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An ergonomic study of work related musculoskeletal disorders among the workers working in typical Indian saw mills

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Abstract*—Musculoskeletal disorders (MSDs) are amongst the most common work-related problem in India. In Indian saw mill yards we find all the conditions which expose workers to MSD risks: hard environmental conditions (low temperatures, slippery and uneven ground), heavy works (manual handling of loads, back flexed and twisted) and dangerous tools and machineries such as chainsaws. The high manual work load can therefore cause MSDs amongst the loggers. This pathology risk increases with the component 'vibration' induced by chainsaws, tractors, skidders and other machineries. In this study we have considered different logger groups working in saw mills and we have analysed their MSD risk exposure, the typical case of manual workers in a saw mill process in northern Karnataka State, India is investigated. Most workers are male. In an Indian saw mill most of the work is still carried out manually hence issues of work related musculoskeletal disorders and injury in different parts of the body are prominent. Postural analysis using REBA, RULA indicates that the workers are working above the safe limit. The average REBA score observed was 7.5. The hazardous postures and MSD's were also justified by the questionnaires and VAS (Visual Analogue Scale) techniques. Moreover the workers were exposed to noise above the OSHA's safe limits for prolonged time. These methods indicated that different body parts at specific postures are vulnerable to injury and musculoskeletal disorders and warrant immediate ergonomics intervention.

Keywords*—Ergonomics, Musculoskeletal disorders, saw mill, RULA, REBA, Noise.

I. INTRODUCTION

There is a growing concern to improve productivity, safety, and quality in manufacturing industries. Some of the common problems of the small scale and unorganised sector industries are improper workplace design, ill-structured jobs, mismatch between workers abilities and job demands, adverse environment, poor human–machine system design, poor working postures and inappropriate management programs. They lead to workplace hazards, poor workers' health, mechanical equipment injuries, disabilities, Work related Musculoskeletal Disorders (WMSDs) and in turn reduce worker productivity and product/work quality and increase cost.

It would, therefore, be extremely difficult to attain the objectives of the manufacturing industries without giving proper consideration to ergonomics. Effective application of ergonomics in work system design can achieve a balance between worker characteristics and task demands. This can enhance worker productivity; provide worker safety, physical and mental well-being and job satisfaction. Many research studies have shown positive effects of applying ergonomics principles in workplaces, occupational health and safety, machine design, job design, environment and facilities design[3]. However, there is still a low level of acceptance and limited application of ergonomics in the manufacturing industries, especially in the SSI's and unorganised sector. Neglect of ergonomic principles brings inefficiency and pain to the workforce. An ergonomically deficient workplace can cause physical and emotional stress, low productivity and poor quality of work. Assessment of exposure levels to MSD risk factors can be an appropriate base for planning and implementing interventional ergonomics programs in the workplace.

To improve the efficiency of the workers their posture needed to be assessed and corrective measures should be adopted to avoid the risk of musculoskeletal disorders and other related problems. The objective of this study is to analyse the working postures of workers engaged in various activities carried out in a saw mill, by applying different postural analysis tools, and to identify the various risk factors associated with MSDs.

The study was carried out in Saw mills situated in northern Karnataka in India where thousands of workers are engaged in these activities. As it is an unorganized sector, no statistical data are available to date as to the accident rates occurred, the number of people employed, and other problems. Hence the only means of these data are through conversations and direct dialogue with the people associated with this profession. Saw milling involves more work than it appears because most of the work is manual, without the use of hydraulics, power, blades, or support equipment. Saw workers, especially sawyers, are exposed to high concentrations of saw dust while cutting the wood. The incidences of Work Related Musculoskeletal Disorders (WMSDs) are quite common in this sector. Investigations are done in different sectors like brickmaking [1], bangles and sculpture making[2], stone painting [4], Minerals Industry[5] although investigations in a saw mill involving manual lifting and working indicating that there was poor standing and lots of deviated wrist positions, accompanied by forceful exertions. Saw-filer position was chosen for assessment and study gave the high rate of upper extremity MSIs observed during the period reviewed visits [6]. But a lack of study on the postural analysis of the saw mill workers was observed in this region. The workers are subjected to the high noise of the horizontal and vertical band saws for

durations above the safe limit. The workers also carry heavy loads on a regular basis causes health problems, apart from other improper work postures. Since it's a cluster industry in this region and employing many, it's necessary to analyse the sector and to identify the hazards and the level of risk implicit in performing the required tasks.
Saw mill is an unorganised sector here in this region, there is no specific worker assigned for labour work. The labours are assigned on the daily wages basis. Through the dialogue and questionnaires it was observed the nearly 80% of the workers suffered pains in thighs, legs and back and nearly 50% suffered the pains in arms and shoulders[Table 3]. Thus it appears that to date there is dearth of data in the Indian scenario about the different risk factors associated with saw mill. This study was an attempt in that direction.

