfare.**

***Index Terms*— Corrugated Carton Box Industry, Data Analysis (SPSS & MATLAB), Ergonomic Interventions, IMU Sensors, Manual Lifting, Musculoskeletal Disorders (MSDs), Workstation Design.**

I. INTRODUCTION

Musculoskeletal disorders (MSDs) are a major occupational health issue in many industries, affecting workers' muscles, tendons, ligaments, nerves, and other soft tissues[1]. These conditions are especially common in the corrugated carton box sector, as the type of work significantly heightens the likelihood of injury[2]. Employees in this field often carry out repetitive tasks, lift heavy objects, and experience extended durations of manual labor, which heightens their risk of musculoskeletal disorders (MSDs)[3]. These activities may cause strain, discomfort, and potentially serious injuries impacting various areas of the musculoskeletal system, particularly the back, shoulders, wrists, and hands. This project seeks to carry out an extensive examination of the risks linked to MSDs in the corrugated carton box sector. Focusing on the unique difficulties encountered by employees in this sector, the research will examine the workplace conditions, the type of duties carried out, and the ergonomic elements that increase the likelihood of MSDs[4]. The goal is to pinpoint the main risk factors and create effective approaches to reduce these risks. Possible strategies could involve reconfiguring workstations to encourage improved posture, using mechanical devices to reduce manual lifting demands, and establishing

Grenze ID: 01.GIJET.11.2.506

training initiatives that teach safe handling practices[5]. Grasping the extent and contributing elements of MSDs in this sector is vital for creating targeted interventions. By tackling these challenges, the industry can elevate standards and practices, thus boosting well-being and productivity[6]. This analysis will offer insights into occupational health, aiding in the creation of safer and healthier workplaces[7]. Ultimately, by decreasing the occurrence of MSDs, the corrugated carton boxes can gain from a more involved and skilled workforce, resulting in higher overall productivity and fewer injuries and absences among workers[8].

II. METHODS

A. Study Design and Setting

The study was a cross-sectional survey conducted between June and November 2024 among workers in a corrugated carton box industry located in Erode, Tamil Nadu, India. The industry comprised nine carton box processing sections, including unloading paper bundles, sheet cutting, pasting, slotting, punching, sealing, bundling, loading, and corrugating machine operations. Workers were engaged in 8-hour shifts daily, providing a comprehensive view of occupational conditions across various stages of carton box production.

B. Study Population

The study focused on workers from a corrugated carton box industry in Erode, Tamil Nadu, across eight core departments: unloading paper bundles, sheet cutting, pasting, slotting, punching, sealing, bundling, and corrugating machine operations. These tasks represent the diverse and physically demanding stages of carton box production. Workers who did not provide informed consent or reported pre-existing musculoskeletal disorders (MSDs)—such as neck, back, wrist, arm, knee, shoulder, foot, or hip pain—were excluded to maintain the study's accuracy and reliability.

III. DATA COLLECTION AND PROCEDURES

A. Survey Questionnaire

In August 2024, a cross-sectional survey was carried out to evaluate the prevalence of musculoskeletal disorders (MSDs) among workers in the corrugated carton box industry in Erode. The data collection included a survey based on interviews and an assessment of MSDs with all qualified participants, offering important insights into occupational health hazards and ergonomic difficulties within this sector. A self-administered questionnaire was employed to collect data from 60 workers, ages 22 to 56. Prior to participation, the objectives and advantages of the study were clarified, and informed consent was acquired in their chosen language. The Research and Development Cell of Nandha Engineering College approved the study.

B. Assessment of Outcomes

In this study, we utilized direct observation alongside the Musculoskeletal Disorder Questionnaire (MDQ) as our primary research methodologies. The standardized MDQ was employed to collect data regarding the prevalence of musculoskeletal disorders (MSD), workplace conditions, and general participant characteristics to facilitate the analysis of musculoskeletal symptoms[9]. The survey consisted of three sections. The initial section is dedicated to gathering demographic information from participants, which includes age, height, weight, body mass index (BMI), marital status, smoking habits, educational background, work experience, and hours worked[10]. The second section investigates the musculoskeletal symptoms reported by respondents and delves into psychological factors and other health issues pertinent to MSD. This part of the questionnaire includes inquiries about the severity of pain experienced, utilizing a Likert scale to assess discomfort related to back pain, where 0 signifies "never," 1 represents severe pain, 2 indicates moderate pain, and 3 denotes mild pain[11]. Various unpleasant sensations, such as discomfort, pain, tingling, numbness, stiffness, swelling, temperature sensitivity, heaviness, and weakness, were taken into account when assessing MSD symptoms[12]. Furthermore, direct observation was conducted to document specific job durations, work postures, handling techniques, and associated risk factors. This additional information was gathered to ensure a thorough analysis of the workplace elements linked to MSD[13].

