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# Study and Validation of workers posture in transformer manufacturing industry through RULA

**Abstract**— This Study is about the evaluation of the workstation to improve the productivity by reducing the lower back pain, shoulder injury, fatigue etc. Musculoskeletal disorders (MSDs) continue to be a tremendous burden in industry with back injury and shoulder disorders being among the most common and costly disorders because of not having proper workstation. In industrialized countries, upper limb work-related musculoskeletal disorders (UL-WMSDs) are the most common form of occupational diseases. They are generating a growing population of workers with reduced working capacity. The link between these pathologies and different aspects of work organization has been convincingly proven. Productivity is an important indicator of economic growth and social health. High performance and productivity require the right sitting posture. So for considering this factor operator needs proper seating arrangement such that their problems regarding the MSDs can be reduced & productivity will be increased. It is revealed that the suggested workstation improves working posture and results in reduced postural stress on operators' bodies and, consequently, reduce prevalence of MSDs symptoms.

**Index Terms:** Ergonomics Evaluation, Musculoskeletal Disorders, Workstation Design, UL-WMSDs, RULA

## I. INTRODUCTION

Work-related musculoskeletal disorders (WMSDs) are one of the greatest occupational health concerns today. Of the many types of WMSDs, low back disorders (LBDs) are the most prevalent and by themselves constitute a major health and socioeconomic problems [1]. Decades of research has identified certain physical workplace factors that increase the risk for MSDs. Perhaps nowhere is the problem of stooped and squatting posture of greater magnitude than in developing countries such as India [1]. An adaptation of such postures is frequently observed in small scale industries in India. The evaluation of the workstation to improve the productivity by reducing the back pain, shoulder injury, fatigue etc. Productivity is an important indicator of economic growth and social health. High performance and productivity require the right sitting posture. In industrialized countries, upper limb work-related musculoskeletal disorders (UL-WMSDs) are the most common form of occupational diseases [3]. So for considering this factor operator needs proper seating arrangement such that their problems regarding the MSDs can be reduced & productivity will be increased. Most of the manually energized operations in these industries are evident of such postures. An industry is identified in central India where 91% of operators are suffering from WMSDs. Here is the study of Transformer Manufacturing Industry is being taken where operators working on the German made Coil Winding Machine. The Transformer winding operation is performed on the winding machine on provided stool arrangement which is hard & flat in surface without any backrest. Figure 1 shows the details of posture adapted [5].

The task of winding transformer is repetitive and continuous thought 9 hours of working in a whole day. In this condition back is bent excessively and postures of different parts of a body dramatically deviate from its neutral. Most of the experienced operators leave their jobs because of poor working conditions and musculoskeletal problems. The ergonomic guideline and principles are meant to provide an orientation towards the physiological and psychological need of the operator. The design is essentially a compromise between the operator's biological needs, as determine by the ergonomics guidelines and physical requirements of the equipment [4]. Basically when one sits on hard surface without any backrest, the Ischia tuber sites acts as fulcrum around which the pelvic girdle rotates under the weight of upper body. Regardless of what one sits on, an armchair, stool, an office chair, a car seat or a wheelchair the body is always mechanically affected. How seating is designed always has an impact. Proper fit becomes much more important when it relates to product that a person will be physically interacting with for hours at a time. There is one thing that every health professional agrees on: good posture is critical to longevity and good health. Alexander Techniques Practitioners, Qi Gong and Yoga masters, Neurologists, Fitness expert and Ergonomist all understand that keeping the body in alignment is of utmost importance [6].

The present study had the following objectives.

1. To investigate the prevalence of musculoskeletal problems in operators' population
2. To improve the working condition by suggesting new workstation
3. To assess the working condition improvement

4. Assessment of the new workstation to improve the productivity



Fig.1 A typical working posture adapted in order to perform Transformer winding operation.

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## II. QUESTIONNAIRE

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 was used for mapping the different areas of pain with its intensity in the body along with the factors like duration and frequency. Worker's Assessment with the help of QEC. The Quick exposure checklist (QEC) quickly assesses the exposure to risks for work-related musculoskeletal disorder (WMSDs). QEC is a practitioner's needs and research on major risk factors [7].

QEC gives an evolution of workplace and equipment design, which facilitates redesign. QEC helps to prevent many kinds of WMSDs from developing and educates users about WMSDs risk in their workplaces. So considering the QEC one survey has been conducted. In that survey seven questions are asked to the operators and the operators have to tick on the options which are provided to their checklist.

