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Ergonomic Risk Assessment of Working Postures in Small Scale Industries

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***Abstract*—Ergonomics is the study of the interaction between people and machines and the factors that affect the interaction. A number of factors play a significant role in ergonomics, and these factors determine the health, safety, comfort and efficient performance at workplace. Work-related musculoskeletal disorders (WMSDs) are the most common problems in manual work in small scale industries. The study presents assessment of working postures of workers from different small scale industries engaged in different activities. About 140 workers from 4 industries namely stone cutting & polishing, saw mills, brick making and dal mill are selected randomly. The study includes administering a musculoskeletal questionnaire to determine the level of MSDs among the workers. The workers are subjected to awkward postures like bending, twisting, heavy load carrying, etc. Evaluation of these postures was carried out using ergonomic assessment tools Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA). It can be concluded from the study that 32% of the postures adopted by workers are in high risk according to RULA and 36% are in high risk according to REBA assessment tools and need to be changed urgently. It is recommended to improve the working postures by ergonomic controls and interventions, and encourage the use of PPEs in order to improve the efficiency of the workers and overall productivity.**

***Index Terms*— Ergonomics, Postures, RULA, REBA, work-related musculoskeletal disorders.**

I. INTRODUCTION

Ergonomics comes from the Greek word meaning “laws of work”. It is also described as ‘fitting the task to man’ which means to fit the human abilities and limitations to the work activities, tools, equipments and work environment. WMSD are diseases related to and/or worsened by work that affects the upper limb and lower limb extremities and the lower back area. WMSD is defined as impairment of joints, tendons and muscles, nerves, ligaments, bones and blood circulation system due to work activities or work environment. WMSDs develop over a period of time due to unnatural or awkward work postures during work. A large range of individual, workplace and psychosocial risk factors are associated with development of WMSDs. Mostly WMSDs occur when the workers are involved in awkward positions like bending, twisting, stretching over head, kneeling, contact stress, carrying heavy loads, vibrations or extreme working conditions. The age

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of the workers also contributes to the development of WMSD since the capacity of physical work decreases with age. [3].

Work-related musculoskeletal disorders (WMSDs) are a major concern in industry, especially in the micro, small and medium industries (MSMEs). It has an impact on the economic costs and health care systems. The costs are associated due to productivity loss, compensation costs and costs due to training of workers. Many studies in literature have revealed that ergonomic factors like unnatural working postures, static load, contact stress and task invariability to be some of the significant factors to contribute to development of WMSDs.

It is therefore important to give due consideration to ergonomics and the use of ergonomic principles to overcome some of the deficiencies in manufacturing systems like reduced productivity, poor quality, absenteeism, labor turnover etc. The application of ergonomics can help the industries in achieving a proper balance between task demands and characteristics of workers. Most of the research studies show positive effect of application of ergonomic principles in work system design, work environment, job design and occupational health and safety, and reduce the postural risks.

However in the micro, small and medium enterprises (MSMEs) in the unorganised sector in developing countries, the application and awareness of ergonomics are negligible.

A. Ergonomics in India

India is one of the fastest growing economies, and a major part of workforce comes from the MSMEs. These industries are mostly in the unorganized or informal sector, and are characterized by poorly designed workplace and work environment, manual work, heavy loading, awkward postures and the prevalence of WMSDs is significant. Occupational safety, health and ergonomic deficiencies exist and these are major contributors to WMSDs and decrease in productivity. Application of ergonomic principles and low cost ergonomic interventions is the solution to overcome these deficiencies in the workplaces. [1, 2]. However, owing to financial constraints and other factors, the MSMEs in the informal sector cannot afford high cost ergonomic solutions and assessments by ergonomists. Hence, the present study is undertaken to identify and formulate some strategies for applying ergonomics in the MSMEs, and apply risk assessment tools to identify awkward postures and suggest low cost interventions for improvement.

II. LITERATURE ON POSTURAL ANALYSIS

As mentioned above, several studies can be found in literature on the ergonomic risk assessments using postural tools like RULA and REBA.