C. Statistical Analysis

The analysis uses the SPSS V20.0 software package to perform all statistical analysis, including the frequency distribution of respondents, the emergence of social psychological factors and the development of muscle disease[14]. It is used to assess descriptive statistics to assess population statistics, profession and health properties. These features include a history of health, gender, position, work experience and corrugated cardboard industry. This analysis assessed the prevalence of upper and lower limb MSDs across different sectors. This program developed specific definitions of upper and lower limb disorders. To determine the risk factors associated with each type of MSD, the upper and lower limb diseases were analyzed separately. This includes the effects of research factors such as increased frequency, repeated exercise, prolonged standing, or confusing, which causes the spread of each disease[15]. The results of the logical regression analysis will be explained to determine the importance of each independent variable size, predicting the possibility of upper and lower limb diseases[16]. These findings will provide information on targeted intervention measures and corrugated paper box industries and the development of human engineering improvement[17].

D. IMU sensor

The Inertial Measurement Unit (IMU) sensor plays a crucial role in recording motion-related data from workers in the cardboard manufacturing industry. It helps track body movements, posture, and repetitive actions involved in various tasks such as lifting, cutting, stacking, and operating machinery[18]. By analysing acceleration, angular velocity, and orientation, the IMU sensor provides valuable insights into the physical demands placed on workers, identifying potential ergonomic risks that could lead to musculoskeletal disorders (MSDs). This data allows for a thorough assessment of workload, helping to detect unsafe movements, fatigue, and overuse injuries[19]. Real-time monitoring ensures immediate intervention when hazardous postures are observed, contributing to injury prevention and workplace safety. Furthermore, the sensor aids in optimizing productivity by highlighting areas where ergonomic improvements can reduce strain and enhance worker comfort[20]. The recorded data supports research and workplace modifications, ultimately leading to improved occupational health standards and a safer working environment.

E. SPSS Software

In the cardboard manufacturing sector, the process of data collection utilizing IBM SPSS commences with the acquisition of pertinent information related to workers through various techniques, including surveys, interviews, biometric data, and machine logs[21]. The information is organized into categories such as demographic characteristics (age, gender, education, experience), work-related factors (job position, shift duration, production levels, machine operation), and health and safety documentation. Furthermore, productivity indicators, including defect rates and efficiency metrics, are also documented[22]. Data is gathered in organized formats, such as spreadsheets or databases, and subsequently imported into SPSS for advanced analysis[23]. The integrity of the data collection process is upheld through the application of validation methods, which minimize errors and ensure consistency in data entry. This systematic approach facilitates comprehensive workforce analysis and informed decision-making[24, 25].

IV. DATA PROCESSING AND ANALYSIS

A. Raw data from IMU Sensor

The raw data, in this case, collected using IMU sensors, present an analysis of the strains in the muscles of corrugated carton boxes-handling workers, where repetitive heavy lifting and probable musculoskeletal disorders could be expected. It would focus on major muscles engaged during such labor, particularly the biceps brachii (left and right), extensor carpi radialis (ECR, left and right), and the trapezius (right). The study evaluates muscle activity under three distinct assistive conditions: work- sharing, the use of trolleys, and hydraulic equipment for load handling. These aids are introduced to mitigate physical strain and reduce injury risks. The data, containing inherent noise due to sensor limitations and environmental factors, undergoes preprocessing in MATLAB to remove noise through advanced filtering techniques. This refined data is possible to calculate the exact values of root mean square, which are quantitative expressions for levels of muscle activity and strain. The research is based on the measurement and comparison of the performance of such assistive devices to lighten the load of the muscle and improve the conditions of the workplace for employees. From an understanding of strain-reducing patterns, this work contributes to safer and efficient work practice, contributing indirectly to improvements in occupational health and productivity in the industry**.** Fig 1 Represents the raw data signal from IMU sensor.

