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ERGONOMIC ANALYSIS OF WORKING POSTURES AT A CONSTRUCTION SITE USING RULA AND REBA METHOD

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ABSTRACT

Musculoskeletal Disorders (MSDs) are the main work-related problems in construction sites around the world. Awkward working posture is mainly responsible for occupational musculoskeletal injuries. The main objectives of the research were to analyse the working postures of construction workers and assess the level of risk of injury in their work. Four categories of working postures were collected from elementary works as a form of still pictures from the construction site. Two assessment tools RULA (Rapid Upper Limb Assessment) & REBA (Rapid Entire Body Assessment) were used to assess the working postures of construction workers. Results showed that Beam and column casting and masonry workers were at high risk of injury due to the absence of maintaining proper working postures during the work. This study suggested to construction workers to maintain proper postures during works for avoiding any occupational injuries.

Keywords: *RULA; REBA; Construction works; Musculoskeletal Disorders (MSDs).*

1. INTRODUCTION

Construction industry is one of the most booming industries in the world. It is one of the most hazardous work place industries with injuries and health problems for workers. Workers are always exposed to various physical factors at work, which include awkward posture, heavy lifting, forceful exertion, vibration, and repetitive motion (Hartmann and Fleischer, 2005). These physical factors were reported to result in an elevated risk for musculoskeletal disorders (MSDs) (Holmström and Engholm, 2003). MSDs are a group of illnesses or injuries that can affect bones, muscles, tendons, nerves, blood vessels, gout, rheumatoid arthritis, osteoarthritis, joints (osteoarthritis, fracture), spinal disks (herniated disks), nerves, bones, ligaments, blood vessels, and more. Muscles can also be affected by tendonitis, fractures, and osteoporosis (Bayzid et al., 2019; Bairwa et al., 2022). Previous studies revealed that the chances of experiencing MSDs by construction workers could be explained by variety of jobs performed by workers without maintaining ergonomic guidelines (Babu and Xavier, 2018; Anagha and Xavier, 2022). The risk of getting occupational health problems can be assessed by applying ergonomics principles.

The science of ergonomics is the art of matching the job to the worker. It examines how internal and external pressures affect the human body (Kibria and Rafiquzzaman, 2019; Parvez et al., 2022; Talapatra et al., 2022). These stresses are developed while workers working on awkward postures (Kulkarni et al., 2018; Parvez et al., 2018). So, it is necessary to maintain proper postures avoiding work-related musculoskeletal disorders. Ergonomics helps to identify worker's postures whether it is proper or awkward. It also assesses the risk of getting injury by the worker with the help of assessment tools (Ahmed et al., 2018). The most commonly used assessment tools are RULA and REBA method to evaluate the working postures (Lynn and Corlett, 1993; Hignett and McAtamney, 2000).

RULA (Rapid Upper Limb Assessment) is an ergonomic assessment tool for the assessment of working postures related to upper limb of the workers. If the work is carried out in a predictable posture, it evaluates the posture and gives a score that indicates the risk level of that work. The risk level identifies the posture whether it is accepted or not, if not then how much the risk is in the work can be known also (Lynn and Corlett, 1993). Another ergonomic assessment tool is REBA (Rapid Entire Body Assessment) used to assess the unpredictable postures like standing, leaning, or others. It evaluates the working postures and gives a score that describes the risk level of work for the specific working posture. These two methods are popular ergonomic tools that require no equipment and easily find out the risk level of predictable and unpredictable postures (Hignett and McAtamney, 2000).

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A research was conducted to determine the workload and potential risk for musculoskeletal disorders (MSDs) during order fulfilment for the role of packer using the REBA method. According to the results, five postures met the requirements for action category (AC) 2, seven postures met those for AC 3, and one position met those for AC 4. The weight of the boxed carton, working while standing, maintaining an arched back, and raising the arms over the trunk; all increased the chance of getting poor posture rating (Lasota, 2014).