Ergonomic postural assessment tools help to identify risks due to unnatural postures while performing different tasks, and determine the possible risk level for occurrence of MSDs**.** Many researchers have used these analysis tools in various occupations and industries.

Available literature shows typical studies conducted on various occupations such diverse industries like weaving workstations and sugar producing activities [9, 10], on automotive components manufacturing [11], In a study on 110 workers in saw mills [7], the high risk postures were about 22% by RULA analysis and 32% were of high risk as analysed by REBA assessment tool. In the study on Bus body manufacturing [8] about 30 to 40 percent postures in high risk category.

In a study on pharmaceutical workers [4], it was found that about 18% were in dangerous postures in packaging section and required change immediately. Another study on carpet weaving in Iran [9] revealed that long hours of static work with awkward posture at traditionally designed looms causes high rate of WMSDs among carpet weavers. Similar study conducted on 116 workers in sugar industry [10] indicated high prevalence of WMSD according QEC assessment tool. The findings of a study conducted on 20 automotive component workers [11] indicated high prevalence of WMSDs suggested change in work station design. The study on machine shop workers [12, 15] indicated high risks in working postures according to REBA analysis and suggested changes in work station design incorporation anthropometry considerations.

Reference [13] Discusses on development of a computer assisted system for application of ergonomics in SSIs. In a study involving 130 workers in small scale forging industry in North India [14], it was found that a majority of workers are under risks of WMSDs due to poor work postures. The studies have indicated that work related musculoskeletal disorders are prevalent in most of the industries and these are a result of awkward postures and poorly designed work stations and working conditions.

III. Objective of Study

The extensive literature survey indicates the presence of work related musculoskeletal disorders among the workers involved in manual work. It is identified that the majority of musculoskeletal problems are related to the unnatural working postures of manual workers. Moreover, these problems are prevalent in small scale industries where the application of ergonomic principles or even safe working conditions is negligible. Hence the present study main objective is to identify and assess risks of Work Related Musculoskeletal Disorders (WMSD) due to unnatural/awkward postures by RULA and REBA assessment tools.

IV. Materials and Methods

The present study for assessing the ergonomic risks in working postures uses tool like Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA).

Table I. Classification of Risks According to RULA and REBA

RULA			REBA		
RULA Score	Risk Level	Action Levels	REBA Score	Risk Level	Action Level
1-2	Negligible	acceptable posture	1	Negligible	No change
3-4	Low	change necessary	2-3	Low	May be necessary
5-6	Medium	change soon	4-7	Medium	Change necessary
7	High	change urgently	8-10	High	Change soon
			11-15	Very high	Change urgently

A. Rapid Upper Limb Assessment

RULA-Rapid Upper Limb Assessment [5] a survey method developed for use in ergonomics assessments of workplaces, where musculoskeletal disorders are prevailing. It is a simple pen and paper tool to assess postural loads on the upper limbs of body. It also assesses posture movement and force associated with tasks. RULA uses a coding system to generate an action list indicating the level of risks and ergonomic intervention required. The risk levels and action required are shown in Table I.

B. Rapid Entire Body Assessment

REBA-Rapid Entire Body Assessment [6] is a postural assessment tool which provides a quick observational analysis of the entire body. It provides a scoring system for muscle activity caused by static, dynamic, rapid changing or unstable postures [8]. REBA also gives an action level indicating the urgency for changing the working postures. The details of REBA action level and risk assessment are given in Table I.

C. Methodology

The present study is carried out in randomly selected small scale industries located in North Karnataka region. The selected occupations are *Dal* mills (pulse processing), Brick making, Stone polishing and Saw mills. An initial survey was carried out in the selected industries by visits and discussions with the supervisor and workers to ascertain the ergonomic deficiencies due to working postures and work environment. The occupations were selected based on the severity of prevalence of WMSDs and poor working conditions. The selected industries were more involved in manual work and heavy postural loading.

These industries are characterised by;

Saw Mills; the work is characterised by carrying and lifting heavy logs of wood, the workers have unnatural postures like bending , twisting, forward bending, pushing, pulling etc. The working conditions are poor, comprise of heat, noise and dust. The ergonomic issues are more prevalent and need to be corrected. The use of personnel protective equipments (PPEs) is negligible.

