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STUDY AND ANALYSIS OF WORK POSTURES OF WORKERS WORKING IN A CERAMIC INDUSTRY THROUGH RAPID UPPER LIMB ASSESSMENT (RULA)

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Abstract:

Work posture is the position and condition of the body or body parts during the performance of work. Good work posture is as important for the performance of tasks as it promotes health and minimizes stress and discomfort during work. The Rapid Upper Limb Assessment (RULA) is a widely used tool designed for the investigations of the work posture. In this concern, this research work has been conducted in a leading ceramic industry of Bangladesh in order to study and assess the work postures of workers working in the production section through RULA. The objective of the research work was to analyze the various work postures of the workers of the selected ceramic industry. To analyze the work postures of workers, rapid upper limb assessment (RULA) technique has been used. RULA has been developed specifically to examine the level of risk associated with upper limb disorder of individual workers by scoring the different body region of the workers. The results of this paper would help identify the good or bad work posture as well as the risk level associated with the different body regions of the workers. It has been found that most workers have been exposed to the upper limb discomfort which has contributed to the bad work postures. Through the analysis of RULA, it has been revealed that no posture is risk free for the workers working in the production section of the ceramic industry. According to RULA, further investigation is needed for 15.38% of workers, prompt investigation and changes are required for 41.02% of the workers and finally 43.59% of the workers need immediate investigation and changes in order to maintain the desired performance level and increase the productivity as well.

***Keywords**: Disorder, Posture, Rapid upper limb assessment, Risk, Stress.*

1. INTRODUCTION

The ceramics manufacturing industry in Bangladesh has been playing an important role in the growth of the national economy. To fulfill the company objectives it is important to produce the quality products. Labor is an important factor of any kinds of industry because they are directly related to the productivity of the system. Their ability, skills, productivity and performance have a great importance towards the increased production. There are some criteria which have a significant impact on the ability, skills, productivity and performance of workers such as work environment, body posture of worker, wages etc. Work posture is the position or attitude of the limbs or body at the time of work. Work posture has a significant impact on workers' efficiency and performance. It directly affects the labor heath issues and their productivity. The work posture is mainly three types, namely, easy posture, fatigue posture and rigid posture. Among them the easy posture is needed for the worker's health as well as to have a positive impact on labor productivity, performance and overall profitability of the industry.

This paper will analyze the different body posture of workers working in the production section of the selected ceramic industry. The poor posture and movement can lead to local mechanical stress on the muscles, ligaments and joints, resulting in discomfort in the neck, back, shoulder, wrist and other parts of the musculoskeletal system. This is because, when maintaining a posture, the joints must be kept in a neutral position with the limbs, as far as possible, close to the body, thus enabling the muscles to deliver the greatest force. On the contrary good posture allows muscles to work properly, decreases abnormal wear on joints, keeps the spine from becoming fixed in irregular positions, prevents backache and muscular pain and contribution to an attractive appearance.

The Rapid Upper Limb Assessment (RULA) designed by McAtamney and Corlett (1993) [1] is a widely used tool designed for the investigations of the work posture. RULA was developed specifically to examine the level of risk

associated with upper limb disorder of individual workers. This tool is used to investigate working postures at one instant in time. This instant is determined by using a coding system of RULA. RULA generates an action list, which determines the level of intervention required to reduce the risk of workplace injuries. The purpose of RULA is to provide a quick method for screening a variety of workstations and to give results that can be explained the conditions of work posture.

The RULA checklist measures postures on a scoring system scale from one to seven. If the score is 1 or 2 posture is acceptable and if the posture is greater than 2 the posture is unacceptable. Higher score of RULA indicates the worst position of postures.

1.1 LITERATURE ON POSTURE

Posture is the position in which body upright against gravity while standing, sitting or lying down. Work posture is the position of the body or body parts during work. Work posture has a significant impact on daily life activities and health issues.

