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Original Research Article

Analysis of posture and discomfort feelings of grinders in different foundries in West Bengal

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ABSTRACT

Background: The most essential part of manufacturing the products is grinding. Health and safety of workers are the most important issues in this unit now a days. High productivity as well as maximum turnover is the highest interest of these units. Target oriented work puts some pressure on the workers that also increase their muscular and body stresses.
Methods: The research work was done in different small-scale grinding units in West Bengal. The snap shot of 20 workers in different grinding units was obtained and evaluated with the help of rapid upper limb assessment. NIOSH's discomfort survey method was used for mapping the different areas of pain, dissatisfactions during the operation. Heart rate and postural stresses were also noticed.
Results: This research work also shows that the poor working conditions enhance the body stresses and the discomfort level of grinders. The highest heart rate also indicates the poor health condition of grinders. Poor environmental conditions, specially noise and heat were common in grinding units.
Conclusions: It can be concluded that MSDs were present in the activities carried out in grinding units where the major number of workers were involved in bad body postures. This research work also shows that the poor working conditions enhance the body stresses and the discomfort level of grinders.

Keywords: Discomfort feelings, Health status, Posture analysis, Rapid upper limb assessment, Stress analysis

INTRODUCTION

Suitable working environment, appropriate occupational hygiene and proper postural methods of the workers are very much neglected in different foundries in West Bengal. The most essential part of manufacturing the products is grinding. Health and safety of workers are the most important issues in this unit now a days. High productivity as well as maximum turnover is the highest interest of these units. Target oriented work puts some pressure on the workers that also increase their muscular and body stresses. Grinders are very much involved and also do their work in very bad work postures in this unit. The grinding is performed on kneeling posture and the grinder has to sit and perform the operation on a fixed jig and fixture on the ground continuously.[1,2] Uncomfortable as well as unergonomic work postures create pain in the different joints, ligaments and muscles among grinders. If no ergonomics alertness taken among grinders, more rapidly work-related diseases will come and musculoskeletal system will be collapsed. The Work-related musculoskeletal disorders (WRMDs) occurred due to the unscientific workstation design and negligence of Ergonomics measures.[3,4] Proper ergonomically design of work-station can increase the productivity, integration, worker comfort, worker variety and security & safety up to a certain extent. Work postures as well as physical load of grinders can be measured and evaluated by using rapid upper limb assessment (RULA) method.[5] There is a particular attention to the neck, trunk and upper limbs of the worker's body for postural and whole-body load calculation. The objective of this research work was to investigate occupational health of grinders engaged in different grinding units in West Bengal. The higher score of RULA indicates that posture was not granted for occupational health and safety of the grinders.[6,7] NIOSH's discomfort survey method was used for mapping the different areas of pain, dissatisfactions during the grinding operation. High intensity of postural stresses also indicates that body posture was not safe. Product quality and efficiency of the grinders will be reduced and body fatigue, muscular pain should be increased if no ergonomic intervention among grinders is taken. Proper planning and scientific body postures of grinders can reduce these problems and improve the health condition of the grinders.[8,9] The appropriate Ergonomics guidance and awareness programs amongst workers are essential to overcome work related musculoskeletal problems that will help to improve health and physical capabilities of the grinders and finally the quality of jobs.[10]

METHODS

The research work was done in different small-scale grinding units at Howrah in West Bengal. The study was started in the month of March 2018 and was continued up to June 2019. The snap shot of 20 workers in different grinding units was obtained and evaluated with the help of RULA. NIOSH's discomfort survey method was used for mapping the different areas of pain, dissatisfactions during the operation. Heart rate and postural stresses were also noticed.

Postural assessment

Different techniques were applied for analysis of body postures of grinders. This tool can be used to assess a variety of tasks, in any sitting position where body posture is static, dynamic or rapidly changing. This method is quicker survey method for use in ergonomic interventions of workplaces where MSDs are reported. This assessment method can access bio-mechanical and postural loading of the worker's body.

RULA analysis

This method was developed by Lynn Mc Atamney and E Nigel Corlett in 1993. It helps to examine Ergonomics especially upper limbs of the worker's body in the work places. Musculoskeletal loads of the workers can be evaluated due to body postures, motion-repetition and force. No special equipments and tools were required for this assessment. An action was generated by using a coding system which indicates the level of intervention necessary to decrease the risk of injury due to physical loading of the workers.[11,12] This method accomplished these goals by providing a "grand score" that can be categorized by action levels. Upper scores indicating urgent changes to be made in the body posture for reducing muscular fatigues and also for improvement of job quality.