Dal Mills (Pulse processing); the milling process is carried out by machines, but manpower is needed for loading, unloading, carrying sacks of pulses. Also the split pulses are spread out for drying in open and collected every day. Work is mostly indoors and the workplace is characterised by poor illumination, high noise levels and dusty environment. The use of PPEs is negligible.

Stone Polishing; the work is characterised by heavy manual material handling, high noise levels, exposure to vibrations, dusty work place and health risks due to silica dust. The workers adopt unnatural postures while lifting heavy slabs of stones and carrying. The use of PPEs is negligible.

Brick manufacturing; the brick manufacturing is characterised by working in outdoors in high temperatures, sometimes up to 45^0 C. The work involves heavy manual lifting, loading and unloading, carrying heavy loads

resulting in awkward postures like bending, twisting, stretching and lifting above shoulders. Workers are exposed to heat stress and carry high risks of WMSDs.

It can be seen from the observations made and with the discussions the authors had with the supervisors and workers that, these industries have ergonomic deficiencies related to work station design, work environment, manual handling, and prevalence of WMSDs due to awkward postures adapted and poor use of personnel protective equipments. The current study focuses only the postural analysis of the difficult postures of workers by RULA and REBA methods.

Among these 4 SSI industries 140 workers were randomly selected for study comprising 37 workers from Stone polishing, 33 workers from Dal mills, 38 workers from Brick manufacturing and 32 workers from saw mills. The demographic characteristics of the selected workers are tabulated in Table II.

The video recording and still photographs of the workers movements during working was recorded. The snapshots of the workers performing their work were obtained for the analysis.

The snapshots of the postures were analysed using RULA and REBA score sheets. According to the scoring sheets the overall body posture is assessed. The more awkward and difficult postures involving high risk are scored higher and those postures with minimum risk are scored lesser.

Necessary changes and corrective actions according to the action levels were recommended for such work postures/activities involving higher risk, to keep away the workers from higher risk.

The RULA assessment scores mainly the upper limbs, neck, trunk, arms and wrist of posture. The range of movement for a posture is divided into different body sections. These body sections are scored such that a score of 1 is assigned to the range of movement or work posture if the risk factors present are minimum. Higher scores are assigned to the postures with extreme risk factors which causes load on the body segments. The RULA scores are divided into four action levels; negligible, low risk, medium risk and high risks respectively. High risk and Medium risk postures need to be addressed urgently to reduce the exposure levels which may be a reason for WMSDs.

REBA assessment tool is used for those activities where whole body and motion of limbs needs to be assessed. Similar to RULA, in REBA the body parts are divided into different segments and each body part is evaluated according to its range of movement and a score is assigned. Higher scores are allocated to such body parts where the postures have presence of more risk factors and lower scores are allocated to those postures where presence of risk factors is minimum. The REBA scores were divided into five action levels namely; negligible, low risk, medium risk, high risk and very high.

V. Results and Discussion

The present study is focussed on study of working postures and assessing them using ergonomic assessment tools RULA and REBA. The demographic characteristics of the workers from four selected SSIs are given in Table II. The average age, average height, average weight and experience are noted. Body Mass Index (BMI) is also calculated to know the obesity levels of the workers.

TABLE II. DEMOGRAPHIC CHARACTERISITICS OF WORKERS

Industry	No. of Workers	Mean age (SD) in yrs	Mean Height in cm	Mean Weight In kg	Mean Experience In yrs	Mean BMI in Kg/cm^2
Saw mill	32	34.70 (10.6)	167.84 (5.29)	59.14 (3.40)	10.46 (6.39)	20.13 (1.05)
Brick mfg	38	26.4 (9.5)	158.2 (11.3)	47.9 (9.7)	9.22 (6.43)	21.30 (0.97)
Dall mill	33	38.66 (7.03)	163.2 (7.56)	59.90 (7.33)	8.93 (4.19)	20.72 (1.23)
Stone polishing	37	29.91 (8.84)	165.6 (7.7)	62.56 (3.74)	7.82 (5.19)	20.42 (1.57)
	140					

A. RULA Assessment

The RULA assessment scores are given in Table III and Fig.1, representing the different categories of the risk levels obtained after analysing the working postures.