Effects of good posture:

1. Helps the muscles in the body to be unloaded and relaxed
2. Improves respiratory and circulatory efficiency
3. Prevents unnecessary strain and fatigue.

Effects of poor posture:

1. Postural defects
2. Easy fatigability and high energy expenditure
3. Pain, bad cosmetic appearance and psychological disturbances.

1.1.1 Rapid Upper Limb Assessment (RULA)

The Rapid Upper Limb Assessment (RULA) was developed by Dr. Lynn McAtamney and Dr. Nigel Corlett of the University of Nottingham's Institute of Occupational Ergonomics. It was first described in a 1993 issue of the journal Applied Ergonomics. This ergonomic technique evaluates individuals' exposures to work postures, forces and muscle activities that have been shown to contribute to repetitive strain injuries (RSIs). Use of this ergonomic evaluation approach results in a risk score between one and seven, where higher scores signify greater levels of apparent risk. A low RULA score does not guarantee that the workplace is free of ergonomic hazards, and a high score does not assure that a severe problem exists. It was developed to detect work postures or risk factors that deserve further attention [2].

1.2 REVIEW OF PAST RESEARCH WORKS

A research was conducted by D. N. Agrawal, T. A. Madankar and M. S. Jibhakate in 2011 on “Study and Validation of Body Postures of Workers Working in Small Scale Industry through RULA”. This paper focused the attention on the ergonomics consideration required to be governed in the small scale industries, a specific case of tractor trolley manufacturing unit is considered, which is deviating from all these aspects. Welding in this industry had been done on kneeling posture as the fixture used for welding was placed on the ground. Continuously worker has to sit on that posture and has to perform welding work. It was observed that due to continuous kneeling posture worker got fatigued frequently and musculoskeletal problems were identified in them which were then validated by using RULA [3].

A research was carried out by Tirthankar Ghosh, Banibrata Das and Somnath Gangopadhyay in 2010 on “Work-related Musculoskeletal Disorder: An Occupational Disorder of the Goldsmiths in India”. They discussed in their paper about MSDs which had been reported in different occupations due to improper body posture and work load. Poor designs of workstation were causes of improper postures such as twisting, bending and over reaching. These postures increased the discomfort and pain at different parts of the body such as back, neck and shoulders. By providing proper work desk, the work condition could have been improved [4].

A research was conducted by Alireza Choobineh, Sayed Hamidreza Tabatabaei, Marzieh Tozihian, and Fatemeh Ghadami in 2007 on “Musculoskeletal problems among workers of an Iranian communication company”. In this research work, nordic musculoskeletal questionnaire and RULA were used to find out the WRMDs and it had been found that there was very high score of RULA (action level 3 & 4). RULA score could be reduced by designing ergonomic workstation and it might reduce the WRMDs among the workers. RULA showed that the awkward working postures and static work had been found to be the major risk factors that the workers encountered. Improper design and ill arrangement of workstation were the causes of postural problems and could have been cured by redesigning workstations based on ergonomics principles and would have reduced the RULA Grand Score [5].

Taylor and Francis described in their paper “What do we mean by a ‘working posture’?” that

work posture is as important for the performance of tasks as it is promoting health and minimizing stress and discomfort during work. Various musculoskeletal symptoms could be experienced by the workers performing their tasks in poor postures which were largely static and that these could be associated with long term risks and injuries. These postures also had a bad impact on labor productivity and performance [6].

2. METHODOLOGY

The action plan followed in conducting the research work is shown in the Figure 1 below.