II. METHODOLOGY

A. Questionnaire and interview technique

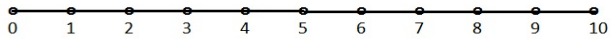
The questionnaire comprised questions pertaining to different problems related to a particular task such as: normal daily activity; discomfort in the different body parts; working hours; resting periods; and total working duration. NIOSH discomfort survey [7] was used for mapping the different areas of pain with its intensity in the body along with the factors like duration and frequency. Also NORDIC musculoskeletal questionnaire was used to analyse areas of pain and their occurrence in the past.

B. Direct observation and activity analysis

Modified form of Drury's (1990) direct observation and activity analysis was applied. The activities in unorganised sectors are varied as compared to those in organised sectors like banking or manufacturing for which the original work has already been devised. In this case the subjects were observed in actual working condition and data from this was used for postural analysis for assessing risk factors for WMSDs on the lines of the work done by other researchers in the unorganized sectors like manual brick manufacturing [1].

C. Visual Analogue Scale

The Visual Analog or Analogue Scale (VAS) [8] is designed to present to the respondent a rating scale with minimum constraints. Respondents mark the location on the 10-cm line corresponding to the amount of pain they experienced. This gives them the greatest freedom to choose their pain's exact intensity. It also gives the maximum opportunity for each respondent to express a personal response style. The VAS frame measures exactly 10 cm. The distances from zero to the markings in cm are result indicators to be processed as continuous variables for statistical analysis.



No Discomfort *Worst Imaginable Discomfort*

D. Postural analysis

Different techniques were applied for postural analysis of work related musculoskeletal risk factors. These methods were Rapid Entire Body Assessment (REBA) method [9] . This method was specifically developed to be useful for assessing MSD risks/working postures found in healthcare and other service industries. However, it can be used to assess a variety of tasks, in any setting, where: the whole body is being used, the posture is static, dynamic, rapidly changing, or unstable, or animate or inanimate loads are being handled either frequently or infrequently; and Rapid Upper Limb Assessment Method (RULA) method [10]. RULA is a quick survey method for use in ergonomic investigations of workplaces where MSD's are reported. It is a screening tool that assesses biomechanical and postural loading on the body. It focuses on the neck, trunk and upper limbs, and is ideal for sedentary workers.[10]. It is a simple, quick and easy to complete. RULA scores indicate the level of intervention required to reduce MSD risks. It compliments other ergonomic methods. Apart from this Strain Index devised by Moore and Garg (1995) was applied. To get employee's perspective for better analysis Quick Exposure Checklist (QEC) [11] was applied as well. QEC has been designed to- assess the change in exposure to musculoskeletal risk factors before and after an ergonomics intervention. QEC involves both the practitioner (observer) and the workers (who have direct experience of performing the job) in conducting the assessment and identifying the possibilities for change. QEC includes the assessment of the back, shoulder/upper arm, wrist/hand, and neck, with respect to their posture and repetitive movement. Information about task duration, maximum weight handled, hand force exertion, exposure to vibration, the visual demands of the task and subjective responses to the work is obtained from the worker.

E. Noise Assessment

Noise is an unwanted or damaging sound that may damage your hearing and cause other health effects such as stress, hypersensitivity to noise, increased blood pressure and increased heart rate. It can also interfere with communication at work, which could lead to accidents. Noise-induced hearing loss is one of the most common occupational injuries, resulting in health problems for many workers and it presents a significant social and economic cost.[16]. Noise has a major effect on one's performance at work, since a peaceful environment may result in good mood and hence in good output from the worker whereas lot of noises over long time may cause hindrance in the work output of the worker. Band saws are widely used in the wood industry. Without any measures to reduce noise at source, they can produce noise levels of over 85 dB (typically 100dB at the operator position). At this level of noise, an employee's daily personal noise exposure is too high well above the OSHA's set limits of 85dB at operator's level for 8 hrs [11], as inferred from this study.