B. Muscle Strain Analysis

Without Aids -The graph reflects an analysis of muscle strains acquired by processing the sensor data obtained from the IMU and represents the biceps brachii (BB-L and BB-R), extensor carpi radialis (ECR-L and ECR-R), and trapezius (TRAPEZIUS-R) muscles under four different work conditions: no aid, trolley aid, hydraulic aid, and both aids. The "Without Aid" condition has the highest strain levels, particularly on the ECR-R muscle, which peaks at about 250 units, indicating a high level of physical stress and injury risk. The use of a trolley

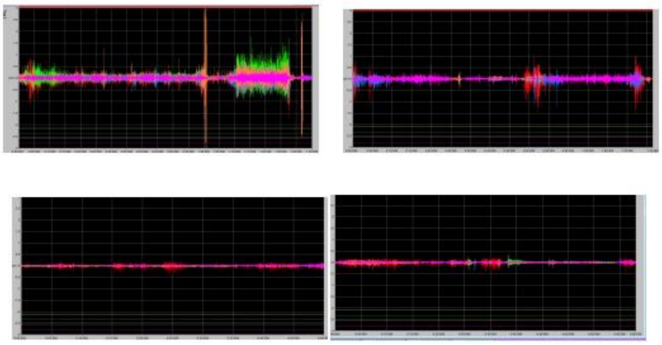

Fig 1. Raw data from IMU sensor

moderately reduces strain, while hydraulic aid provides further relief, especially for muscles like the trapezius and biceps brachii. The "Combined Aid" scenario shows the greatest muscle strain reduction across all muscles tested, so the integration of multiple assistive tools probably offers the best ergonomic approach. MATLAB was useful to filter out noise from raw IMU data, in calculating RMS values to gauge muscle strain, and also in creating visual plots like the one below for easy comparisons. Thus, findings establish the significance of assistive technologies in reducing muscle strain during labor-intensive tasks, ensuring better worker safety and health and better efficiency. **Fig 2** By application of sensor observes the strain during work environment.

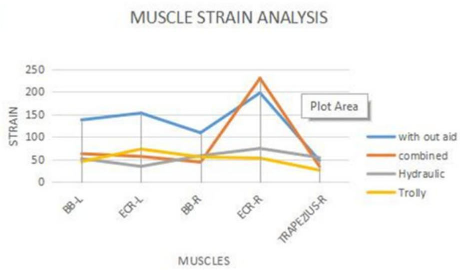

Fig 2. Muscle strain analysis for subject 1

Combined Aids-The graph shows the muscle strain analysis results obtained from raw IMU sensor data processed and analyzed in MATLAB, highlighting key muscles: biceps brachii (BB-L and BB-R), extensor carpi radialis (ECR-L and ECR-R), and trapezius (TRAPEZIUS-R) at different working conditions: no aid, trolley, hydraulic aids, and combining aids. In the "Without Aid" condition, as represented by the blue line, the strain is at its highest across all muscles, especially on the ECR-R muscle, peaking at 250 units, which reflects considerable stress and a potential for musculoskeletal injuries. Using a trolley, represented by the orange line, is effective in reducing strain as compared to working without aid; however, the strain remains higher than in the case of hydraulic or combined aid. Hydraulic support (gray line) reduces the strain on the muscles more significantly, especially on ECR-R and trapezius muscles, although it is not uniform over all muscles. The "Combined Support" case (yellow line) shows the maximum reduction in muscle strain on all measured muscles, pointing to the ergonomic benefits of combining several assistive devices. In the analysis, MATLAB played an important role in preprocessing raw sensor data to remove noise and calculate root mean square (RMS) values to quantify strain. The visualizations that have been generated, as in this graph, are helpful for making detailed comparisons. The findings highlight the use of assistive technologies to reduce muscle strain and improve worker safety and productivity in labor-intensive industries, such as the carton box handling sector. **Fig 3** Analysis of strain after implementation of combined support.

V. RESULT

The bar graph titled **"LOADING WORK vs. PAIN"** vividly illustrates the physical toll loading work takes on different body parts. It reveals that the shoulders endure the highest strain, with nearly 90% of individuals reporting discomfort, likely due to tasks involving lifting, overhead movements, and carrying heavy loads. Back pain ranks second at around 70%, often resulting from bending, twisting, or improper lifting techniques, while hip pain follows closely at approximately 60%, possibly caused by prolonged standing and uneven weight distribution. Moderate pain levels are observed in the neck, arm, and knee, ranging between 40% and 60%,

