Ergonomic Evaluation of Foundry Activities to Identify Risk of Musculoskeletal Disorders

Asif Qureshi[a], Vivek Khanzode[b], K. Manivannan[c]

[a] KIT's College of Engineering, Kolhapur, India, qasif@rediffmail.com
[b] National Institute of Industrial Engineering, Mumbai, India, vkhanzode@nitie.ac.in
[c] School of Mechanical and Building Sciences, Vellore Institute of Technology, Vellore, India, kmanivannan@vit.ac.in

Abstract: Musculoskeletal disorders (MSDs) result into loss of productivity in metal cast-ing industry, especially small foundries. The objective of this study is to identify the foundry activities involving risk of MSDs and to quantify the same. It also aims to demonstrate interventions to reduce the risk and to improve productivi-ty.Rapid Entire Body Assessment (REBA) is used to examine MSD risks. A sam-ple of 105 workers from 9 small scale foundrieswas selected for conducting REBA analysis. One of the high risk activities was selected for improvement and workstationwas redesigned as part of ergonomic intervention. REBA score was calculated for the modified workstation and improvement was quantified.From results, it is concluded that risk levels can be reduced significantly by simple inter-ventions in worksystem design which may further lead to improvement in produc-tivity.

1.Introduction

Workplace ergonomic is major contributor to occupational safety and health issues. Musculoskeletal disorders (MSDs) are commonly caused by poor ergonomic design. MSDs are major cause of absence of work force affecting organizational productivity (Shengli Niu-2010).Workers need to lose productive time from work to recover from MSDs.The magnitude of workplace MSDs is largely unreported in industrial sectors, particularly in developing countries like India. However, approximately 50 % of MSDs among working population can be prevented through ergonomic intervention(ILO, ...).

The metal casting industry (foundries) is a fundamental industry in manufacturing sector. Manual material handling (MMH) in foundries causes overexposure to three major types of ergonomic hazards: awkward postures, repetitive motions, and forceful exertions, leading to MSDs (Bernard, 1997).In spite of technological developments in foundries, automation levels are low, and hazardous material including molten metal is still handled manually, especially in small foundries. On this background, we find very few studies analyzing MSD issues in foundries(for example, Ling Li et.al. 2005), and almost none in Indian foundries.

Numerous methods are available for MSD risk assessment including self re-port, observational methods and direct methods. A commonly used tool for inves-tigating MSDs under self report category is Nordic Questionnaire(Kuorinka et.al. 1987) which includes subjective assessment. On the other hand, Rapid Entire Body Assessment (REBA) is an observational postural analysis tool based on body-segment specific ratings, using a scoring system for muscle activity including static, dynamic, rapidly changing and unstable postures.

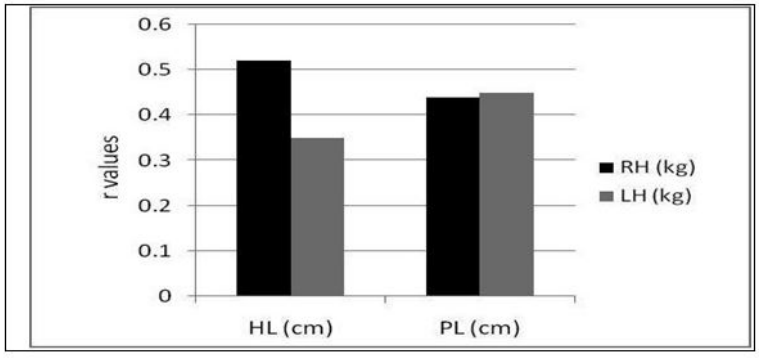
REBA is validated with an inter-observer reliability of 62-85%(Hignett andMcAtammey, ----) and provides a benchmark of choosing intervention priorities. In this study, we use REBA to evaluate MSD risk of a select activities carried out routinely in small foundries. Further, we demonstrate how low-cost interventions can be effectively used to reduce the MSD risk in industrial worksystems.

2 Methodology

2.1 Subjects: We included nine foundries in Western India for study purpose. These foundries are small scale units with virtually no automation. Almost all of the workers in selected foundries are male, ranging from 20 to 52 years of age. The consent of management and workers was obtained before study. The subjects selected belong to worker and helper category on shop-floor. Study was carried out during working hours of day shift (i.e. between 8 a.m. to 5 p.m.).

2.2 Methods and Data Collection: Demographic data and background information (Age, Weight, Height, Expe-rience, department and designation, working duration) of the subjects were col-lected. Medical history, specifically regarding MSDs was also referred. For REBA analysis, photographs of 105 workers in selected working postureswere takenfrom different angles. Care was taken to obtain angles of body parts accurately.