### Worker's Assessment by QEC

1. What is the maximum weight handled in this task?
  - A: Light (5 kg or less)
  - B: Moderate (6 to 10 kg)
  - C: Heavy (11 to 20 kg)
2. How much time on average do you spend per day doing this task?
  - A: Less than 2 hours
  - B: 2 to 4 hours
  - C: More than 4 hours
3. When performing this task (single or double handed), what maximum force level exerted by one hand?
  - A: Low (e.g., Less than 1 kg)
  - B: Medium (e.g., 1 to 4 kg)
  - C: High (e.g., More than 4 kg)
4. Do you experience any vibration during work?
  - A: Low (or no)
  - B: Medium
  - C: High
5. Is the visual demand of this task-
  - A: Low?
  - B: High?
  - C: Medium
6. Do you have difficulty keeping up with this work?
  - A: Never
  - B: Sometimes
  - C: Often

After this I need to check the answers which are given by the operators so that the operator's problems can be understood. For example we can understand that where is the problem exactly, where is the intensity of the problem i.e. stress, strain, low back pain, shoulder injury, etc. We can understand all this by result and analysis

### III. BODY DISCOMFORT AREA

Musculoskeletal discomfort surveys collect information on the location of discomfort by reference to specific body regions or by use of partial or whole body diagrams that designate specific regions to be assessed. Less commonly body maps are shaded by respondents to identify regions of discomfort. The number of regions targeted varies in relation to the interest of study. [7]

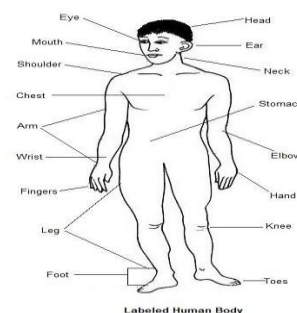


Fig.2 Labelled Human Body

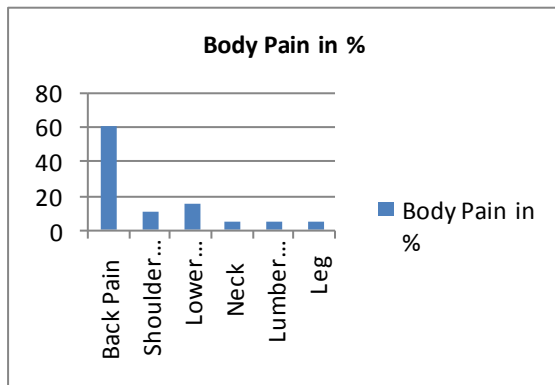


Fig 3: Result & Analysis

IV. POSTURAL ANALYSIS

Different techniques are applied for postural analysis of work related musculoskeletal risk factors. These methods are Rapid Upper Limb Assessment Method (RULA) method and Rapid Entire Body Assessment (REBA) method.

A. RULA

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. It is a simple, quick and easy to complete. RULA scores indicate the level of intervention required to reduce MSD risks [10].

B. RULA ACTION LEVEL

RULA –6 Steps

1. Observe the task  
–photos vs. video
2. Select postures for assessment  
–worst vs. most frequent
3. Score the postures
4. Process the scores
5. Determine final score
6. Confirm action level

Table 1: Rula score with its requirements for action

Final Rula Score	Requirements for action
1 or 2	Indicate that posture is acceptable if it is not maintained or repeated for long period.
3 or 4	Indicates that further investigation is needed and changes may be required
5 or 6	Indicates investigation and changes are required soon.
7	Indicates investigation and changes are required immediately.

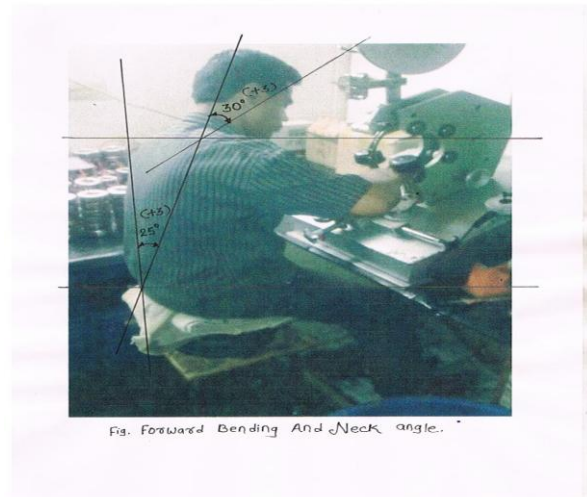


Fig. Forward Bending And Neck angle.

Fig.4 Forward bending and Neck angle



Fig. Upper and Lower Arm Angle.

Fig.5 Upper and Lower arm angle

**RULA Employee Assessment Worksheet**

**A. Arm and Wrist Analysis**

Step 1: Locate Upper Arm Position: +1, +2, +3, +4

Step 2: Locate Lower Arm Position: +1, +2, +3, +4

Step 3: Locate Wrist Position: +1, +2, +3, +4

**B. Neck, Trunk and Leg Analysis**

Step 9: Locate Neck Position: +1, +2, +3, +4

Step 10: Locate Trunk Position: +1, +2, +3, +4

Step 11: Legs: +1, +2, +3, +4

**SCORES**

Table A: Wrist Posture Score

	1	2	3	4
Upper Arm	1	2	3	4
Lower Arm	1	2	3	4
Wrist	1	2	3	4
Final	1	2	3	4

Table B: Neck Posture Score

	1	2	3	4
Neck	1	2	3	4
Trunk	1	2	3	4
Legs	1	2	3	4
Final	1	2	3	4

Table C: Neck, Trunk and Leg Score

	1	2	3	4	5	6	7
Neck	1	2	3	4	5	6	7
Trunk	1	2	3	4	5	6	7
Legs	1	2	3	4	5	6	7
Final	1	2	3	4	5	6	7