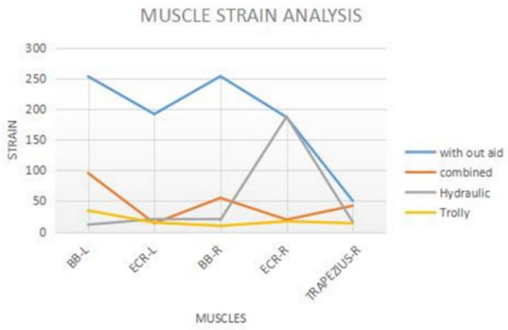

Fig 3. Muscle strain analysis for subject 2

indicating the significant strain from repetitive motions or poor ergonomics. Foot pain, although the least reported at below 30%, still highlights the impact of prolonged standing or unsuitable footwear. The graph underscores the urgent need for ergonomic solutions, proper lifting techniques, and preventive measures to reduce physical strain and enhance workplace safety for those engaged in physically demanding tasks. **Fig 4** Progress that shows the shoulder pain raises high during work.

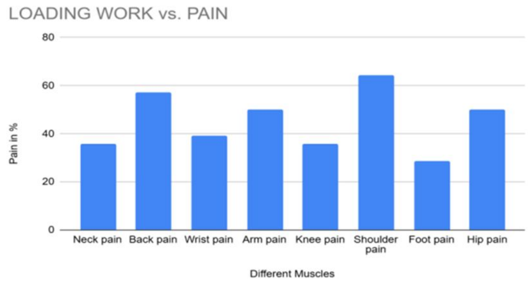

Fig 4. Loading work vs Pain

The **Fig 5** shows a person manually lifting cardboard cartons without ergonomic aids, which can cause muscle strain. IMU sensors are used to collect data by placing electrodes on five key muscle regions: the left and right biceps brachii (BB-L, BB-R), extensor carpi radialis (ECR-L, ECR-R), and trapezius muscle. This setup helps analyze muscle activity, providing insights for ergonomic improvements and injury prevention in physically demanding tasks.

Fig 5. Subject lifting the load without aid (Trolley)

The **Fig 6** shows a person lifting a stack of cardboard cartons using an aid, specifically a trolley, to assist in material handling. This setup contrasts with tasks performed manually without support. The use of such equipment significantly reduces the physical strain on the body, improving both efficiency and ergonomics during lifting activities.In this scenario, the muscular effort is monitored using an Inertial Measurement Unit (IMU) sensor system, with electrodes strategically placed on five key muscle regions: the left and right biceps brachii (BB-L, BB-R), the left and right extensor carpi radialis (ECR-L, ECR-R), and the trapezius muscle. Data collected during this activity is expected to show lighter changes in muscle activity compared to previous scenarios without a lifting aid. The reduced load-bearing requirement when using the trolley alleviates stress on major muscle groups, highlighting the ergonomic benefits of material handling aids. Such findings are valuable for designing safer and more efficient work environments by demonstrating the importance of supportive tools in minimizing physical exertion and reducing injury risks.

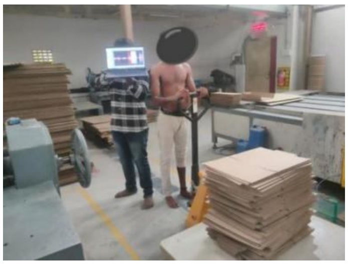

Fig 6. By operating trolley reduces the work load

Fig 7, a subject is seen lifting a cardboard carton box with the assistance of another individual, indicating a shared workload. The lifting activity is being monitored, and the raw data of muscle activity will be measured using an Inertial Measurement Unit (IMU) sensor. To analyze the muscle engagement during this task, electrodes are strategically placed on five major muscle regions: **BB-L (Biceps Brachii - Left), ECR-L (Extensor Carpi Radialis - Left), BB-R (Biceps Brachii - Right), ECR-R (Extensor Carpi Radialis - Right), and Trapezius muscle**. The IMU sensor will capture the movement dynamics, while the electrodes will record electrical muscle activity during the lifting process. The collected data will then be processed, and a graphical representation will be generated. Compared to the previous data set, the new graph will show minor variations, indicating slight changes in muscle activity levels. This analysis will help in understanding muscle strain distribution, workload sharing efficiency, and potential ergonomic improvements in manual lifting tasks.