Ray et al. (2015) carried out a biomechanical evaluation on a Manual Material Handling (MMH) tasks or jobs to a typical construction work system in India under diverse work environments. They found the Manual Material Handling (MMH) tasks or jobs considerable risky. They also recommended redesigning hazardous jobs to increase workers' ergonomic performance and decrease occupational risks such MSDs, fatigue, work stress, etc. Purnomo et al. (2016) evaluated the working postures of construction workers using the REBA (Rapid Entire Body Assessment) approach. They revealed that 80% of construction workers had poor posture due to usages of conventional techniques and equipment and workers were at significant risk of getting musculoskeletal problems.

A study was undertaken by Kulkarni et al. (2018) to assess and understand the role of ergonomics in various tasks in the construction sector. Other objectives of the study were to determine the prevalence of musculoskeletal disorders and to recommend preventative measures for each job with a high-risk factor. The study evaluated the workers' posture using the Rapid Upper Limb Assessment and Rapid Entire Body Assessment techniques. A small number of construction procedures, including granite cutting, bricklaying, and plastering, were investigated to be risky.

Another study on manual feeding of a wood-cutter was carried out to compare RULA and REBA and determine which method is more appropriate and effective for determining the risk of biomechanical postural overload. This study evaluated the postures assumed by an operator during manual feeding of a wood chipper. The goal of the study was to determine which method was more appropriate and effective for determining the risk of biomechanical postural overload. The findings highlighted a number of upper-limb posture problems and demonstrated that RULA is a more cautious approach to preserving operator health while performing the intended duties. Discussion is had over how to enhance interactions between people and wood chippers (Micheletti Cremasco et al., 2019).

The construction industry is one of the largest industries in Bangladesh. It also plays an important role on national economy. It has contributed a total of 7.83% to the GDP of Bangladesh (BBS, 2021). Approximately 3.43 million workers are now currently working in this industry (Roy and Islam, 2019). Moreover, the risk of getting injuries by the construction workers is more than other industries (Ahmed, 2019). On the other hand, most of the worker are unskilful and unaware aware about this work risks. In addition, they have no knowledge about constructional working safety as well as ergonomic principles. They do not maintain proper postures while working. As a result, they are more at risk of Musculoskeletal Disorders (MSDs) due to their awkward postures and in the long run, they can be permanently disabled. So it is necessary to evaluate the working postures of the workers. As far the author's knowledge, very few studies were conducted on construction workers especially in Bangladesh. Therefore, aim of the research is to assess the work postures of construction workers by using RULA and REBA assessment tools and recommend if the posture is acceptable or not. The study would be helpful to find out the current state of the working postures of workers on a construction site and this diagnosis can help them to avoid work-related injuries.

1.1 Scope of the Study

The investigation is limited to four construction tasks with a development of high risk of musculoskeletal disorders (MSDs). The workers those who had at least 5 years working experience in building construction sector were taken into account in this study. The purpose of this study does not extend to continuous worker monitoring.

1.2 Limitations of the Study

The construction site is a diverse working area. Only four types of working postures were selected for analysis. Moreover, a limited number of workers were involved in the study. For analysis, still pictures was used which were static but the real situation of work is dynamic.

2. METHODS

2.1 Participants and Data Collection Procedure

A total of 35 participants working in a building construction site situated in Khulna city, the south west region of Bangladesh, participated in this study. The participant performed a wide range of activities and four categories of works (Figure 1) were considered in this study. Author collected still pictures of working postures shown in figure 1 from the selected building construction site using a portable camera by the supervision of an ergonomist. Images from multiple frames and angles were captured for better accuracy. Selected categories of work performed by participants were column and beam casting, masonry, sand and cement mixing, and material handling works which are briefly described as following:

Figure 1: Workers doing Beam and column casting (Left side), Sand and cement mixing (Middle) and Masonry (Right side) work in awkward posture.

Column and Beam Casting: Column and beam casting is a crucial process in construction work that involves creating structural elements such as columns and beams using concrete. These elements provide support and stability to buildings and other structures.

Masonry: Masonry is a construction technique that involves building structures using individual units, such as bricks, stones, concrete blocks, or tiles, and bonding them together with mortar. Masonry has been used for centuries and is known for its durability, strength, and aesthetic appeal.

