An Ergonomic Analysis of Working Posture of Selected Brick Kiln Workers using Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA) Method

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Abstract

Musculoskeletal Disorders (MSDs) represent a predominant occupational hazard within the global brick kiln industry. Poor working posture is one of the primary causes of musculoskeletal injuries in the workplace. This research is intended to investigate the working postures of brick-kiln workers and systematically evaluate the associated risk of injury. Digging, mud transferring, mixing clay, molding, and loading are the five main procedures that were considered to examine the working postures. Pictures of the various working processes were obtained using a portable camera. Two assessment tools RULA (Rapid Upper Limb Assessment) and REBA (Rapid Entire Body Assessment) were used to assess the ergonomic risks associated with brick-making processes. The results from this study identified digging, clay mixing, manual molding, and loading operations as high-risk operations due to the prevalent disregard for optimal working postures. In summation, this research underscores the pressing issue of musculoskeletal disorders in the brick kiln sector, primarily caused by suboptimal working postures. Carefully implementing RULA and REBA assessment tools has revealed specific duties with elevated injury risks. This research urges the consistent adoption of proper ergonomic postures by brick kiln workers, thus enhancing workplace safety and overall occupational well-being.

Keywords
Musculoskeletal Disorders (MSDs), RULA, REBA, Brick kilns.

1. Introduction
Bangladesh has about 6,000 authorized brickfields and numerous illegal ones which collectively manufacture approximately 23 billion bricks annually(Saha and Rahman 2013). This thriving industry contributes around 1% to the country's GDP and provides employment opportunities for over a million individuals. Considering Bangladesh's population of 159.9 million and its current growth rate, an estimated 4 million new houses will need to be built each year to meet the housing demands of the growing populace, further propelling the growth of the brick sector (Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants 2017). In this industry, most of the workers are uneducated. Moreover, there is a serious lack of proper professional training and awareness regarding safe and healthy work practices (Sain and Meena 2018). Working in adverse conditions results in various health issues and musculoskeletal disorders (MSDs) among brick kiln workers (Sain and Meena 2018).

The brick industry typically entails a lot of manual labor and physically demanding activities. Although automation and other technology have decreased the amount of physical labor, manual labor tasks are still customary and frequently required in brick manufacturing processes. Numerous brick production chores such as clay preparation, manual molding, firing, cooling, etc. are frequently performed in hazardous and unmanaged environments, which increases the risk of accidents, illnesses, and fatalities, especially those connected to musculoskeletal disorders (MSDs). This study focuses on brick field workers to analyze the most problematic working postures in brick-making processes and identify the risk level of the respective process.

1.1 Objectives

The objective of this study is to analyze the musculoskeletal disorders based on the RULA-REBA method of workers of selected brick industries in Sylhet, Bangladesh, and to find out and analyze the most problematic postures associated with the prevalence of musculoskeletal disorders during the operations (clay preparation, Manual Molding, clay mixing, mud transferring, and loading of bricks) of brick making process.

2. Literature Review

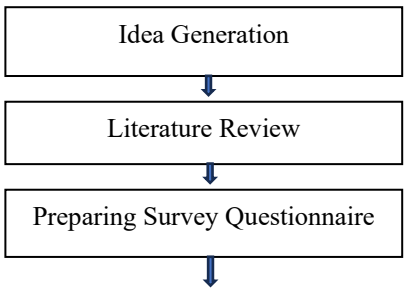
Previously published papers and articles on a particular subject play a crucial role in identifying important issues and proposing potential explanations. They serve as valuable guides for defining research problems, informing the selection of research methods, and shaping the interpretation of results. Research always builds upon the foundation laid by earlier studies, advancing incrementally, even if it's just a small step, toward addressing problems and answering questions. Therefore, researchers must stay informed about the most recent discoveries and findings.