Questionnaires and interview technique

The questionnaires consist of questions pertaining to different problems related to this particular operation. Daily activity of the worker, discomfort level of different body parts, working and resting periods were plotted and calculated. NIOSH body discomfort survey was used for mapping and plotting different areas of pain of the body parts with its intensity. Body discomfort level can also be calculated with the help of this method.

CAD model of human body

Figure 1 indicates the actual work posture of the grinder. 3D model of the human body was developed with the help of solid works software (Figure 2). The model was exposed to ANSYS for analysis of stresses. The upper part of the grinder's body was directly involved with the grinding operation. The upper part of the body i.e. trunk, clavicles, upper arm, fore arm, neck and hands were connected by anatomically motivated to restrict articulations. These are pelvis, neck, sterno clavicular joints, shoulders, elbow and wrists. The upper part of the body provides twenty (20) degree of freedom: DOF for each neck joint is three, three for each shoulder, three for pelvis, two for each elbow and two for each wrist.

Figure 1: Actual working posture of grinder.

Body stress calculation

Body discomfort and injuries are associated with different joints of the human body. To get accurate results, the distribution of stresses in different body parts, muscles and joints in a specific work posture and particular work load is required. It is important and also necessary to develop realistic models to understand the performance of the human body. The muscle stress during the grinding was studied in details by developing a 3D model in Solid Works software and analysis of body stress and muscles is done in ANSYS-R17.0 software. The FEM analysis was done in ANSYS-R17.0 software to get von Mises stresses at particular load and work posture.

Heart rate analysis

To get accurate results, the heart rate in a specific work posture and particular work load is required. The heart rate of grinders during grinding was taken with the help of heart rate monitor and also analyzed.

Sampling technique

After the selection of sites, extensive interaction was carried out with different activities of foundry task. During these, interactions of workers were motivated to cooperate as required by the design of the study, after careful and repeated follow-up a total number of 20 workers were selected for the study.

Inclusion and exclusion criteria of samples

Selection of subject in this investigation was made randomly. It was again stratified based on age, gender, lifestyle etc. Each and every subject as well as management of workplace of this investigation were briefed about the objectives of the study. It is interesting to note that all the management agreed to cooperate, but certain employees did not agree to participate. According consent was taken from each subject. It may be further mentioned that even after covering 8 subject numbers of samples, some of the data had to be described due to some problem like other disease, due to the age range and number of years of their occupation. This had to be discarded as it did not match with the selection criteria as mentioned below. The age range of the sample is between 20 to 48 years. The sample which is engaged for last 2-years or more years in these industries has been taken for calculation. The sample was a past history of musculoskeletal trauma and diseases and/or other diseases affecting their musculoskeletal systems are not included in my study. Now 20 numbers of subjects had been selected for the study.

Framework and flow chart

Occupational safety & health are the major concerns in small scale units to improve the productivity and job quality. Some of the common problems are improper design, mismatch between worker abilities & job demand and adverse environment. It has been noticed that human factors improve the productivities, workers' health, safety and job satisfaction. From this frame work and flow chart (Figure 3), it is clear that ergonomically designed work stations can reduce muscular problems, physical fatigue and will improve workers' health. Proper ergonomic knowledge, planning and awareness can also reduce physical and mental stresses.

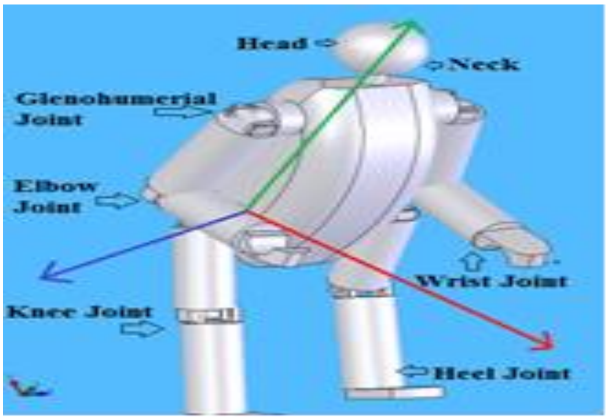

Figure 2: CAD model of grinder with different joints.

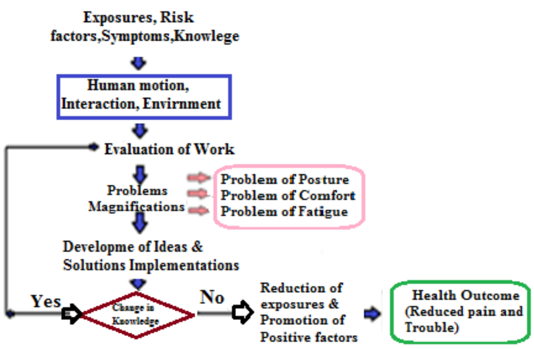

Figure 3: Flow chart of health outcome of grinders.