Sand and Cement Mixing: Mixing sand and cement is a common practice in construction and masonry work. The mixture of sand and cement is typically used to create mortar, which serves as the binding agent in various applications, such as bricklaying, plastering, and rendering.

Material Handling: In the construction site, different equipment & tools of construction work need to be transported from one place to another during the work is considered as Material handling.

2.2 Rapid Upper Limb Assessment (RULA)

The RULA (Rapid Upper Limb Assessment) scoring method (Lynn and Corlett, 1993) is used to evaluate the ergonomic risks associated with upper limb tasks performed by workers. It focuses on assessing the postures and movements of the neck, trunk, arms, and wrists. Here is a general overview of how to calculate the RULA score:

- Postural analysis: Divide the task into key steps or postures and observe the worker during each step. Assign a score based on the posture of the upper body, neck, trunk, and arms. The scores range from 1 (low risk) to 7 (high risk) for each body part.
- Force assessment: Evaluate the forces exerted by the worker during the task. Consider factors such as the weight of objects lifted, the frequency of lifting, and the force exerted by specific body parts. Assign a score ranging from 1 (low force) to 5 (high force) for each body part involved in force exertion.

- Duration: Assess the duration of the task. Assign a score based on the length of time the worker spends in each posture. Higher scores are given for postures held for longer durations.
- Combine scores: Add the scores from the postural analysis, force assessment, and duration for each body part. This will result in two separate scores for the upper arm and the wrist/hand.
- Overall score: Use a lookup table or scoring sheet specific to the RULA method to combine the upper arm and wrist/hand scores. The table will provide a combined score that corresponds to an overall risk level. The risk levels typically range from low to very high.

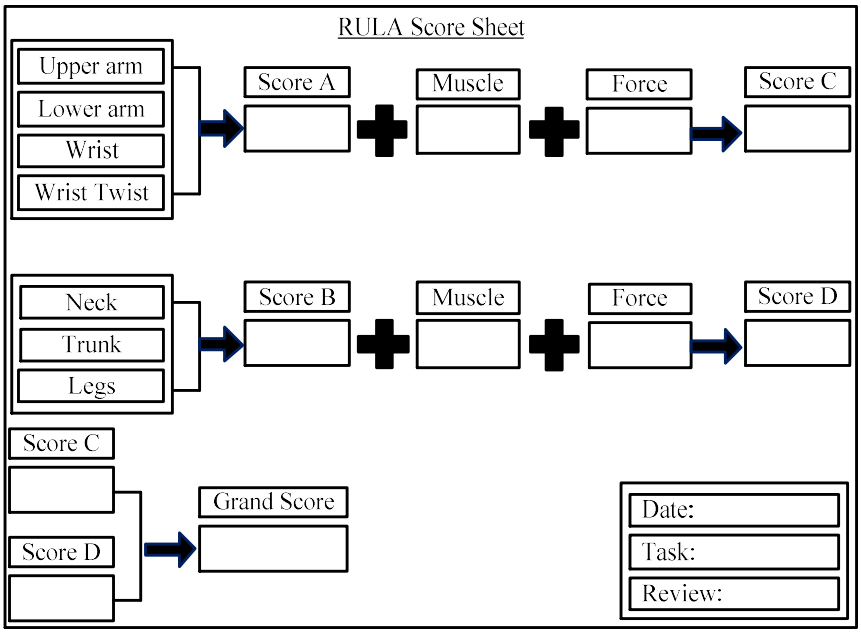

Figure 2: RULA Scoring Sheet.

2.3 Rapid Entire Body Assessment

The Rapid Entire Body Assessment (REBA) (Hignett and McAtamney, 2000) is a biomechanical assessment tool used to evaluate and score the level of musculoskeletal risk associated with specific tasks. It observes the body posture during each identified task component. Moreover, it assesses the angles and positions of body segments such as the head, neck, trunk, arms, and legs.

