

Ergonomic Risk Assessment of Workers in Manufacturing Industry using Posture Analysis Tools

Arvind Bhardwaj, Manish Dev, Sarbjit Singh and Rahul S Mor

Abstract— The presents study is aims at assessment of posture analysis of the workers working in small manufacturing industry. The study was conducted on 54 workers engaged in various manufacturing processes. The different operations performed by workers were material handling, metal strip cutting, drilling, frame welding, hammering, frame fitting and grinding etc. The small questionnaire related to Musculoskeletal Discomfort was filled by workers. To assess the ergonomic risk of a job or task, ergonomic assessment tools Rapid Upper Limb Assessment (RULA) and Quick Exposure Check (QEC) were used. A videography and photos of various processes were taken to record different movements and postures of the workers during various tasks. The videos were cropped after every ten seconds to get snapshots and these snapshots were analysed to fill the RULA and QEC score Sheets. Out of 54 workers 28 (51.85%) have lower back discomfort followed by upper back 24 (44.5%), Shoulder 23 (42.59%), Neck 20 (37.03%) were the most prominent areas of body having Musculoskeletal Discomfort. Whereas elbow, knees and ankle/feet were found to be least affected areas. The RULA scores revealed that majority of workers i.e. 18 (33.33%) need investigation and changes requires soon in there working postures whereas 14 (25.33%) workers fall in the category of further investigation needed and changes may be required. 13 (24.07%) workers found to be investigated and changes are required immediately. Further posture is acceptable if it is not maintained or repeated for long period in case of only 9 (16.66%) workers. According to QEC 17 (31.48%) workers are at high risk and investigation & changes in their postures are needed soon. Followed by 15 (27.77%) workers at moderate risk level who need further investigation and changes might be required. 13 (24.07%) workers were found to be at very high risk and investigation & changes are immediately needed in their case. Frame welding, hammering and frame fitting jobs were at very high risk and high risk as these lie in the percentage categories >70% and 50-69% respectively of QEC Score. While material handling, metal strip cutting, drilling and grinding jobs were at low and moderate risk.

Index Terms— Posture Assessment, Rapid Upper Limb Assessment, Quick Exposure Check

I. INTRODUCTION

In the present era, technology has made great edge in every domain of engineering. With the advent of technology old methods are being replaced by new machines and equipment, but still there are many phases where old or traditional methods are used and many tasks are done manually. Taking current scenario of manufacturing industries in developing countries like India, workers face many health related problems. Workers indulge themselves in various tasks in Manual Material Handling (MMH) tasks like carrying heavy Steel Bars, Steel Sheets, Angles, Girders, Welding, Drilling, Grinding, Hammering etc.

Department of Industrial and Production Engineering, Dr. B R Ambedkar National Institute of Technology Jalandhar, Punjab (INDIA)

Work Related Musculoskeletal Disorders (WMSD) are one of health problem and it has been revealed from many research studies and industrial investigations that these disorders are preventable by avoiding wrong postures, ergonomic assessments, Ergonomic design interventions.

According to Occupational Safety and Health Association (OSHA) musculoskeletal disorders (MSDs) are disorders and injuries of soft tissues like muscles, ligaments, tendons, joints and cartilage and nervous system. Almost all the tissues, including nerves and tendon sheaths are affected by them. These disorders are cumulative trauma disorders, occupational overexertion syndrome, repeated trauma and repetitive stress injuries. MSDs represent one-third of work injuries, having significant social and economic consequences [1, 2]. MSDs can cause pain, stiff joints, numbness, tingling, muscle loss, difficulty in moving and sometimes paralysis. Prolonged exposure to MSD can cause damage to the workers' body. Repetitive movements and exerting excessive force irritate tendons and raise pressure on nerves. Unsupported positions or awkward posture that exceeds physical limits can compress nerves and affect tendons; static posture that a worker holds for long period can restrict blood flow and harm the muscles. Too much vibration from machine and tools can reduce the flow of blood, harm nerves and causes muscle fatigue working in cold temperatures.

In this paper ergonomic assessment tools were used to assess the worst working postures during work so that these can be avoided to reduce risk of injuries and MSDs. Rapid Upper Limb Assessment (RULA) and Quick Exposure Check (QEC) are the two methods used to assess the risk factors associated with MSDs. Section 1 of this paper is the introduction part like musculoskeletal disorders, definitions given by OSHA and introduction about posture assessment tools etc. Section 2 is the methodology, Section 3 contains results and discussion and finally, Section 4 is conclusion part.

II. METHODOLOGY

A. The Rapid Upper Limb Assessment (RULA)

RULA was designed by McAtamney and Corlett in 1993. The RULA score sheet was used to assess the posture of upper limbs mainly arms and wrist. Each body part is divided into sections depending on the range of movement and these sections are numbered so that the number 1 is assigned to the range of movement or working posture where minimal risk is involved.[4] Higher numbers are assigned to parts of the movement range with more extreme postures indicating an increasing presence of risk factors causing load on the structures of the body segment. The exposure scores according to RULA were divided into four risk categories: negligible, low, medium and high. Medium and high

risk actions should be urgently noticed to reduce the level of exposure of risk factors. Higher is the RULA Score greater will be the risk.