F.C. Trevelyan and R.A. Haslam (2000) conducted research to identify musculoskeletal disorders in a handmade brick factory. They concluded that over 50% of molders reported discomfort with the elbow, wrist, lower back, and legs. They also said that the truck loading task element needs to be modified to reduce the load handled and improve wrist/hand posture. Amar Kundu et al. (2019) investigated the work posture in mud-transfer (Brick-making industry) activity to reduce musculoskeletal disorders in associated muscles and pain in different body joints. They found that workers mostly had wrist, shoulder, and thigh pain and suffered average-to-moderate levels. Banibrata Das (2019) researched to estimate the different ergonomic risk factors associated with brick making, identify potential gender differences and the prevalence of Work-related musculoskeletal disorders (WMSDs), and psychological stress among brickfield workers. He concluded that both groups of brickfield workers (male and female) suffered from discomfort or pain in different parts of their bodies – specifically in the lower back region.

Wahyu Sidiq Saputra, and Trio Yonathan Teja Kusuma (2020) researched to analyze the activity of material handling work by using Rapid Entire Body Assessment and Rapid Upper Limb Assessment approaches and create a design proposal by using 5-Step Method of Concept Designing to design working aids. They proposed some new tools to reduce lower back pain. They concluded that Brickfield workers mainly suffered from lower back pain. Most of the research works have been conducted on the analysis of working posture & musculoskeletal disorders (MSD) in Brickfield workers involved with several types of operations (clay preparation, molding, mud-transfer, heating) by various researchers around the world and the researchers used more than two techniques (RULA REBA, OWAS, NBM) in their research work. No research works have been conducted on the analysis of working postures in each step of making bricks for the development of musculoskeletal disorders in workers who are involved with the brick manufacturing factory in Sylhet, Bangladesh using the RULA-REBA Method.

3. Methodology

An action plan was developed to ensure a logical and sequential progression throughout the study. The stages involved in this study are described in Figure 1. The decision was made to investigate the working postures and associated risk levels using RULA and REBA methods. As previously mentioned, some research papers on musculoskeletal disorders, working postures, and workers were reviewed.



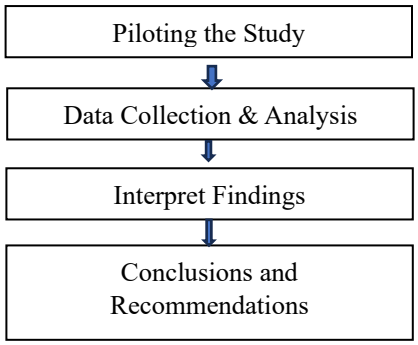


Figure 1. Action Plan of the Study

3.1 Tools and Techniques (Rula and Reba)

The Rapid Upper Limb Assessment (RULA) is a valuable tool for promptly evaluating the impact of postures on the musculoskeletal system, encompassing the neck, trunk, and upper limbs, as well as muscle function and external loads. Similarly, the Rapid Entire Body Assessment (REBA) technique serves as a postural analysis system with heightened sensitivity to musculoskeletal risks across various tasks, particularly in the healthcare and service industries. According to Dohyung Kee's research in 2022, RULA and REBA are particularly well-suited for analyzing postures and their connection to Musculoskeletal Disorders (MSDs). In this study, both RULA and REBA techniques will be applied to assess the postures utilized in problematic activities within brick production.

4. Data Collection

Slovin's formula offers a method for estimating the required sample size in random sampling techniques. By considering the population size and the desired margin of error, researchers can determine an appropriate sample size to obtain accurate results. This formula enables researchers to confidently select a sample that represents the larger population accurately and ensures the validity of their findings.

Slovin's formula is written as follows:

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

Where, n = Sample size, N = Total population, e = Error tolerance level.

In this study, Slovin's formula is used to determine the sample size from the total number of brick-making workers (approx. 350) of the four selected brick-making plants in Sylhet, Bangladesh. Let's consider the level of confidence of this study to be 95 percent and the value of e will be 0.05. So, by calculating and rounding to a whole number, the sample size is found to be 187. It means that 187 respondents need to be selected for data collection from the survey questionnaire.