Fig 7. Load carried out by combined support without aid

The **Fig 8**, a subject is seen lifting and transporting a stack of cardboard carton boxes using a hydraulic trolley. This setup indicates an assisted lifting method, reducing the direct strain on the muscles compared to manual lifting. The movement and muscle activity during this task are being monitored, and the raw data will be recorded using an Inertial Measurement Unit (IMU) sensor. To analyze the muscle engagement while handling the trolley, electrodes are strategically placed on five major muscle regions: **BB-L (Biceps Brachii - Left), ECR-L (Extensor Carpi Radialis - Left), BB-R (Biceps Brachii - Right), ECR-R (Extensor Carpi Radialis - Right), and the Trapezius muscle**. The IMU sensor captures movement dynamics, while the electrodes measure electrical muscle activity during the task. The collected data will be processed to generate a graphical representation, which will then be compared with previous datasets. Since the lifting process here involves trolley assistance rather than direct manual handling, the graph is expected to show slight variations in muscle activity levels. These changes can help in understanding how assisted lifting techniques impact muscle load distribution and efficiency in reducing physical strain.

VI. DISCUSSION

The discussion of this research on musculoskeletal disorders (MSDs) in the corrugated carton box industry highlights the urgent need for ergonomic workplace interventions to reduce health risks and improve worker conditions. The study identified repetitive tasks, manual lifting, and poorly designed workstations as key factors contributing to MSDs, primarily affecting the neck, back, shoulders, and wrists. Using IMU sensors, researchers observed significant muscle strain, particularly in the extensor carpi radialis and trapezius muscles, when tasks were performed without assistance. The introduction of ergonomic tools, such as trolleys, hydraulic equipment,

Fig 8. Combined support of subject handling with aid(Trolley)

and combined aids, substantially reduced muscle strain. The combined aid scenario proved the most effective, delivering the greatest relief across all tested muscles and demonstrating its superior ergonomic benefits. These findings underscore the importance of assistive technologies in reducing physical effort, lowering injury risks, and enhancing productivity. Statistical analysis using SPSS confirmed a strong relationship between job demands and the prevalence of MSDs. The research advocates for industry-wide changes, including workstation redesign, training on proper lifting techniques, and the adoption of assistive devices, to enhance worker safety and well-being. The study concludes that comprehensive ergonomic strategies are essential for creating safer, healthier, and more productive environments in labor-intensive industries such as corrugated carton box manufacturing.

VII. CONCLUSION

This research underscores the high prevalence of musculoskeletal disorders (MSDs) among workers in the corrugated carton box industry, with the neck, shoulders, back, and wrists being the most affected areas. A cross-sectional study involving 60 employees in Erode identified key factors contributing to MSDs, such as repetitive tasks, manual lifting, and poorly designed workstation layouts. Data collected through self-administered questionnaires and IMU sensors revealed that muscle strain was most significant in the biceps brachii, extensor carpi radialis, and trapezius muscles when no ergonomic aids were used. However, the implementation of assistive tools, such as trolleys and hydraulic equipment, resulted in a marked reduction in physical strain and improved work efficiency, with combined aids providing the greatest relief. SPSS analysis highlighted a clear connection between ergonomic risks and decreased productivity, while MATLAB processing confirmed the effectiveness of strategies for reducing muscle strain. These findings emphasize the need for ergonomic improvements, including optimized workstation designs, mechanical load-handling tools, and employee training on safe practices. Such interventions are essential to creating a healthier and safer work environment, reducing the prevalence of MSDs, and boosting productivity within the industry.

ACKNOWLEDGMENT

We would like to thank **Kongu Engineering College**, Department of Mechatronics, for giving us the opportunity to do this project. We are grateful to our staff members for their support and guidance throughout the work. We also sincerely thank **Sri Saisuka Anishteque** company for providing us with the chance to work on this project and gain valuable practical experience. Lastly, we appreciate the efforts and cooperation of our team members in completing this project successfully.

REFERENCES

[1] Greggi, C., et al., Work-related musculoskeletal isorders: a systematic review and meta-analysis. Journal of Clinical Medicine, 2024. 13(13): p. 3964.

[2] Liu, L. and F. Guo, *Workers' subjective discomfort, muscle fatigue, and kinematics during a manual packaging task.* Work, 2022. **73**(3): p. 871-879.

[3] Mishra, S. and K. Sarkar, *Work-related musculoskeletal disorders and associated risk factors among urban metropolitan hairdressers in India.* Journal of occupational health, 2021. **63**(1): p. e12200.

[4] Kulkarni, M.S. and F.F. Shaikh, *Work-related Musculoskeletal Disorders and Health-Related Quality of Life Among Corrugated Box Factory Workers in India.* Indian Journal of Occupational and Environmental Medicine, 2024. **28**(1): p. 61-64.