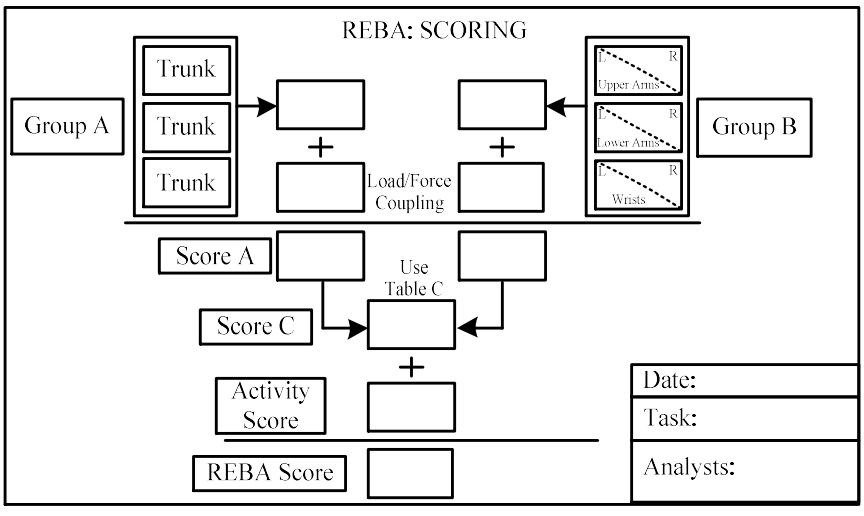

Figure 3: REBA Scoring Sheet.

To calculate the REBA (Rapid Entire Body Assessment) score, follow these steps:

- Postural analysis: Assess the posture of different body parts involved in the task. Assign a score to each body part based on its posture, ranging from 1 (low risk) to 4 (high risk). Use predefined criteria to compare the observed postures with the scoring guidelines.
- Force assessment: Evaluate the force exerted by the worker during the task. Consider factors such as the weight of objects lifted, the frequency of lifting, and the force exerted by specific body parts. Assign a score to each body part involved in force exertion, ranging from 1 (low force) to 3 (high force).
- Frequency and duration: Take into account the frequency and duration of the task. Assign a score based on the number of repetitions or cycles performed and the duration of each cycle. Higher scores are given for tasks with higher frequencies and longer durations.
- Upper body assessment: Add the scores for the neck, trunk, and upper arms together to obtain the "upper body score."
- Lower body assessment: Add the scores for the legs and lower arms together to obtain the "lower body score."
- Final score calculation: Use a scoring table or matrix specific to the REBA method to combine the upper body and lower body scores. The table will provide a combined score that corresponds to an overall risk level. The risk levels typically range from low to very high.

2.4 Recommendations of RULA and REBA assessment

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: RULA and REBA final Score Elaboration.

	Grand Score	Risk level	Score Meaning (Recommendation)
RULA	1-2	1	Posture is acceptable
	3-4	2	Further investigation is needed, change may be needed
	5-6	2	Further investigation is needed, change is needed soon
	7	2	Investigation is needed to implement change soon
REBA	1	1	Risk is negligible
	2-3	2	Risk is low, change may be needed
	4-7	3	Risk is medium, further investigation is needed , change soon
	8-10	4	Risk is high, need implement change after investigation
	11+	5	Risk is very high, implement change

3. RESULTS

3.1 RULA Assessment

In RULA analysis, workers' upper arm, lower arm, wrist position, and wrist twist were evaluated. Neck, trunk, and leg postures were also scored according to RULA analysis. Moreover, working postures were evaluated with the help of RULA scoring sheet and all these workers have been categorized here according to the risk level of RULA recommended in Table 1.

It has been observed from RULA assessment results shown in figure 4 that the column and beam casting workers were at a high level of risk among all the construction workers as 80% of them fell in the level 4 risk region. Moreover, 50% Masonry workers were also fell in this risk region. However, the workers who were doing material handling, and mixing cement and sand had the least risk of injury which was risk level 2. 80% material handling workers existed in risk level 3 region which indicates that further postural investigation was needed for avoiding unexpected MSDs. In addition, masonry (50%), and cement and sand mixing (60%) workers were also exposed themselves at level 3 risk of getting injuries.