5. Results and Discussion

For this cross-sectional study, five different operations of the brick manufacturing process were analyzed, namely digging, mud transferring, clay mixing, manual molding, and loading process of bricks. Percentages of different musculoskeletal effects for different operations of brickmaking were plotted using Microsoft Excel.

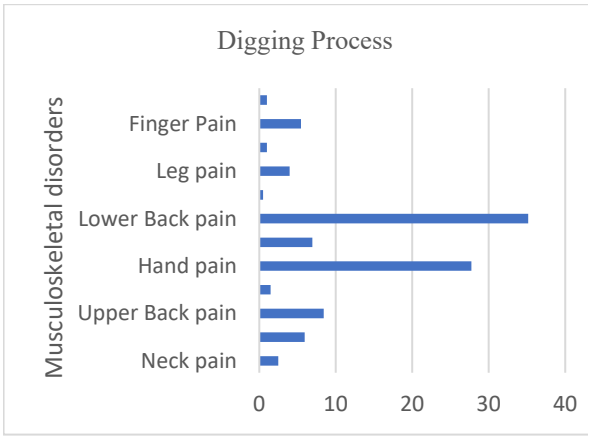


Figure 2. MSDs in Digging Process

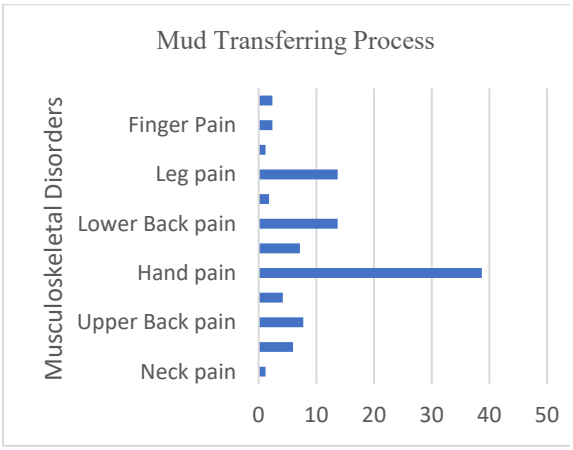


Figure 3. MSDs in Mud Transferring Process

Figure 2 shows that among 187 participants of digging operation, 35.5% of them experienced lower back pain and 28% of them experienced pain in their hands. From figure 3, it is seen that 38.8% of workers experienced hand pain and 13.69% of workers experienced both lower back pain and leg pain while transferring mud from the clay preparation section to the manual molding section.