The standard analysis procedure forsections A and B of REBA was adopted examining respective body parts (neck, trunk, leg, and arm, wrist). The angles were measured by marking lines along the relevant body segments on the photo-graphs(Figure1). REBA scores were calculated and risk levels evaluated for each activity department-wise (molding, melting, pouring, and fettling). To demonstrate low cost intervention to reduce the risk of MSDs, one of the high risk activities was selected from molding section (shell mold making). Worker prepares one complete mold by stacking 16 sand molds one on the other. Such 8 complete molds are required for one pouring cycle, and 6 pouring are scheduled eachshift. The REBA activity score for shell mold making was found to be 10 (Figure 2). A modified workstation was designed for this activity as shown in Figure 5. For this modified workstation REBA score was calculated and compared with the old method. Cycle time was recorded for both old procedure and modified one and compared.



ISBN 978-93-5258-836-7

Table 2 Involvement of elderly in Light Indoor Leisure / Hobby Activities

Parameters Studied	Group I 61 - 70yrs (n=61)		Group II 71 – 80yrs (n=47)		Group III >81yrs (n=23)		Females (Group I+II+ III)	Males (Group I+II +III)	Total
Gender	Females (n=27)	Males (n=34)	Females (n=17)	Males (n=30)	Females (n=14)	Males (n=9)	Females (n=58)	Males (n=73)	Total (n=131)
Light Indoor games									
Carom	9	19	9	17	4	4	22	40	62
	(33.3)	(55.9)	(52.9)	(56.7)	(28.6)	(44.4)	(37.9)	(54.8)	(47.3)
Chess	8	15	8	14	2	3	18	32	50
	(29.6)	(44.1)	(47.1)	(46.7)	(14.3)	(33.3)	(31.0)	(43.8)	(38.2)
Crossword/	5	8	10	14	1	1	16	23	39
Puzzle	(18.5)	(23.5)	(58.8)	(46.7)	(7.1)	(11.1)	(27.6)	(31.5)	(29.8)
Light Leisure / Hobby Activities									
Reading	20	26	14	28	8	8	42	62	104
	(74.1)	(76.5)	(82.3)	(93.3)	(57.1)	(88.9)	(72.4)	(84.9)	(79.4)
Watching	16	14	13	25	8	5	37	44	81
TV	(59.3)	(41.2)	(76.5)	(83.3)	(57.1)	(55.6)	(63.8)	(60.3)	(61.8)
Writing	7	9	6	12	6	6	19	27	46

3 Results and Discussions

The REBA score indicates the risk and action level(Table-1). The REBA score varies from low (1) to very high risk level (11) among the sample. 30.47% of the sample is exposed to high risk level and 16.19% to very high risk level(Figure 3).Thus, activities carried out by 46.66% of the workers need immediate intervention. Population exposed to medium risk level is also considerable (44.76%) and action isnecessary for those.

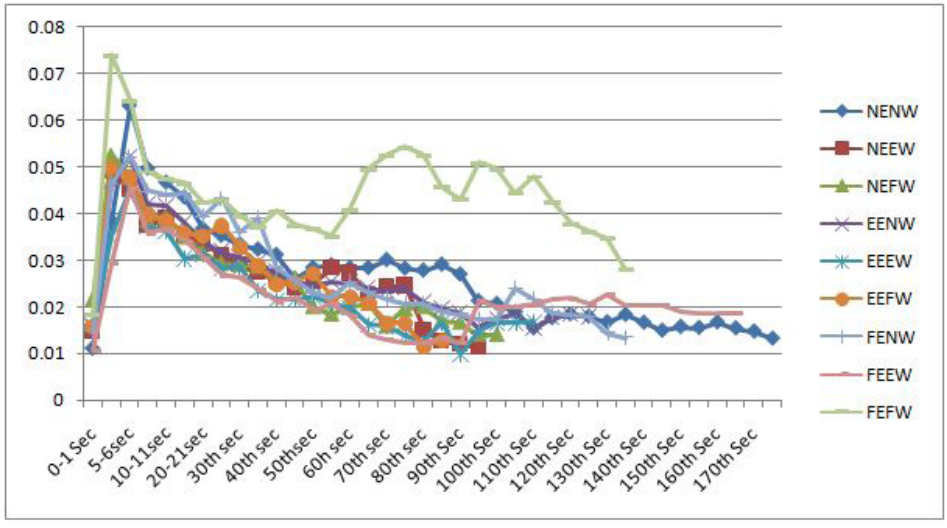
Posture	Force	FCR	ECR	Correlation formula (y=mX + C
NENW	Force	0.97	0.92	FCR activity=(0.0017*force)+0.0121 ECR activity=(0.0045*force)+0.0296
NEEW	Force	0.92	0.81	FCR activity=(0.0019*force)+0.0060 ECR activity=(0.0057*force)+0.0359
NEFW	Force	0.90	0.85	FCR activity=(0.0044*force)+0.0198 ECR activity=(0.0157*force)-0.0155