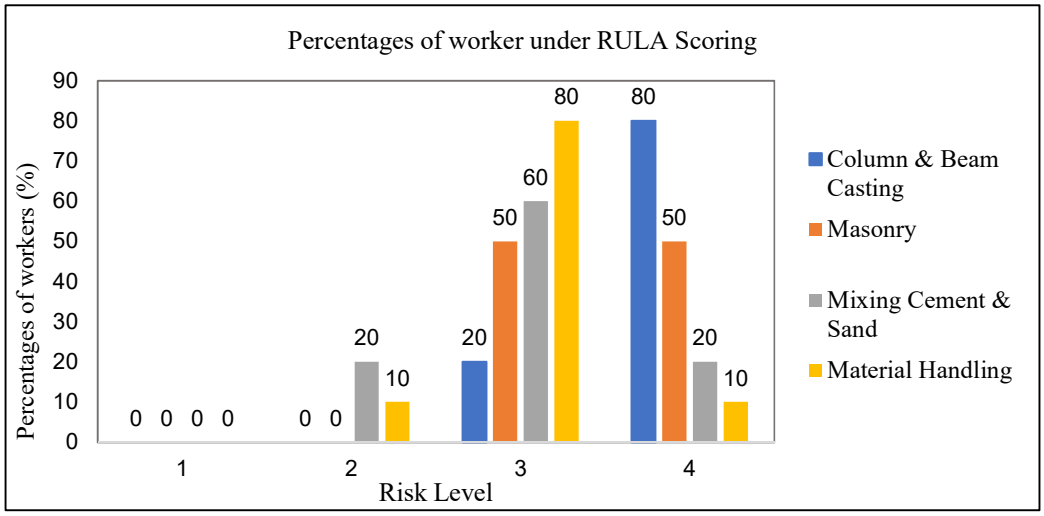

Figure 4: Percentages of construction workers under RULA Scoring.

3.2 REBA Assessment

The Rapid Entire Body Assessment (REBA) is a biomechanical assessment tool used to evaluate and score the level of musculoskeletal risk associated with specific work tasks. It observes the body posture during each identified task component. Moreover, it assesses the angles and positions of body segments such as the head, neck, trunk, arms, and legs. Working postures were evaluated with help of the REBA scoring sheet and all these workers have been categorized here according to the risk level of REBA recommended by Table 1.

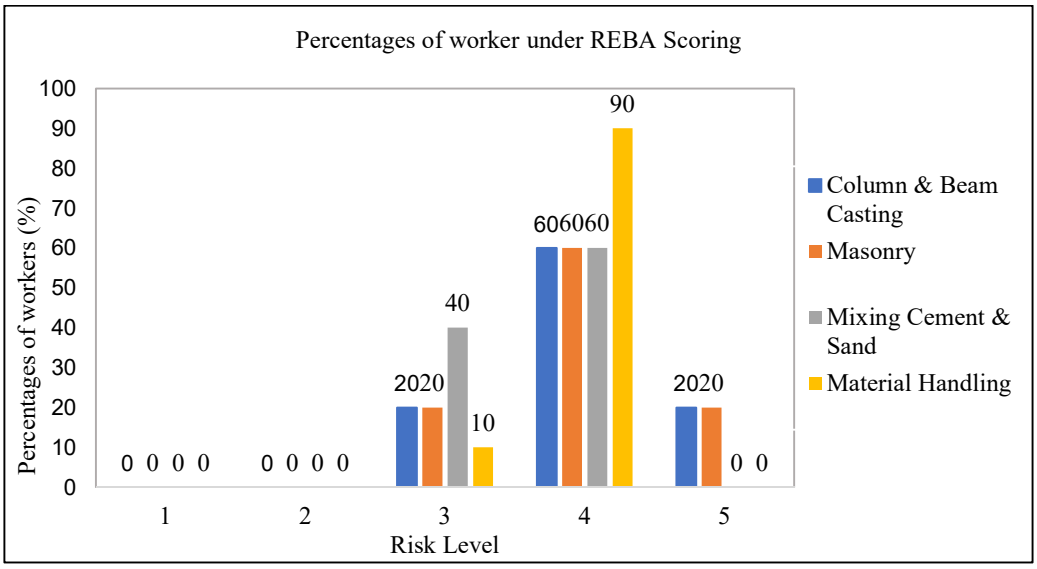

Figure 5: Percentages of construction workers under REBA level of risk.