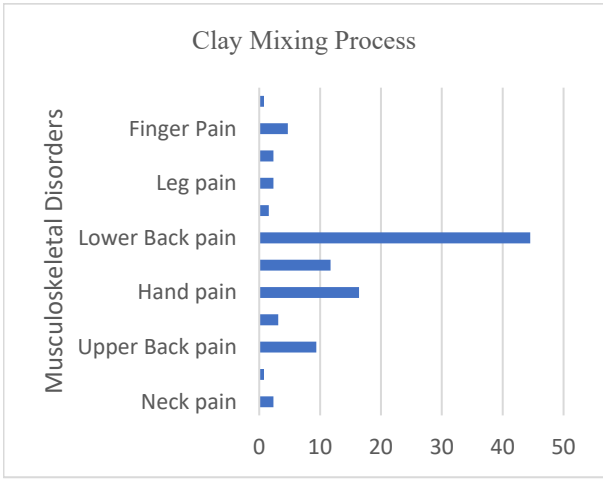


Figure 4. MSDs in Clay Mixing Process

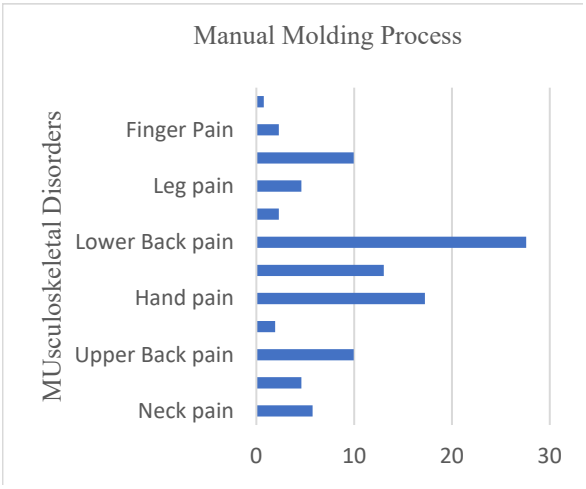


Figure 5. MSDs in Manual molding Process

Figure 4 concludes that the most prevalent pains during mixing raw mud with water were lower back pain (44.53%) which was followed by hand pain (16.40%). Figure 5 explains that among 187 participants of the molding operation, 27.58% of them experienced lower back pain, and 17.24% of them experienced hand pain.

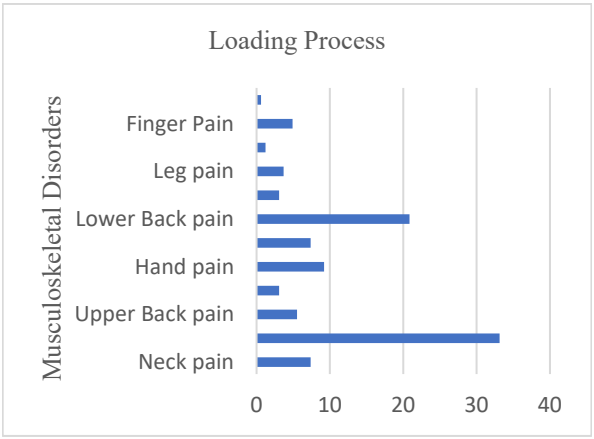


Figure 6. MSDs in loading process of bricks.

Figure 6 explains that among 187 participants in loading operations, 33.12% experienced shoulder pain, and 20.85% experienced lower back pain. The most prevalent pains in this section were shoulder pain which was followed by lower back pain and upper back pain respectively according to Figure 6.

5.1 Rula and Reba Assessment

Pictures of different working postures were collected from four selected brick-making plants using a portable camera under the supervision of an ergonomist as shown in Figure 7. To ensure accuracy, images were captured from multiple frames and angles. The working postures of 15 participants for each process were documented to assess the RULA and REBA scores. According to the grand score of RULA and REBA scoring sheet, work posture is assessed whether it is appropriate or further investigation is needed for changing the posture based on the recommendation shown in Table 1.

Table 1. Recommendations of RULA and REBA Assessment (Kibria 2023).

Method	Grand Score	Risk level	Risk status	Score Meaning (Recommendation)
Rula	1-2	1	Negligible risk	Posture is acceptable
	3-4	2	Low risk	Further investigation is needed, change may be needed
	5-6	3	Medium risk	Further investigation is needed, change is needed soon
	7	4	Very high risk	Investigation is needed to implement change soon
Reba	1	1	Negligible risk	No action required
	2-3	2	Low risk	Change may be needed
	4-7	3	Medium risk	Further investigation is needed, change soon
	8-10	4	High risk	Need implement change after investigation
	11+	5	Very high risk	Investigate and change immediately

Figure 7(a) : Digging process.

Figure 7(b) : Clay mixing process.

Figure 7(c) :Mud Transferring Process .

Figure 7(d) :Manual molding process.

Figure 7(e) :Brick loading Process .

Figure 7. Different working postures of each process

5.1.1 Rula Assessment

Within the framework of RULA analysis, an assessment was conducted to examine the positioning of workers' upper arms, lower arms, wrists, and wrist rotation. Additionally, evaluations were made regarding the postures of their necks, trunks, and legs, and these were assigned scores following the RULA analysis method. Furthermore, their working postures were assessed using the RULA scoring sheet, and based on the results, all these workers have been classified into various risk levels as outlined in Table 1.