TABLE III. RULA ASSESSMENT SCORE

RULA Activity score	Stone polishing N=37(%)	Saw mills N=32(%)	Brick mfg. N=38(%)	Dal mill N=33(%)	Total N=140(%)
1	4(10.81)	3(9.37)	3(7.89)	5(15.15)	15(10.71)
2	11(29.72)	6(18.76)	10(26.32)	7(21.22)	34(24.3)
3	10(27.04)	11(34.37)	12(31.57)	12(36.36)	45(32.14)
4	12(32.43)	12(37.5)	13(34.22)	9(27.27)	46(32.85)

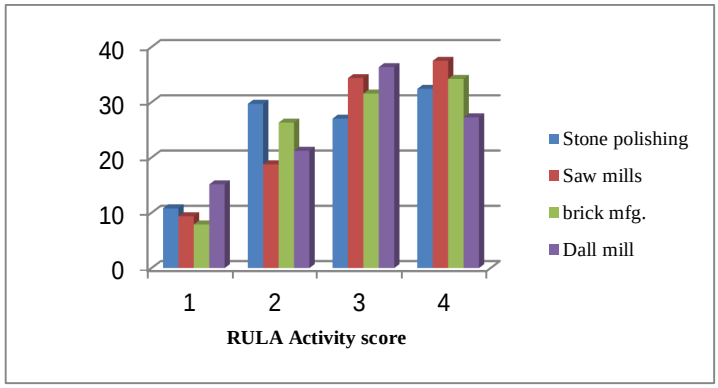

Figure 1.Percentage of Workers in RULA Assessment

The assessment scores are also presented graphically in Figure 1. It can be seen from the figure that about 32 % in stone polishing, 37 % workers in saw mills, 34 % workers in brick manufacturing and 27 % workers from dal mills are at a high risk, under category 4 of RULA assessment. The action required is to investigate further and change the posture immediately. Similarly about 27 % workers in stone polishing, 34 % workers in saw mills, 31 % workers in brick manufacturing and 36 % workers in dal mills have medium risk and fall under category 3 of RULA action level, which requires investigating further and changing the postures soon. Similar results were obtained by [7] in saw mills and [8] in brick manufacturing industries. In a pharmaceutical packaging work [4] 18% of workers had very high risk. In the present study high risks postures are prevalent across all occupations indicating immediate interventions. Ergonomic interventions like engineering controls or administrative controls are suggested. If the workers are continuously exposed to such high risks, the risks of WMSDs increases and may have an impact on the worker health, quality and productivity. Overall from Table III it can be seen that about 32.85 % of workers have high risk, and just about 10 % of total postures are acceptable without any risk.

B. REBA Assessment

The results of the REBA assessment are tabulated in Table IV and Fig.2; it is observed that a majority of the workers are working in unacceptable postures at high risks. About 35 % workers in very high risks and 32 % workers in high risk category can be seen in stone polishing industry. In saw mills 46 % workers are in high risk category and 28 % in very high risk category. In brick manufacturing 34 % in very high risk and about 32 % in high risk are found. In a similar study by [7] on saw mills about 34% workers had high risk postures and about 20% had very high risks. In dal mills 36 % in high risk and 30 % in very high risk are found. Similar results were reported in the studies conducted by [12] on manufacturing workers and [14] on forging industry workers. If the workers continue to work in the same postures without any intervention, they are prone to high risk of musculoskeletal disorders in the future. It is recommended that the postures be investigated further and changed immediately. Over all REBA assessment highlighted about 32 % of working postures in very high risks and around 36 % in high risk categories across all four selected industries. It is recommended that workers avoid unnatural working postures which require extreme bending, turning, twisting etc.