TABLE 1. RULA SCORE AND ACTION LEVEL

RULA SCORE	ACTION REQUIRED
1-2	Posture is acceptable if it is not maintained or repeated for long periods
3-4	Further investigation is needed and changes may be required
5-6	Investigation and changes are required soon
7+	Investigation and changes are required immediately

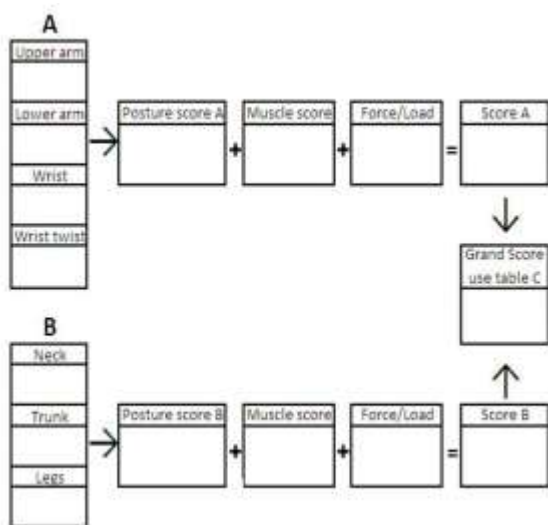


Fig.1: RULA Work Sheet
(Source: McAtamney and Corlett, 1993)

B. Quick Exposure Check (QEC)

QEC developed by Li and Buckle (1998), designed to assess the exposure to musculoskeletal risk factors of the back, shoulders and arms, hands, wrists and neck [5] Risk Levels were categorised into four parts namely Acceptable, Moderate, High and Very High. QEC provides the strong bases for the ergonomic design intervention to reduce the musculoskeletal disorders.

TABLE II. RISK LEVEL AND RECOMMENDATION IN QEC.

QEC %	Risk Level	Recommendation
< 40%	Acceptable risk	Acceptable posture
40-49 %	Moderate risk	Further investigation needed; changes might be required
50-69 %	High risk	Investigation and changes needed soon
>70%	Very high risk	Investigation and changes needed immediately

III. RESULTS & DISCUSSION

Table-3 shows the Frequency of Musculoskeletal Disorders reported by various workers in manufacturing industry. Out of 54 workers of Lower Back 28 (51.85%) followed by upper back 24 (44.5%), Shoulder 23 (42.59%), Neck 20 (37.03%) were the most prominent areas of body having Musculoskeletal Discomfort. Whereas elbow, knees and ankle/feet were found to be least affected areas.

TABLE 3. MUSCULOSKELETAL DISCOMFORT IN VARIOUS PARTS OF BODY OF WELDERS

Sr. No.	MSD	Frequency	Percentage
1	Neck	20	37.03
2	Shoulder	23	42.59
3	Elbow	8	14.81
4	Wrist/Hands	15	27.77
5	Upper back	24	44.5
6	Lower back	28	51.85
7	Hips/Thighs	13	24.07
8	Knees	9	16.66
9	Ankles/Feet	5	9.2

TABLE 4. ACTION LEVEL BASED ON RULA GRAND SCORE

RULA Grand Score	ACTION REQUIRED	No. of Workers	Percentage
1-2	Posture is acceptable if it is not maintained or repeated for long periods	9	16.66
3-4	Further investigation is needed and changes may be required	14	25.93
5-6	Investigation and changes are required soon	18	33.33
7+	Investigation and changes are required immediately	13	24.07

Table-4 reveals that majority of workers i.e. 18 (33.33%) need investigation and changes requires soon in there working postures whereas 14 (25.33%) workers fall in the category of further investigation needed and changes may be required. 13 (24.07%) workers found to be investigated and changes are required immediately. Further posture is acceptable if it is not maintained or repeated for long period in case of only 9 (16.66%) workers.

TABLE 5. RULA SCORE DISTRIBUTION ACCORDING TO DIFFERENT JOB PROCESSES

Job Description	RULA Score				Total(n=54)
	1-2	3-4	5-6	7 +	
Material Handling	2	4	-	-	6
Metal Strip Cutting	1	1	3	-	5
Drilling	-	2	4	-	6
Frame Welding	1	2	4	5	12
Hammering	-	3	5	4	12
Frame Fitting	3	-	-	3	6
Grinding	2	2	2	1	7
Total	9	14	18	13	54

Table-5 shows that Frame welding, frame fitting jobs have high RULA score. This means Investigation and changes are required immediately also in case of hammering Investigation and changes are required soon.