The results of the RULA assessment, as depicted in Figure 8, highlight that clay-mixing process workers face the highest risk level among all brick field workers. Specifically, 86.67% of manual clay mixing process workers fell into the level 4 risk category. Moreover, 80% of workers involved in the digging and loading processes also shared this elevated risk level. Furthermore, 6.67% of mud transferring workers, and 6.67% of manual molding workers were also identified as being at level 4 risk, underscoring the urgent need for investigations and potential changes to prevent musculoskeletal disorders (MSDs).

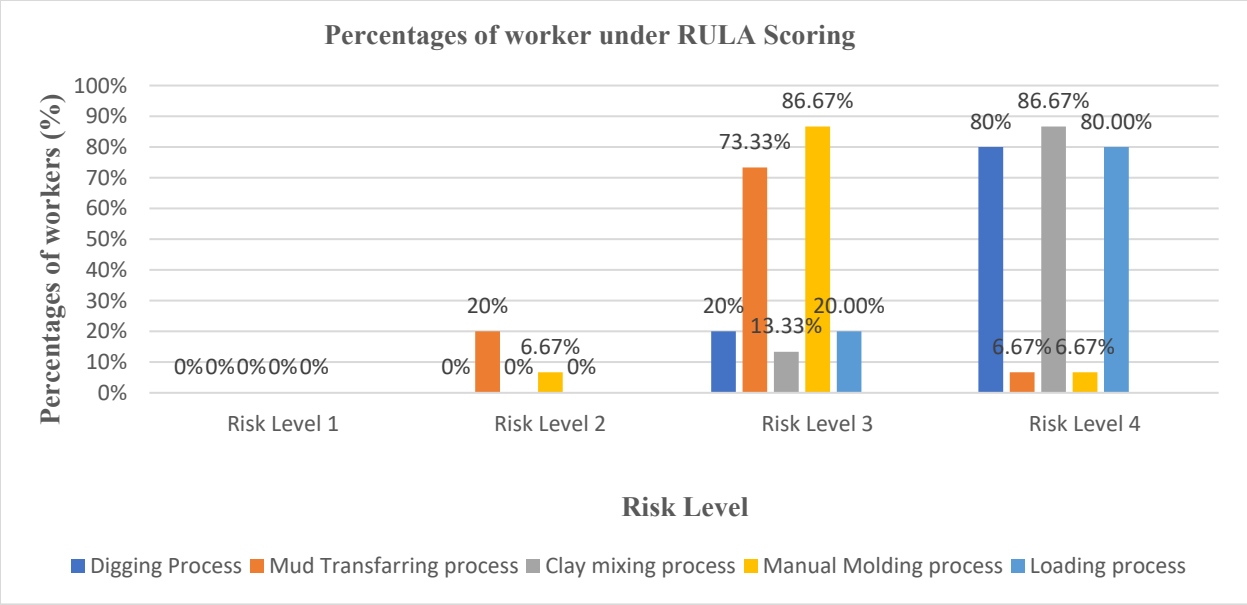


Figure 8 . Percentages of Brick kilns workers under RULA Scoring.

Additionally, 86.67% of manual molding workers, 73.33% of mud transferring workers, and 20% of loading process workers were categorized in the level 3 risk region, suggesting the necessity for further posture analysis to avert unforeseen MSDs. Furthermore, 20% of mud-transferring workers were found to be at level 2 risk for injury, warranting attention to mitigate their risk.

5.1.2 Reba Assessment

The Rapid Entire Body Assessment (REBA) is a biomechanical assessment instrument employed to appraise and assign scores to the degree of musculoskeletal risk linked to particular job assignments. It scrutinizes the bodily stances during various phases of these tasks, examining angles and orientations of body segments, encompassing the head, neck, trunk, arms, and legs. The assessment of working postures was conducted using the REBA scoring sheet, and subsequently, these workers have been classified in accordance with the risk levels established by Table 1.

The findings from the REBA assessment indicate that specific tasks carried significant musculoskeletal risks:

- Digging (27%), mud transferring (13%), clay mixing (13%), manual molding (33%), and loading (40%) were identified as being at an exceedingly high-risk level, falling within the level 5 risk region, as depicted in Figure 9.