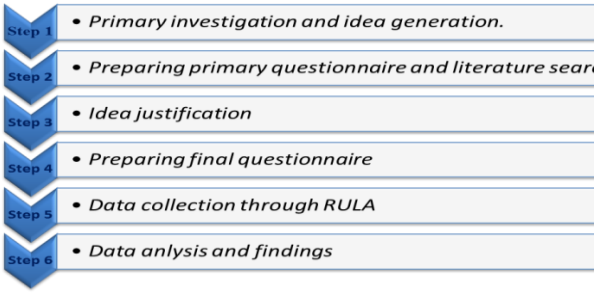

Figure 1. Methodology of research work

2.1 Data Collection and Analysis Procedure

In conducting this research work, data have been collected through rapid upper limb assessment (RULA) work sheet. The different work postures of workers have been observed in the view point of RULA. The observed work postures have been assessed in terms of RULA score and the various scores have been compiled according to RULA worksheet in order to get RULA grand score.

RULA deals with mainly the following body parts, namely, upper arms, lower arms, wrists, wrist twist, neck, trunk and leg. The individuals scores of all these body regions have been collected, evaluated and assessed in order to obtain the RULA grand scores which indicate the overall condition of work postures of the worker working in the different sections of the industry.

2.2 RULA Worksheet

The necessary data regarding the assessment of different body parts and work postures have been collected through the help of RULA worksheet which is shown in Figure 2. At first, the initial and final arm and wrist posture scores have been assessed in association with the initial and final neck, trunk and leg posture scores. The resultant scores have been evaluated and compiled together with the muscle use and muscle force or carrying load score in order to assess the RULA grand score.

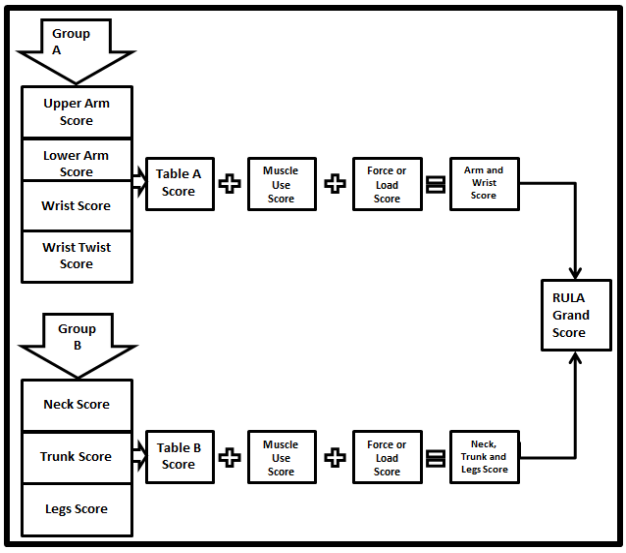

Figure 2. RULA worksheet

3. DATA ANALYSIS THROUGH RULA

3.1 Assessment and Evaluation of Initial and Final Arm and Wrist Position Score

The RULA work sheet scoring system is used to gather the overall score of different body regions of 39 workers of the selected ceramic industry. In the following sections the assessment and evaluation of different work postures have been conducted.

3.1.1 Assessment of lower arm, upper arm, wrist and wrist twist score

Upper arm position scores of workers have been assessed by considering the forward or backward movement of the upper arm, abduction of upper arm, support of upper arm and the condition of shoulder. Wrist position and wrist score of workers have been assessed by considering the upward or downward position, the bending condition and the twist of the wrist.

3.1.2 Evaluation of initial arm and wrist posture score

Initial upper arm, lower arm, wrist and wrist twist scores are tabulated in table A of RULA worksheet according to the standard of RULA and combined score is obtained by the intersecting values of the upper arm and relevant lower arm

score and the wrist position score and relevant wrist twist score. Higher values of initial arm and wrist scores increase the RULA grand score which eventually reduces the validity of work posture.

Table 1.Evaluation of initial arm and wrist posture score

Table A									
Arm Score		Wrist Position Score							
		1		2		3		4	
Upper Arm	Lower Arm	Wrist Twist		Wrist Twist		Wrist Twist		Wrist Twist	
		1	2	1	2	1	2	1	2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

From Table 1, after assessment of upper arm, lower arm and wrist twist scores, it can be shown that if upper arm position score is 3 and lower arm position score is 2 from the column of arm score, and if the wrist position score is 2 and wrist twist score is 1; then the initial arm and wrist posture score will be 4 according to table A of RULA worksheet.