III. RESULTS AND DISCUSSION

A. Questionnaire and interview technique

Table1: **General physical information of the workers, n=30**

Variables	Workers of Sawmill Mean (SD)
Age (years)	33.1 (± 8.61)
Height (cm)	165.39 (± 3.7662)

Table 2: **Mean duration of work and rest per day with average number of working days in a week**

Workers	Duration of work per day (in hour)	Duration of rest per day (in hour)	Number of absent in a week (in days)	Number of working days in a week
Saw mill worker	11(± 2.38)	1.5(± 1.0)	2.1 (± 1.08)	6

Table 3: **Discomfort feeling (pain) at different body parts among saw mill workers, (n=30, NIOSH discomfort survey)**

Number of affected workers	Different body parts				
	Neck	Shoulder	Wrists	Hand	Low Back
Pain	22 (73%)	14 (47%)	23 (77%)	20 (67%)	26 (87%)

NIOSH's discomfort survey was used for mapping the different areas of pain, the results also showed that the discomfort frequency among the workers was frequently i.e. once a week for almost 65% of the workers, and discomfort intensity of severe among 33% workers and moderate among 47% and mild among the 20% workers, the duration of intensity was observed to be within 1 to 24 hrs among 75-80% of the workers. Also NORDIC questionnaire suggested that pain was common among the workers of saw mills and was being experienced frequently during last 1 year. This indicates the problem of MSDs is serious in saw mills and must be attended very soon.

B. Direct observation and activity analysis on 30 workers.

The typical south Indian saw mill comprises of a general manager in charge of the plant, assisted by the plant superintendent. The following men report to the superintendent: saw mill foreman, master mechanic, bookkeeper, and shipping clerk. Most work at the saw mill is done manually without much use of powered vehicles. In nearly 80 sawmills in this region all movement of the logs from unloading section to the carriage, from carriage to the delivery point is done manually, many such manual activities were observed for few minutes to 2 hours at a stretch for both seated and standing position of the workers. The work involved predominant effort from the trunk and arms. The work in a typical saw mill starts right from the unloading of raw wooden logs (up to 5 quintals) into the unloading section of the mill. Then these logs are moved to the horizontal band saw with the help of levers as shown in figs. 1 & 2.

Fig. 1 Worker moving the log manually Band saw

Fig. 2 Worker moving the wooden logs on the horizontal

Pictures 1 & 2 shows worker moving the log of wood in the horizontal band saw with the help of levers. From these postures this can be inferred that the due to heavy load of the log there is lot of stress on the back and arms of the worker which is substantiated by the REBA score of '9' which indicates high risk and a need of immediate ergonomic intervention. This method of moving the logs with the help of levers is the only means of moving the logs apart from the hand carriage vehicle; no powered vehicles are used for this purpose. A worker has been seen moving these logs frequently from the unloading point to the carriage of horizontal band saw.

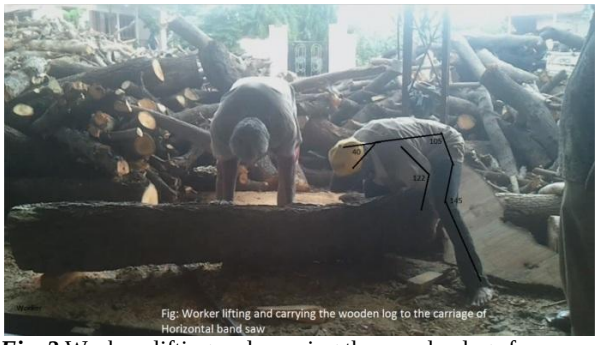


Fig. 3 Workers lifting and carrying the wooden logs from Unloading area

Fig. 4 Workers bending and lifting the heavy logs frequently.

Figures 3 & 4 are more examples of improper postures of the workers in moving the logs, With REBA scores of '10' and '9' respectively, further more from the picture it is observed that the frequent bending to lift the log is hazardous to the back in long run, both indicating the need of immediate ergonomic intervention.

After the log is placed on the carriage of the horizontal band saw the operator is constantly required to provide the motion to the carriage using the rotating lever so that the saw blade of the band saw does the required cutting.

Fig 5.Worker moving the carriage of band saw using lever

Figures 5. shows the operator moving the carriage using rotary lever. It was observed that QEC would be better tool as it includes both observer's assessment and worker's assessment. It was seen that the total score was '70' suggesting further investigation. The worker is required to be seated without the back support and constantly move the carriage for prolonged time.

After the first cutting of complete log, the carriage of band saw is returned by the worker as shown in figure 6 and the feed is given to the saw blade or in other words the saw blade of the band saw is lowered by the operator as shown in figure 7. Applying RULA on the fig 8. Gave the score of '7' suggesting high risk and immediate need of change, although not for prolonged time but this is done frequently say every 10 mins, for every cut on the wooden log.