RESULTS

The result of RULA score indicates that the working postures of most of the workers were above the line indicated in the (Figure 4). An immediate change of Ergonomic intervention was needed of the grinders. The result of this study revealed that the grinding workers were engaged in manual handling jobs, leading to various muscular disorders primarily affecting the upper part of the body.

Table 1: Demographic data of the grinding workers (n=20). Values are presented as Mean ± SD (range).

Parameters	Grinding
Height (cm)	164.5±3.1 (160-172)
Weight (kg)	57.5±7.75 (47-72)
Age (Year)	30.6±8.29 (18-53)
Experience (Year)	11.45±7.50 (2-33)
BMI (Kg/m)	21.21±2.60 (17.21-25.51)
BSA (m^2)	1.61± 0.10 (1.47-1.81)

Table 1 shows the demographic data of the grinding workers (n=20) and the values are presented as mean±SD (range). Table 2 also shows the resting and working physiological characteristic of the workers. The values are presented as mean±SD (range).

Table 2: Resting and working physiological characteristic values are presented as Mean ± SD (range).

Parameters	Grinding
Resting Heart Rate (bpm)	71±2.24 (68-76)
HR Max (bpm)	189± 8.29 (167-202)
Heart Rate Reserve (bpm)	118±9.28 (97-132)
Resting VO_2 (ml/Kg/min)	9.20± 1.26 (2-33)
VO_2 Max(ml/Kg/min)	38.11±5.96 (26.18-48.75)
Resting Body Temp (^{0}F)	98.5± 0.25 (98.10-99.00)
Working HR (bpm)	113± 11.12 (94-133)

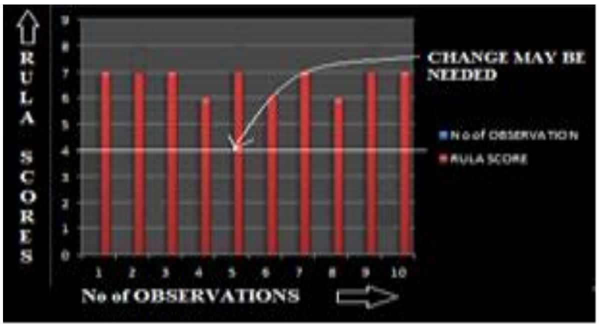

Figure 4: RULA score of grinders.

Software ergo-fellow was used for plotting the different areas of pain, dissatisfactions of the grinder's body during grinding operations. Figure 5 indicates the discomfort, frequency in different body parts of the grinders.

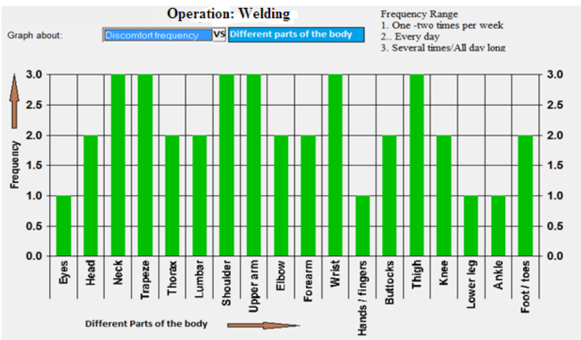

Figure 5: Discomfort frequency in different body parts of grinders.

More than 80% of the grinders were getting affected in their wrist, hand, trapeze and neck due to unsuitable position of electrode holder, body posture and unergonomic man machine interface.

Based on heart rate, Figure 6 shows the pie-chart which indicating the percentage of time spent in different work load in grinding operation of the workers.

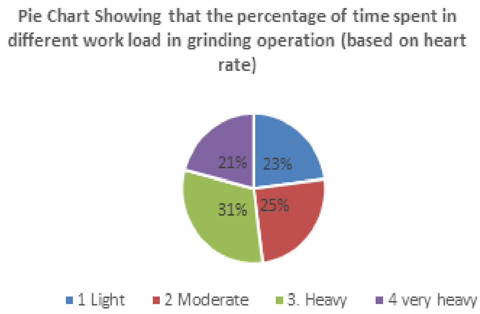

Figure 6: Pai-chart during grinding operation.