Final Score: 5

Fig.6 RULA Employee Assessment Worksheet

## V. APPLICATION OF RULA

After investigating the MSD's through the questionnaire in the industry, it has been observed that there is need of investigation. So with the help of RULA the postures are evaluated for finding the severity of the problem. Figure shows the pictures of workers use angles are evaluated by graphical method and which are evaluated through RULA; it consists of two areas for assessment of whole body which is divided into Posture A & Posture B. This method investigates body parts as upper arm, lower arm, wrist, wrist twist, neck, trunk and limb. The working postures of the workers and the angle at which they are working are recorded by taking photographs. Graphs are made on the photograph to find the angle of posture so that it can be evaluated through RULA. From fig.4, it can be observed the upper arm and lower arm angel of the workers posture and by selecting the related position of the mannequin in the worksheet of the database of RULA the score of '+3' and '+2' has obtained respectively. While working the shoulder get raised and arm get abducted so it gives score of '3' individually and it will be get added to the previous score. So the final score of upper arm is '3'. In the same way for lower arm, by selecting the mannequin score of '2' has been obtained and as the arm is working across midline of the body and. while working worker has to move the arm out to the side of the body. So the grand score of the lower arm is '+2'. From figure 3, we can observe the neck angle of the posture of the worker and related to that the mannequin from worksheet is selected and it gives the score '+3'. Now the neck movement forwarded to the operation of the transformer winding. Figure 3 shows that the worker is bending on the operation side while working, so the neck side bend gives score of '+3', inclination of trunk gives the score '+3'. So the final score of neck is '+3' and the trunk score is '+3'.

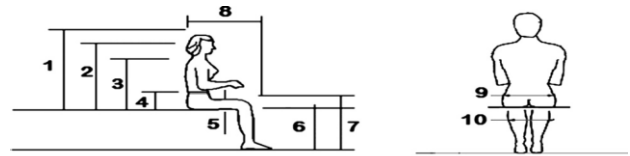
So considering all these factors or postures from section A and section B we will get the final score '5'. Final Score '5' indicates that, "investigation and changes are required soon."

## VI. SITTING PARAMETER

- Chair back strength of 150 pounds.
- Chair stability if weight is transferred completely to the front or back leg.
- Leg strength of 75 pounds applied one inch from the bottom of the leg.
- Seats strength of 225 pounds dropped from 6 inches above the seat.
- Seat cycle strength of 100,000 repetitions of 125 pounds dropped from 2 inches above the seat
- While sitting upright, your elbow should be at 90 degrees angle. If they are not, move your seat up or down. If you use armrest, they should be high enough to slightly lift arms at the shoulder to take stress of your neck and shoulder.
- If you are sitting at a computer with your head facing forward, your eyes should be aimed at the centre of computer screen. If your screen is higher or lower than your gaze, raise or lower it accordingly.
- Your feet should be flat on floor with 90 degrees angle at knees. You should be able to slide your fingers

easily under your thigh and slide your fist behind your calf and front of your chair. If you cannot do these things, you can prop your feet up with a footrest or add a lumber support to the back of your chair.

- Your ears should be aligned over your shoulder.[10]



1	Sitting Height
2	Eye Height
3	Shoulder Height
4	Elbow Rest Height
5	Thigh Clearance
6	Popliteal Height (Stool Height)
7	Knee Height
8	Buttock-Popliteal Length
9	Hip Breadth
10	Knee-to-Knee Breadth

Figure7: Anthropometry Measurement

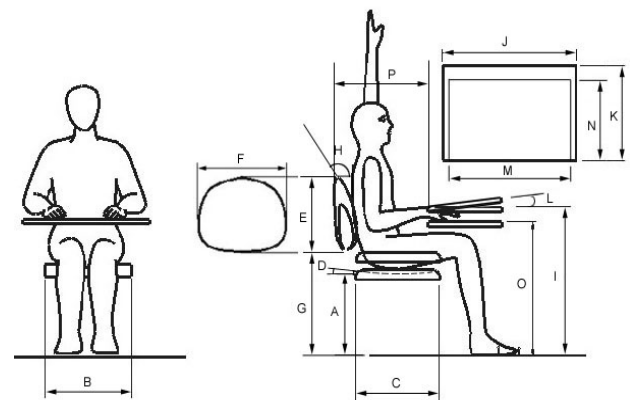


Figure8: Design & development of chair

## VII. CONCLUSION

The body pain in the operator will be minimized due to implementation of ergonomic chair. This leads to increase in productivity and efficiency of the worker. Rest pauses minimizes due to which lead time decreases. Capability and concentration of workers increases due to less fatigue observed.

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