Fig 6.Workers manually moving the carriage

Fig 7.Worker giving the feed to the horizontal band saw

In case of small wooden logs chain saw and vertical band saw machine is used instead of horizontal band saw as shown in pictures 8 and 9 respectively. Both the postures giving the REBA scores of 3 and 7 respectively. While observing the employee using the chain saw it is inferred the either of the shoulder is abducted or raised causing a hazardous posture which may result in MSD's.

Fig 8.Worker working on the vertical band saw

Fig 9.Worker using the chain saw to cut the wooden logs

For the cutting operations to carry out smoothly the blades of the saw machines needs to be constantly sharpened using files and grinders. Figure 11 shows the worker sitting without a back support and arm support and grinding the saw blades for smoother cutting. Fig 12 showing the worker providing the zigzag pattern to the blades of the vertical band saw because it pushes the wooden log down on the work table, this is done after almost every hour. Applying strain index for the clip of cycle duration 78 seconds the strain index for right hand is much high i.e. above 60 and for left hand is below 3. Hence safe for the left hand but unsafe for the right hand.

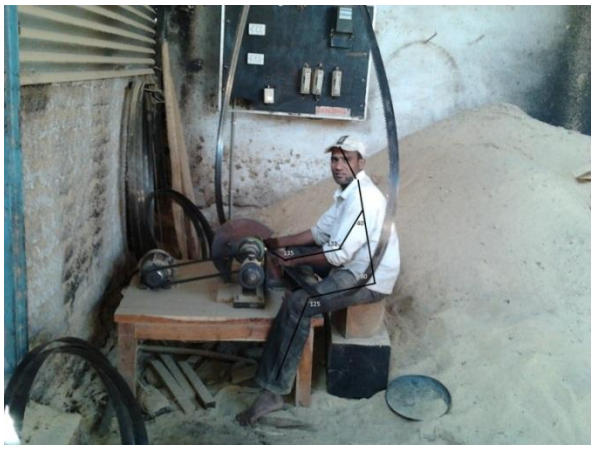


Fig.10 Worker grinding the saw blades

Fig. 11Worker giving zigzag pattern to the saw blades

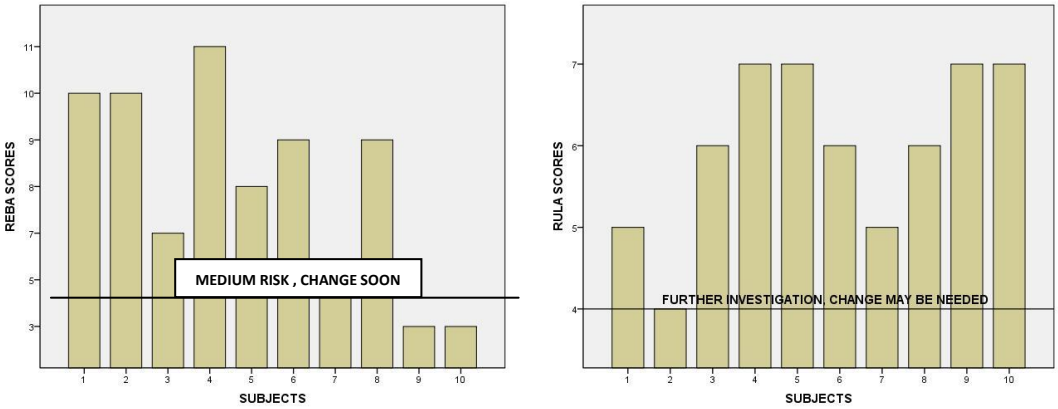
C. Visual Analogue scale

Table 4: **VAS rating among Saw mill workers**

Study groups	VAS rating
Saw mill worker	6.94 ± 1.38

Respondents were asked to mark the location on the 10-cm line corresponding to the amount of pain they experienced. This gave them the greatest freedom to choose their pain's exact intensity. It also gave maximum opportunity for each respondent to express a personal response style. Table 4 shows the Visual analogue scale ratings for a sample of 25 workers and a mean score of 6.94 indicating a high intensity of pain.

D. Postural Analysis.



The above graph shows the RULA and REBA Scores for 10 subjects, it indicates that posture scores of most workers are well above the assumed safe scores hence immediate change or ergonomic intervention is needed in the current workplace. Rapid Entire Body Assessment (REBA) (Hignet and McAtamney, 2000) and Rapid Upper Limb Assessment (RULA) (McAtamney and Corlett, 1993) working posture analysis were used to analyse the postures and the associated risks. REBA scores (Table 1) were very high (11/11) in the sections where log shifting is done manually by the workers. RULA scores were consistently high in all the sectors. Average RULA score was 6 and Strain Index (Moore and Garg, 1995) was applied to get an insight into repetitiveness of the job and the resulting strain on the limbs. Value was very high in the sharpening operation on the saw blade (70), The results of this study revealed that the saw mill workers are engaged in rigorous hand intensive jobs, leading to various MSDs primarily affecting the upper extremity of the body. It can be observed from the present study that work-related incidents affect different body parts of the workers. This has also lead to a high rate of workday loss. It has also been observed that unskilled workers fail to keep their commitments because of absenteeism.