3.1.3 Evaluation of final arm and wrist position score

Final arm and wrist position scores are evaluated by adding the muscle use score and muscle force or carried load score with the initial arm and wrist position score obtained from Table 1. Higher value of arm and wrist score increases the RULA grand score. The final arm and wrist position score has been evaluated by the following equation.

$$S_c = S_x + S_y + S_z \quad \text{----------(1)}$$

Here,
S_c=Final arm and wrist posture score
S_x= Initial arm and wrist score
S_y=Muscle Use Sore
S_z=Muscle Force or Carried load Score

Note: 1. If muscle does not move within one minute, it is considered as static condition of muscle. If the muscle action is repeated at least four times within one minute, it is considered as dynamic condition of muscle. But for both condition score 1 is added.

Note: 2. Muscle force is the amount of force which is acted on the muscle at the time of working. Muscle load is the amount of load applied by the muscle to carry the desired load.

In assessment of muscle load score, it is taken into consideration through RULA sheet that if the load applied by the muscle is-
Less than 2 kg (intermittent), score = 0
2 kg to 10 kg (intermittent), score = 1
2 kg to 10 kg (static), score = 2
More than 10 kg, score = 3.

After evaluation of the muscle use and muscle load score, the final arm and wrist posture score has been obtained by adding the initial arm and wrist score with the muscle use and muscle force score and Table 2 shows the final arm and wrist posture score of 39 number of workers together with the relative percentages of the workers for each and every score. Accordingly the result is plotted in the Figure 3 below.

Table 2. Evaluation of final arm and wrist posture score of workers

Final Arm and Wrist posture score	Number of worker	Percentage
4	10	25.64%
5	19	48.72%
6	6	15.38%
7	2	5.13%
8	2	5.13%

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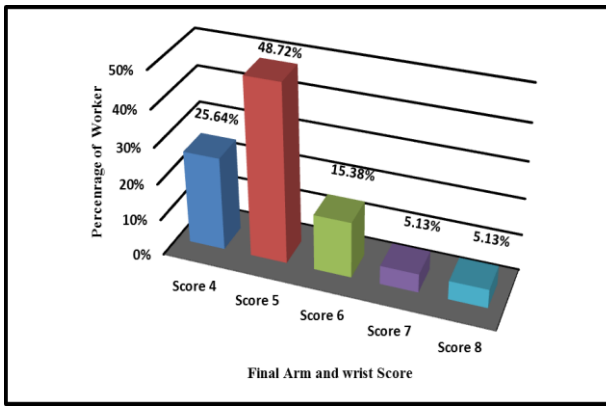

Figure 3. Evaluation of final arm and wrist posture score of workers

It has been shown from the Figure 3 that the final arm and wrist position score for maximum number of workers (48.72%) is 5 which indicates relatively good condition of final arm and wrist posture. The resultant score is 4 for a significant number of workers (25.64%). However, for 15.38% workers the score is 6, and the final arm and wrist posture score is 7 as well as 8 for 5.13% workers which indicate bad work posture.

3.2 Assessment and Evaluation of Initial and Final Neck, Trunk and Leg Posture Score

3.2.1 Assessment of neck, trunk and leg posture score

Neck and trunk position score of 39 workers have been calculated considering the forward or backward movement, twisting and the side bending condition of neck. Leg position score has been obtained by observing the legs if they have support or not. It has been considered during the data collection procedure according to RULA sheet that if leg has support the score is 1 and if not, the score is 2.

3.2.2 Evaluation of initial neck, trunk and leg posture score

Neck, trunk and legs posture scores have been tabulated in table B of RULA worksheet according to the standard of RULA and the combined neck, trunk and legs position score is obtained by the intersecting value of the neck posture and the trunk posture and relevant leg position score. The following Table 3 shows assessment of the initial neck, trunk and leg posture scores.