TABLE IV. REBA ASSESSMENT SCORE

REBA Activity score	Stone polishing N=37(%)	Saw mills N=32(%)	brick mfg. N=38(%)	Dall mill N=33(%)	Total N=140(%)
1	0(0)	0(0)	0(0)	0(0)	0(0)
2	3(8.3)	1(3.13)	2(5.26)	3(9.09)	9(6.4)
3	9(24.26)	7(21.87)	11(28)	8(24.24)	35(25.04)
4	12(32.33)	15(46.87)	12(32.53)	12(36.36)	51(36.42)
5	13(35.11)	9(28.13)	13(34.21)	10(30.31)	45(32.14)

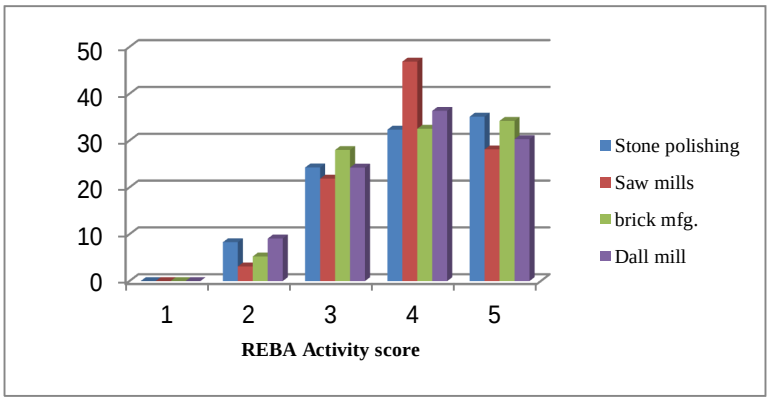

Figure 2.Percentage of Workers in REBA Assessment

VI. CONCLUSION

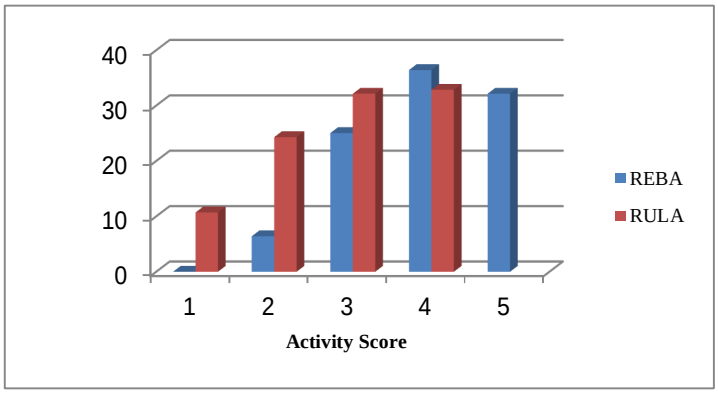

Figure 3.Percentage of Workers in RULA &REBA Assessment

The evaluation of body postures has been carried out for four different manufacturing industries in the small scale sector by RULA and REBA postural assessment tools, as indicated in Figure 3. The studies have indicated about 36 percent working postures in selected industries fall in high risk category and 32 percent in very high risk, according to REBA score. It is due to the awkward postures adapted by workers in different tasks. An immediate change in postures is suggested by incorporating changes by ergonomic interventions, like engineering controls and administrative controls. In a particular study in dal mills, the provision of personnel protective equipments like masks and ear plugs reduced the worker complaints by 14%. In another case in stone polishing industry, engineering interventions were suggested in manual material handling by providing a push cart for transfer of stone slabs from stores to polishing machine. It reduced the WMSD complaints by about 23%. It can be concluded that majority of the workers are working in uncomfortable and unnatural postures as found by the assessment. In SSIs awareness of ergonomics and its application for

the safety, comfort and productivity is a major issue. The workers are under moderate to high risks of musculoskeletal disorders as the results of analysis indicate. It is recommended to investigate further and incorporate low cost ergonomic interventions, educate and train the workers on safe working postures, improve the work environment, provide and encourage the use of personal protective equipment, in order to increase the efficiency of workers and productivity of the enterprise.

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