Table 3 Involvement of elderly in sports or exercise type of Physical Activity

Parameters Studied	Group I 61 - 70yrs (n=61)		Group II 71 – 80yrs (n=47)		Group III >81yrs (n=23)		Females (Group I+II+ III)	Males (Group I+II +III)	Total
Gender	Females (n=27)	Males (n=34)	Females (n=17)	Males (n=30)	Females (n=14)	Males (n=9)	Females (n=58)	Males (n=73)	Total (n=131)
Walking	14	24	13	25	12	8	39	57	96
	(51.8)	(70.6)	(76.5)	(83.3)	(85.7)	(88.9)	(67.2)	(78.1)	(73.3)
Yoga	19	23	12	23	8	6	39	52	91
	(70.4)	(67.6)	(70.6)	(76.7)	(57.1)	(66.7)	(67.2)	(71.2)	(69.5)
Home	11	15	9	17	7	4	27	36	63
Exercise	(40.7)	(44.1)	(52.9)	(56.7)	(50.0)	(44.4)	(46.5)	(49.3)	(48.1)
Jogging	10	9	3	5	0	2	13	16	29
	(37.0)	(26.5)	(17.6)	(16.7)	(0.0)	(22.2)	(22.4)	(21.9)	(22.1)

Risk analysis of each department was carried out. Graph of department v/s number of workers is plotted according to different risk levels. Melting and Pouring Departments are prone to very high risk levels, followed by Fettling. Ac-tivities like preparing mold, pouring molten metal and fettling are found to be more prone to MSDs due excessive load handled, awkward posture or a combina-tion of both(Figure4).

It is possible to reduce risk levels by simple intervention. This is demon-strated for one activity of high risk level (REBA score = 10) from shell molding department. Present method of mold making by squat sitting (Figure 3) can be carried out with modified workstation in form of table (Figure 5). This reduces REBA score from 10 (high risk level) to 3 (low risk level).



Intervention provided to reduce risk level also assists to improve productivi-ty. The productivity is measured in terms of cycle time required to complete one mold and in turn number of molds per shift. Time saved with modified workstation was observed to be 30 seconds/mold. Total time required per shift reduced to 448 minutes from 476 minutes considering allowances. There is saving of 28 minutes/shift (i.e. 5.85%), which contributes to produc-tivity improvement directly.

ISBN 978-93-5258-836-7

4 Conclusion

Automation of foundry activities definitely reduces risks associated with MSDs. However, small scale industries find this cost prohibitive. Hence, it is ne-cessary to provide simple and cost effective interventions to reduce risk levels. REBA is a tool which can be effectively used in small foundries to identify risk levels of different activities. Risk levels can be reduced significantly by simple, low-cost interventions at the level of workstation redesign.

These interventions al-so help to reduce work content and hence improve productivity. The objective of this study was to identify the foundry activities involving risk of MSDs and to quantify the same, and also to demonstrate low-cost interven-tionsdirected towards risk mitigation. Both these objectives are achieved to a great extent as part of the work carried out under this study.

References

1. Bernard, B.P. (Ed.), Musculoskeletal disorders and workplace factors : a critical review of epidemiologic evidence for work related musculoskeletal disorders of the neck, Upper Ex-temity, and Low Back. Cincinnati : DHHS (NIOSH) Publication No. 97-141(1997)
2. ShengliNiu, Ergonomics and occupational safety and health : An ILO perspective, Applied Ergonomics, 41, PP. 744 – 753,(2010)
3. Hignett S, McAtamney L., Rapid Entire Body Assessment (REBA). Applied Ergonomics ;31 :201-205. (2000)
4. Kuorinka, B.Jonsson, A. Kilbom, H. Vinterberg, F. Biering-Sorenson, G. Andersson and K. Jorgenson, Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms, Applied Ergonomics, 18 pp. 233-237 (1987)
5. Ling Li, Patrick G. Dempsey, Jian-guo Xu, Lin-na Ge, You-xin Liang, Risk factors for the prevalence of musculoskeletal disordes among Chinese foundry workers, International Journal of Industrial Ergonomics,35,pp. 197- 204,(2005)