DISCUSSION

A poor posture contributes to stress and stress donates to poor posture. When the body is stressed, the muscle of human body tense up.[13,14] The different joints and muscles of the human body are the most affected parts due to poor posture. Sitting in a slouched position on the shop floor for an extend period of time put a great deal of the stresses of upper as well as lower body specially if the grinder body is not supported.[15,16] Poor work posture increases body stresses and other physical problems as well. The human body is designed to stand strong and erect, effortlessly. Poor posture leads to back pain during grinding in a long period of time. The three-dimensional finite element model consists of 13810 elements which are connected through 25837 nodes.[17] The stress contour map revealed that the maximum intensity of stress varied from 4.3656×108 Pa to 1.6371×107 Pa for particular work posture and load (Figure: 7). Node numbers 6460 to 7600, 13919, 17371 mark highly stressed denoted by red colors. Stress intensity vs node number is also shown in the (Figure 8).

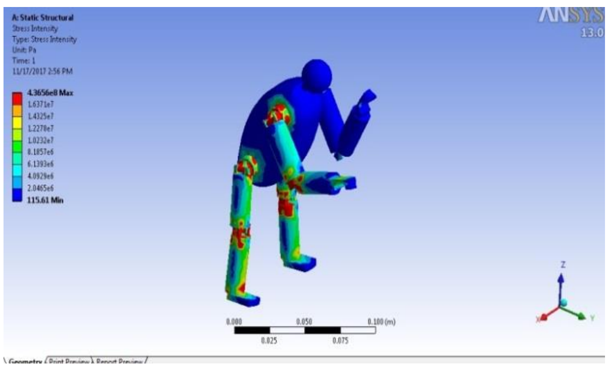

Figure 7: Stress intensity distribution patterns of grinder.

Figure 9 indicates heart rate in bpm of the worker with respect to time in minutes. In the last 40 minutes the heart rate increased markedly for being in an awkward work posture for a long time. The rate in the 1st working zone is within the acceptable range, which exceeded beyond the severe level due to inappropriate body posture.

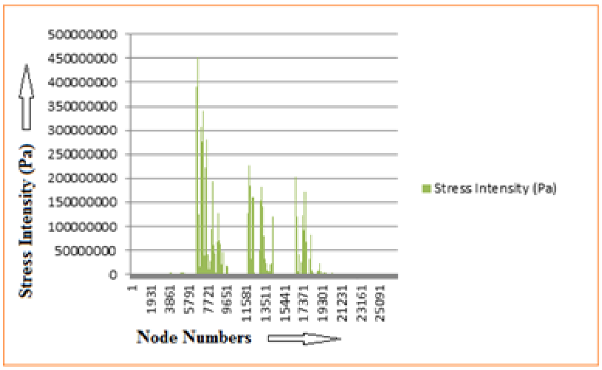

Figure 8: Stress intensity vs node number.

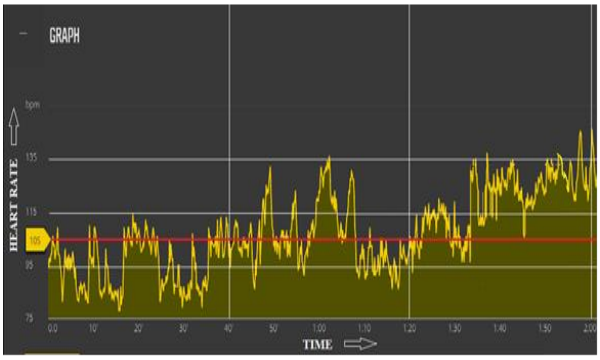

Figure 9: Heart rate vs time during grinding operation.

Limitations

In this research work, cardio-vascular strain in terms of cardio-acceleration stress of angle grinder was studied. Therefore, similar types of analysis and studies like swing frame grinders may be conducted in the future. This research work would be very useful for the workers working in any MSME unit. The grinding activities in the foundry of the private organization were studied. The grinding activities in the foundry of government organization of grinders and large units may be studied in the future.

CONCLUSION

The optimization for postural prediction, heart rate analysis, stresses in different body parts, discomfort of different joints were presented in this research work. It can be concluded that MSDs were present in the activities carried out in grinding units where the major number of workers were involved in bad body postures. This research work also shows that the poor working conditions enhance the body stresses and the discomfort level of grinders. The higher heart rate also indicates the poor health condition of grinders. Poor environmental conditions, specially noise and heat were common in grinding units. The analysis indicates that immediate change in body posture was needed for a healthy working environment. The modified and redesigned workstation may reduce the score RULA, body stresses, level of body discomfort and increase the quality of work.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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