Table 3. Evaluation of initial neck, trunk and leg posture score

Table B												
Neck Posture Score	Trunk Posture Score											
	1		2		3		4		5		6	
	Legs		Legs		Legs		Legs		Legs		Legs	
	1	2	1	2	1	2	1	2	1	2	1	2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

From Table 3, it has been shown that if neck posture score is 3, trunk posture score is 4 and legs score is 1; then the combined neck, trunk and legs posture score will be 5 according to the table B of RULA worksheet.

3.2.3 Evaluation of final neck, trunk and leg posture score

Final neck, trunk and leg posture scores have been evaluated by adding the muscle use score and muscle force or carried load score with the initial neck, trunk and leg posture scores obtained from Table 3. The final neck, trunk and leg posture score has been evaluated by the following equation.

$$S_f = S_i + S_j + S_k \text{ ----------(2)}$$

Here,
S_f= Final neck, trunk and leg position score
S_i= Initial neck, trunk and leg score
S_j= Muscle Use Sore
S_k= Muscle Force or Carried load Score

The following Table 4 has been constructed after evaluation of the final neck, trunk and leg posture scores and it shows the value of final neck, trunk and leg posture scores for 39 workers in association with the relative percentages of the workers for each and every score. Finally the result is plotted in the Figure 4 below.

Table 4. Evaluation of final neck, trunk and leg posture score

Neck, Trunk and Leg position score	Number of worker	Percentage
3	3	7.69%
4	11	28.21%
5	8	20.51%
6	12	30.77%
7	4	10.26%
8	1	2.56%

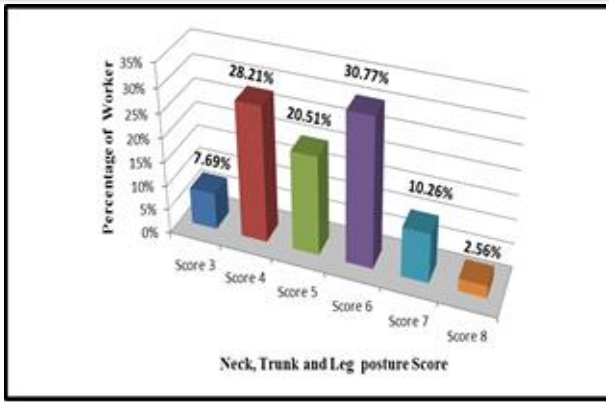

Figure 4: Evaluation of final neck, trunk and leg posture score

From the figure 4 it has been found that no workers have the final neck, trunk and leg posture score of 1, 2 or even. The score for 7.69% workers is 3, for 28.21% workers the score is 4, for 20.51% of workers score is 5, for 30.77% of workers the score is 6, for 10.26% of workers score is 7 and for 2.56% of workers the score is 8 respectively. The score for majority of the workers (79.5%) is 4 to 6 which indicates relatively a bad condition of neck, trunk and leg posture.

3.2.4 Evaluation of RULA Grand Score

The final arm and wrist scores and the final neck, trunk and leg scores have been tabulated in table C of RULA worksheet according to the rules of RULA and the RULA grand score has evaluated by the intersecting value of these two scores. The final evaluation of RULA grand score is presented in Table 5. The equation used for assessment of the RULA grand score is given below:

RULA Grand Score=Intersecting Value of S_c and S_f

Table 5: Evaluation of RULA grand score

Table C								
Wrist and Arm Score (Final A Score)	Neck, Trunk and Legs Score (Final B Score)							
	1	2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

After assessment of wrist and arm score, it has been shown from Table 5 that, if wrist and Arm Score (S_c) is 6 and neck, Trunk and Legs Score (S_f) is 5; then the RULA grand score will be 6 according to the table C of RULA worksheet.