- Furthermore, 60% of those involved in digging, 80% of mud transferring, 67% of clay mixing, 53% of manual molding, and 60% of loading workers were assessed to have a risk level of 4 according to REBA analysis. Risk level 4 signifies a high risk necessitating further examination.
- Notably, workers engaged in clay mixing and manual molding exhibited the highest risk of injury compared to their counterparts in other roles. Importantly, it's evident that clay mixing, and manual molding tasks present the most concerning risk levels compared to other work activities. Based on these findings, immediate attention and action are required to address the ergonomic concerns associated with these tasks and ensure the safety and well-being of the workers involved.

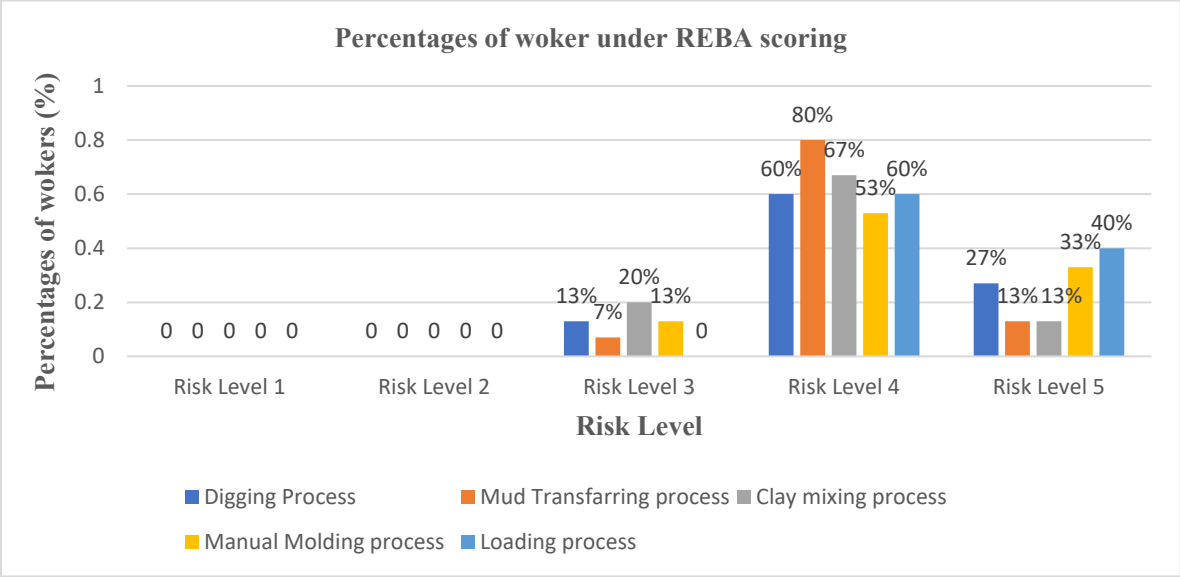


Figure 9 . Percentages of Brick kilns workers under REBA Scoring.