It has been observed from REBA assessment that column and beam casting (20%), and masonry workers (20%) were at a very high level of risk and their risk level fell in the level 5 region shown in figure 4. 60% workers of each of the category who were doing masonry, column and beam casting, and mixing cement and sand had the chance of getting injury in the risk level of 4 according to REBA analysis. 90% workers who were doing

material handling were also in risk level 4 which asserted that the risk was high and further investigation was needed. However, workers who did column and beam casting works were at the highest level of risk of injury compered to masonry, material handling, and cement and sand mixing workers.

3.2 Comparison of RULA and REBA Assessment

Figure 6 shows the percentages of worker fall in the different risk levels according to RULA and REBA score analysis. RULA score revealed that 51.42% of workers maintained their work postures at high risk level which signifies investigating and changing their posture as early as possible. In addition, 42.86% workers exposed themselves at very high risk of getting injuries that indicates to immediately altering their postures. Only 5.72 % workers exposed a medium level of risk due to their improper working postures.

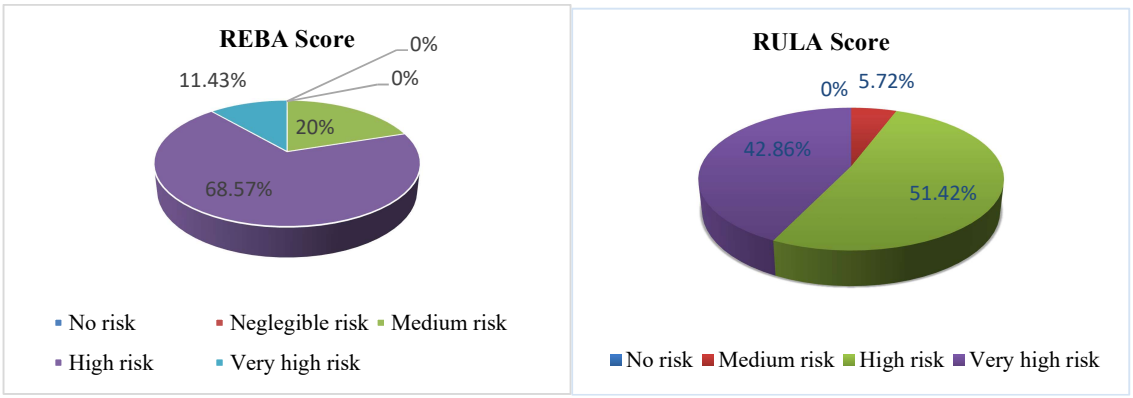

Figure 6: Comparison of RULA and REBA score.

On the other hand, the REBA assessment approach discovered awkward postures and excessive repetitions in the arm, wrist, and elbow areas that led to the reported injuries. According to REBA assessment, 68.57% workers who fell into the high level of risk getting MSDs and 11.43 % workers exposed themselves at very high level of MSDs risk due their awkward working postures. In conclusion, both of the assessment methods provided a nearly similar results and most of the workers did not maintain acceptable working postures.

4. DISCUSSIONS

In RULA analysis, workers' upper arm, lower arm, wrist position, and wrist twist were evaluated. Neck, trunk, and leg postures were also scored according to RULA analysis. Results showed that 51.42% of workers were in risk level 3 and 42.86% of workers were in risk level 4. It indicated that workers' posture was not acceptable. On the other hand, the Rapid Entire Body Assessment (REBA) is a biomechanical assessment tool used to evaluate and score the level of musculoskeletal risk associated with specific work tasks. It observes the body posture during each identified task component. Moreover, it assesses the angles and positions of body segments such as the head, neck, trunk, arms, and legs. Results showed that 68.57% of workers were in risk level 4 and 11.43% of workers were in risk level 5. It is seemed that most of the workers did not maintain proper working posturing. Similar findings were noted by researchers (Venkatachalam et al., 2023; Tao et al., 2023). RULA and REBA assessments of the current study (figure 6) showed that there was a high chance of developing CTDs and MSDs among the workers. To protect the workers and enhance production, the process needs to be looked into more thoroughly and changes need to be made (Anagha and Xavier, 2022).