Different RULA score indicates different meaning. Higher RULA score indicates the lower validity of work posture and higher risk. On the contrary, lower RULA score indicates the higher validity of work posture and association of lower risk. The various ranges of RULA grand score indicates the terms and conditions and the regarding decisions about work posture which is shown in Table 6. According to table 6, Green color is used for good work posture and red color is used for bad work posture.

Table 6: Elaboration of RULA grand score

RULA Grand Score	Decision about Posture
1-2	Posture is acceptable if it is not maintained or repeated for long periods.
3-4	Further investigation is needed and change of posture may be required.
5-6	Further investigation and changes are required soon.
7+	Investigate and changes are required now.

In the following Table 7, the RULA grand score of 39 workers has been arranged according to their relevant scores and the percentage of workers for different scores has been shown accordingly.

Table 7: RULA grand score of different workers

RULA Grand Score	Number of Worker	Percentage
4	6	15.38%
5	6	15.38%
6	10	25.64%
7	17	43.59%

Table 7 shows that the RULA grand score for 6 workers is 4 and 5 respectively, for 10 workers the score is 6 and for 7 workers, the score is 7 and the relative percentage of the workers is also presented in the Figure 5 below. It also indicates that no workers have acceptable work posture and most of the workers are working in high posture related risk.

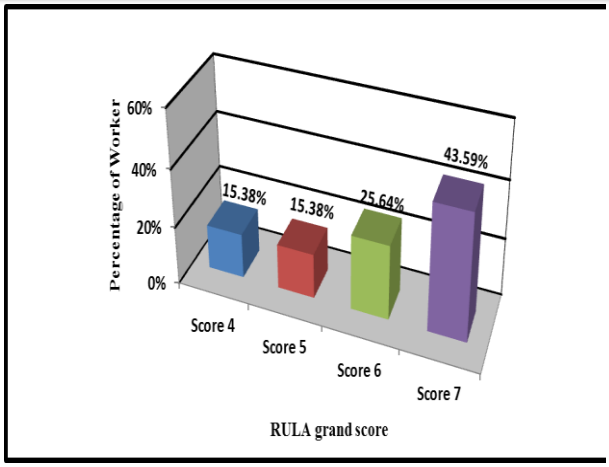

Figure 5: RULA grand score of different workers

From figure 5 it has been revealed that no existing posture is valid according to the standard of RULA. Further investigation or change may be required for 15.38% workers because their RULA grand score is 4. Further investigation or rapidly changing posture is required for 41.02% (15.38%+25.64%) workers as they have the score of 5 or 6. Must investigation and changing posture is required for 43.59% workers because they have the RULA grand score of 7.

4. CONCLUSION

The objectives of this research work was to identify the good and bad work posture of the workers working in a selected ceramic industry as well as to analyze the status of different work postures in terms of RULA grand score. This research work was conducted in the machining and production, lifting, carrying and packaging sections of the industry. In order to conducting the work, 39 workers from these units had been selected. Data for analyzing the body posture were collected and analyzed via rapid upper limb assessment (RULA). According to this method, a score is calculated for the position of arms, wrists, neck, trunk and leg. Score 1 indicates the most neutral posture and gradually increasing scores shows the worst position. The combined individual scores for arm and wrist provide score A and neck, trunk and leg provide score B of RULA worksheet. Muscle use and force exerted are attributed by a score of 0 or 1. These scores are added to scores A and B to obtain the grand score of RULA. The range of grand score is 1 to 7 which shows the condition of posture from good to worst respectively. In the analysis of RULA, no posture is risk less because no score were found of 1 or 2. The RULA grand score of 15.38% of workers were between 3 and 4 indicating that further investigation is needed and change of posture may be required. RULA grand score is between 5 and 6 for 41.02% of the workers studied indicating that the prompt investigation and changes are required soon. And finally for 43.59% of the workers studied, the RULA Grand Score is 7 indicating that the immediate investigation is needed and changes are required as soon as possible.

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