5.2 Comparison of RULA and REBA Assessment

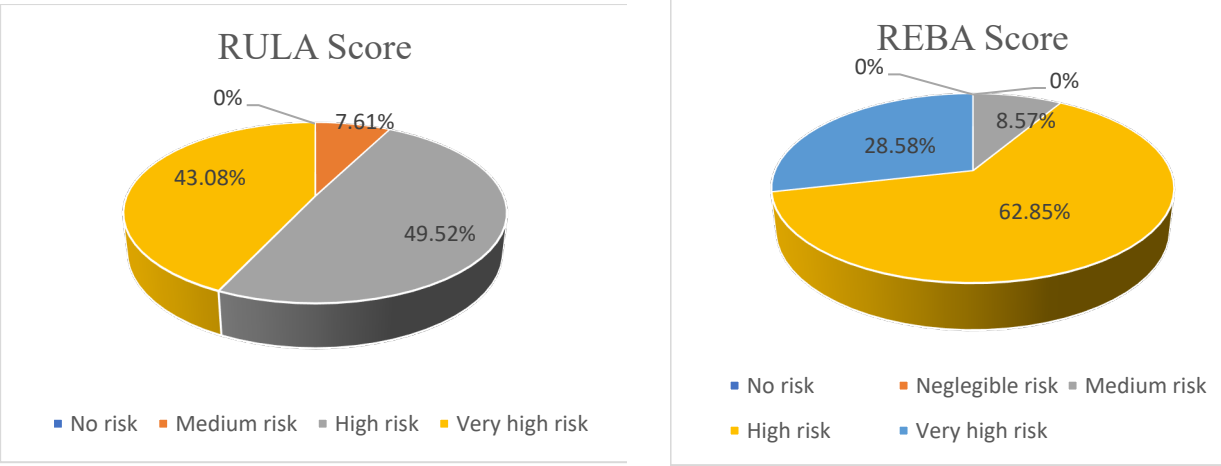


Figure 10. Comparison of RULA and REBA score.

Figure 10 presents the distribution of laborers across varying risk levels as discerned through the analysis of RULA and REBA scores. The RULA score denoted that 49.52% of the workforce exhibited work postures classified as high-risk, thereby underscoring the imperative for expeditious investigation and subsequent adjustments in posture. Furthermore, an alarming 43.08% of employees were ascertained to be at an elevated risk, warranting immediate interventions in posture to mitigate the likelihood of injury. Conversely, a mere 7.61% of personnel were exposed to a moderate level of risk attributable to suboptimal work postures.

Conversely, the REBA assessment methodology pinpointed unnatural postures and excessive repetitive movements in the arm, wrist, and elbow regions as contributory factors to reported injuries. In accordance with the REBA assessment, an overwhelming 62.85% of the workforce was categorized as harboring a high risk of developing Musculoskeletal Disorders (MSDs), while 28.58% of individuals were found to be susceptible to a very high risk of MSDs owing to their precarious work postures. To summarize, both assessment modalities yielded congruent results, underscoring the prevalence of unsatisfactory work postures among the majority of laborers.

The findings of this research can be summarized as: Hand pain was the highest reported pain during mud transferring (38.8%) and hand pain was the 2nd highest reported pain during digging process (28%) and clay mixing process (17.24%). Lower back pain was the highest reported pain during digging (35.5%), clay mixing (44.53%), manual molding (27.58%) process. The tasks of digging, manual molding, and clay mixing are the most concerning and high-risk activities, with RULA scores of 7, 6, and 7, respectively. Additionally, these tasks have REBA scores ranging from 8 to 10, , indicating a high level of risk. It is crucial to promptly investigate these issues and take necessary steps to lower the risk levels of RULA and REBA.

6. Conclusion

Bangladesh is the world's fourth-largest brick producer. More than 1 million people are working in different brick plants. In ten years, the number of brick kilns will probably rise by 2 to 3 percent due to population growth(Saha and Rahman 2013).The process of brick production is inherently physically demanding, and laborers engaged in this occupation frequently encounter a spectrum of work-related injuries. Within the realm of occupational hazards, it is noteworthy that the brick kiln industry ranks among the most perilous occupations globally, marked by the highest injury rates. Among these injuries, musculoskeletal disorders (MSD) predominate as the most prevalent nonfatal occupational injuries and ailments among workers, particularly those who engage in labor-intensive activities inherent to brick production, encompassing tasks such as brick firing, as well as the loading and unloading of bricks. This study was conducted to ascertain and analyze the prevalence of musculoskeletal disorders among laborers engaged in brick manufacturing activities in Sylhet, Bangladesh. The research primarily aimed to identify the musculoskeletal effects associated with each specific task involved in brick production, and subsequently determine the potential postures linked to these issues. Furthermore, the study conducted a risk analysis of postures assumed during each brick production operation using the RULA-REBA analysis. This enabled the identification of precarious postures that potentially contributed to musculoskeletal issues.

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