It was evident from Both RULA and REBA (figure 4 and 5) analysis that the column and beam casting , material handling and Masonry workers having a high risk of developing CTDs because of their abducted lower-body postures, repetitive movements, and wrist flexion and extension required to complete their tasks. For extreme levels of posture, it has been observed that the worker's upper arm and lower arm angle was excess than normal posture like (45 – 90) ° or more. Their wrist twist & wrist position was not maintained at recommended angle at 15°. Moreover, their posture was static in long period of time. The majority of concrete block workers were at high risk because they often bent over and stretched to reach supplies and tools. The concrete blocks, mortar, and other equipment should be stored on an elevated platform (Kunar et at., 2021; Domingo et al. 2015). This reduces needless motions and keeps all the equipment within easy reach. A substantial number of manual material handling workers were at risk from poor lifting practices. In order to properly handle the building materials, the workers should receive sufficient training (Domingo et al. 2015). They need to stand in ways that

evenly distribute the weight of the building materials across their bodies. Avoid lifting or carrying objects with one side of the body as it will strain that side and put a strain on the worker's trunk. The risk was influenced by the weight of the construction supplies. By using tools like trolleys, these efforts can be reduced (Kulkarni et al., 2018; Gurnani et al., 2021).

5. PRACTICAL IMPLICATIONS

Ergonomic analysis can be used to examine every single task involved in construction sites. In large-scale construction projects, skilled personnel with having knowledge about ergonomics should be employed for implementing ergonomic practices. The same worker's working posture should be the subject of an ergonomic analysis, and recommendations or work designs for the same activity can be communicated to all other workers with the use of safety training programs, real-world work demonstrations, etc. As a result, a safe and healthy work environment will be created, lowering the project's overall cost and duration.

6. CONCLUSIONS

In this study, postural analysis has been done for the working posture of construction workers. The identification of the risk of injury among the workers was the purpose of this study. These four types of construction works have been evaluated with two popular tools RULA and REBA. Results showed that most of the workers are at the highest level of risk. Column & beam casting work posture is the riskiest and has the highest score for risk of injury among other types of working postures. All activities related to Construction work should be analysed through ergonomics. Ergonomic analysis can be conveyed through postural assessment and proper work design, arranging safety training, and live demonstration. This will help in reducing worker fatigue, which will enhance occupational health and reduce overall costs.

6.1 Suggestions and Recommendations

Construction workers should flow the following guidelines to mitigate the risk of getting unexpected MSDs.

- All Activities required to be redesigned.
- The majority of concrete block workers were at high risk because they often bent over and stretched to reach supplies and tools. For these workers, an immediate adjustment in posture is advised. The concrete blocks, mortar, and other equipment should be stored on an elevated platform. This reduces needless motions and keeps all the equipment within easy reach.
- Trolleys or conveyor belts should be used for tasks like moving materials in order to minimize lifting and external loads on the body of the worker. Additionally, the worker might be given a platform to rest his bucket on while he loads the dug-up dirt inside, making it easier for him to lift the bucket without having to bend over significantly.
- When mixing sand and cement, use a mixing container or a cement mixer designed for the task. It is necessary to position the mixing container at a comfortable working height to avoid excessive bending or reaching. Shovel or mixing tool with an appropriate handle length can be used to maintain good leverage and minimize strain on arms and back. It is recommended to mix the materials by using controlled and smooth movements, avoiding sudden or jerky motions.

6.2 Future Scope

In this study, the RULA and REBA approach are used to analyse the posture of construction workers. Future works may use more advanced computer-based programs and other ergonomic tools. To increase the precision of the findings, the sample size can be varied widely. Only four specific tasks were taken into consideration for this study. This can be enhanced by including all construction tasks in the study location. External factors such as past medical histories and physical characteristics of the workers can be considered for future studies.

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