TABLE 6. RISK LEVEL AND RECOMMENDATIONS BASED ON QEC PERCENTAGE

QEC %	Risk Level	Recommendation	Number of Workers	% of Workers
< 40%	Acceptable risk	Acceptable posture	9	16.66
40-49 %	Moderate risk	Further investigation needed; changes might be required	15	27.77
50-69 %	High risk	Investigation and changes needed soon	17	31.48
>70%	Very high risk	Investigation and changes needed immediately	13	24.07
			54	

Table-6 shows that 17 (31.48%) workers are at high risk and investigation & changes in their postures are needed soon. Followed by 15 (27.77%) workers at moderate risk level who need further investigation and changes might be required. 13 (24.07%) workers were found to be at very high risk and investigation & changes are immediately needed in their case.



Hammering



Grinding



Welding

Fig. 2: Workers performing different operations in Industry

TABLE 7. QEC SCORE DISTRIBUTION ACCORDING TO DIFFERENT JOB PROCESSES

Job Description	QEC Score				Total (n=54)
	< 40%	40-49%	50-69%	>70%	
Material Handling	2	4	-	-	6
Metal Strip Cutting	1	1	3	-	5
Drilling	-	3	3	-	6
Frame Welding	1	2	4	5	12
Hammering	-	3	5	4	12
Frame Fitting	3	-	-	3	6
Grinding	2	2	2	1	7
Total	9	15	17	13	54

Table-7 shows that Frame welding, hammering and frame fitting jobs were at very high risk and high risk as these lie in the percentage categories >70% and 50-69% respectively of QEC Score. While material handling, metal strip cutting, drilling and grinding jobs were at low and moderate risk.

IV. CONCLUSION

From Posture assessment tools RULA and QEC it is clear that workers are working in poor working postures. The results reveal that awkward postures were adopted by workers due to lack of awareness of ergonomics in the working processes of manufacturing industry. This means that most of the workers are working under high risk of Work related musculoskeletal disorders. Immediate change in postures, work rest cycles, ergonomic intervention in work stations, appropriately designed

equipment are recommended to improve the health of workers for enhancing work productivity.

REFERENCES

- [1] Morse, T.F., Dillon, C., Warren, N., Levenstein, C., Warren, A., The economic and social consequences of work-related musculoskeletal disorders: the Connecticut Upper-Extremity Surveillance Project (CUSP). *Int. J. Occup. Environ. Health* 1998, 4 (4), 209-216
- [2] Punnett, L., Wegman, D.H., Work-related musculoskeletal disorders: the epidemiologic evidence and the debate. *J. Electromyogr. Kinesiol.* 2004, 14 (1), 13-23.
- [3] Sahu, S., Moitra, S., Maity, S., Pandit, A. K., & Roy, B. A Comparative Ergonomics Postural Assessment of Potters and Sculptors in the Unorganized Sector in West Bengal, India. *International Journal of Occupational Safety and Ergonomics*, 2013, 19(3), 455-462.
- [4] McAtamney and Corlett, RULA: A survey method for the investigation of work-related upper limb disorders. *Applied Ergonomics*, 1993, 24(2), 91-99
G. David et al. The development of the Quick Exposure Check (QEC) for assessing exposure to risk factors for work-related musculoskeletal disorders. *Applied Ergonomics*, 2008, 39 57–69. Website:
- [5] Occupational Safety and Health Association (OSHA).



Dr. Arvind Bhardwaj is currently working as Professor in the department of Industrial & Production Engineering, and Dean- R&D at National Institute of Technology, Jalandhar, India. He has worked as the Director, Global Institutions, Amritsar; and Head, Department of Industrial & Production Engineering and Dean, Students Welfare at NIT, Jalandhar. He has more than 26 years of research & teaching experience, and his research interests includes: technology management, logistics & supply chain management, occupational health & safety, operation research, human factor engineering etc. He may be contacted at bhardwaja@nitj.ac.in



Manish Dev is currently the Ph.D. Research Scholar in the department of Industrial & Production Engineering, National Institute of Technology, Jalandhar, India. His study is focused on 'Occupational Health of welders working in Unorganized Sector'. His research interest includes: Ergonomics and Human Factors Engineering, Occupational Health and Safety, production engineering etc. He may be contacted at devmanish08@gmail.com



Dr. Sarbjit Singh is currently working as an Associate Professor in the department of Industrial & Production Engineering, and Associate Dean- R&D at National Institute of Technology, Jalandhar, India. He has worked as the Head, Department of Industrial & Production Engineering, NIT Jalandhar; and Dy. Dean, Punjab Technical University, Jalandhar. He has more than 20 years of research & teaching experience, and his research interest includes: supply chain management, environmental planning and control, lean production, occupational health & safety, human factors engineering etc. He may be contacted at bals@nitj.ac.in



Rahul S Mor is currently the Ph.D. Research Scholar in the department of Industrial & Production Engineering, National Institute of Technology, Jalandhar, India. His study is focused on 'Supply Chain Management in Dairy Industry'. His research interest includes: lean manufacturing, green supply chain management, production engineering etc. He may be contacted at iersmor@gmail.com