E. Noise Assessment

Noise measuring equipment	: Sound Level Meter
Manufacturer	: LT Lutron.
Model	: SL-4001.
Range	: 35-130 Db. in 3 Ranges.
Accuracy	: ±3 dB.
Microphone	: ½ Inch electric condenser microphone.
Power	: 9V battery powered, DC 6 mA.

Table 5: **Noise measuring equipment specs.**

Noise levels generated by sawmill saws in operation have been reported to vary from 80dB(A) up to 120dB(A)[12].Not only cutting noise is very high, there is also the additional factor that, even when idling, saws can produce noise levels up to 95dB(A).It is well recognised in industry that noise is a serious problem with saws. One of the unique features of the noise associated with wood product plants is its intermittent nature. The noise exposure level at which precautionary actions are required to prevent hearing loss. OSHA defines the Action Level as an 8-hour time-weighted average noise exposure of 85 dBA. According to OSHA regulations, noise exposures at or above this Action Level require follow-up measures that include noise monitoring, annual audiometric testing for exposed employees, hearing protection, training and recordkeeping.

The observations on the saw mill showed that the workers were exposed to sounds of 90-100 dB for more than 6 hours daily.

Equipment	Sound in dB(A) range	Point of observation	Average duration of operation in hours
1. Chain saw	87-90	Operators ear level.	5
2. Horizontal Band Saw	92-95	Operators ear level.	9
3. Vertical Band Saw	95-100	Operators ear level.	8
4. Both HBS & VBS	94-98	5 ft. from both machines	8

Table 6: **Noise in decibels at different observation points.**

As it is evident from the above table that the workers are exposed to the noise above the set limits of the OSHA hence it can be deduced that the workers are at risk to noise induced hearing loss. It is suggested to use personal protective equipments (PPEs)

IV. CONCLUSIONS

From above discussions we can conclude that unawareness about ergonomics is observed in industry in which work is undertaken. Musculoskeletal disorders are present in the various activities carried out in saw mills where a significant number of workers are working in bad postures and it shows that there is a need to change the body postures. On the basis of analysis of results and scores obtained by the various tools applied in analysis of the working conditions and postures, it can be concluded that, there is a lack of ergonomics planning and methods in small scale and unorganised saw mills which are very large in numbers and employ thousands of workers. Thus the workers are under moderate to high risk of Musculoskeletal disorders (MSDs). The average scores of both the RULA and REBA are high and percentage of scores for neck and trunk are high for the subjects analysed, and this evaluation shows that there is a need of investigation and immediate changes are needed in the workplace. The techniques like strain index which considers the factor of repetition also revealed the work is done frequently without desired breaks, and attentions to safe work environment and organization are not adequate. Right tools are not available to carry out effective routine maintenance. Most operations carried out in the mills are largely supported by manual handling which often results in overexertion and a long term health hazards. Personal Protection devices such as earmuff or plug, hand gloves are not used adequately and are often considered as irrelevant and disturbing. Dust and wood wastes are not properly disposed. This was evident from heaps of wood shavings and saw dust accumulation around saw milling machines. Training is also important: to train and to inform operators about the correct positions and the manual movement techniques may reduce many incorrect postures

The noise produced in the both the saw mills is above the desired limits and it should be reduced. Finally it was observed that none of the companies had any safety policies, materials, etc., in place, but a work methodology of most economical ways was followed irrespective of its effect on the workers. Focus should be on these challenges in practical terms to form a safety legislation, comprehensive systems approach and monitoring group in the industry to guide the management in the implementation in order to reduce or eliminate workplace hazards. The present study recommends that p there is dire need of implementation of ergonomics interventions with proper awareness among workers.

In developing countries like India, the scale of use of human resources in small- medium scale in labour-intensive industries is enormous. In this situation, it must be obvious that very small improvements in working conditions, implements, tool design or working methods can lead to large benefits. It is believed that occupational health programs should focus more on the informal sector, which employs a large proportion of workers. Paying attention to occupational health and safety in this sector and improving working conditions will undoubtedly have considerable impact on the national economy and the quality of people's life.

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