[5] Contreras-Valenzuela, M.R. and C.A. Martínez-Ibanez, *Hierarchical clustering analysis of musculoskeletal stress factors and their risk level in cardboard manufacturing: research from PLIBEL.* Journal of Occupational Health, 2024. **66**(1): p. uiae008.
[6] Brandl, C., et al., *Comparing risk assessment methods for work-related musculoskeletal disorders with in vivo joint loads during manual materials handling.* Scientific Reports, 2024. **14**(1): p. 6041.
[7] Hilmi, A.H., A.R.A. Hamid, and W.A.R.A.W. Ibrahim, *Recent Advances in Ergonomic Posture Research: Assessing Innovations in Occupational Health and Musculoskeletal Disorder Prevention.* Malaysian Journal of Ergonomics (MJEr), 2024. **6**: p. 76-89.
[8] Handoyo, J., W.W. Basuki, and R. Sukwadi, *Implementation of health safety and environment engineering risk management in corrugated carton box companies.* Saudi J Eng Technol, 2022. **7**(7): p. 348-352.
[9] Poochada, W. and S. Chailklieng, *Self-reported musculoskeletal disorders questionnaire for agriculturists: An online self-assessment tool development.* Plos one, 2022. **17**(12): p. e0277548.
[10] Dogan, S.K., et al., *The utility of faces pain scale in a chronic musculoskeletal pain model.* Pain Medicine, 2012. **13**(1): p. 125-130.
[11] Michaleff, Z.A., et al., *Measuring musculoskeletal pain in infants, children, and adolescents.* Journal of Orthopaedic & Sports Physical Therapy, 2017. **47**(10): p. 712-730.
[12] Krishnan, K.S., G. Raju, and O. Shawkataly, *Prevalence of work-related musculoskeletal disorders: Psychological and physical risk factors.* International journal of environmental research and public health, 2021. **18**(17): p. 9361.
[13] Uchenna, O., K. Lawani, and B. Hare. *Whole-body assessment tool for musculoskeletal disorders risk factors among road construction workers.* in *2024 People in Construction (W123) and Safety, Health, and Wellbeing in Construction (W099) International Conference: Harmony in Global Construction Trends: People, Technology and Society*. 2024. CIB.
[14] Cao, M., et al., *Effects of low-volume functional and running high-intensity interval training on physical fitness in young adults with overweight/obesity.* Frontiers in Physiology, 2024. **15**: p. 1325403.
[15] Jin, X., et al., *Prevalence and associated factors of lower extremity musculoskeletal disorders among manufacturing workers: a cross-sectional study in China.* BMJ open, 2022. **12**(2): p. e054969.
[16] Santos, C., et al., *Risk factors, symptoms, and prevalence of lower limb work-related musculoskeletal disorders among orthopedic surgeons.* International Journal of Industrial Ergonomics, 2024. **101**: p. 103597.
[17] Donisi, L., et al., *A logistic regression model for biomechanical risk classification in lifting tasks.* Diagnostics, 2022. **12**(11): p. 2624.
[18] Lindqvist, J., *A participatory approach to eliminating Musculoskeletal disorder risk factors in a paper industry workflow: Developing an assisting tool for paper industry workers by exploring work tasks through participatory design activities*. 2024.
[19] Motta, F., et al., *The Use of Wearable Systems for Assessing Work-Related Risks Related to the Musculoskeletal System—A Systematic Review.* International Journal of Environmental Research and Public Health, 2024. **21**(12): p. 1567.
[20] Rahman, M.H., et al., *Predictive health analysis in industry 5.0: A scientometric and systematic review of motion capture in construction.* Digital Engineering, 2024: p. 100002.
[21] Baklouti, S., et al., *A Novel IMU-Based System for Work-Related Musculoskeletal Disorders Risk Assessment.* Sensors, 2024. **24**(11): p. 3419.
[22] Fiandini, M., et al., *How to calculate statistics for significant difference test using SPSS: Understanding students comprehension on the concept of steam engines as power plant.* Indonesian Journal of Science and Technology, 2024. **9**(1): p. 45-108.
[23] Keraga, M.N., H. Lööf, and A. Stephan, *Innovation and employment in sub-Saharan Africa: New evidence from the World Bank Enterprise Survey*. 2024, Royal Institute of Technology, CESIS-Centre of Excellence for Science and ….
[24] Zou, L., et al., *Measuring Corporate Digital Transformation: Methodology, Indicators and Applications.* Sustainability, 2024. **16**(10): p. 4087.
[25] Ullagaddi, P., *Digital transformation strategies to strengthen quality and data integrity in pharma.* International Journal of Business and Management, 2024. **19**(5): p. 16-26.