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Ergonomic Design Analysis of Operator's Motions to Reduce Musculoskeletal Disorders

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Abstract - *The posture of workers while completing the tasks assigned to them is an important aspect when it comes to calculate efficiency, productivity and safety of the worker. This dissertation concentrates on systematic study of ergonomic assessment tools such as Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA) for mapping Musculoskeletal Disorders (MSDs). The advantages of these tools are sensitivity for musculoskeletal risks by classifying the bodies to the parts (wrist, upper arm, lower arm, neck, trunk, and legs); useful for manual tasks risk assessment, proposes the prioritization for corrective measures according to risk assessment and risk level. The detailed step wise procedure is followed to carry out the calculation which finishes with determining the risk factor so that preventive actions can be carried out.*

Key Words: Posture, safety, ergonomic, RULA, REBA, Musculoskeletal Disorder, risk level

1. INTRODUCTION

1.1 Ergonomics

The efficiency of people in their work environment is termed as Ergonomics. The psychological and physical behavior of workers during the work process is studied under Ergonomics. Assessment of Human capabilities during the work gives the Operator data. Small scale industries in countries like India play an important role by hiring the majority of workforce in industries. The most commonly observed physical problem in workers is musculoskeletal disorder. The reason behind this problem is continuous standing of workers and most of the tasks handled manually. When the postural analysis tools such as Rapid Upper Limb Assessment and Rapid Entire Body Assessment were tested on workers, it showed that the workers are working above the secure limit.

1.2 Musculoskeletal Disorders (MSDs)

The injuries or disorders that affect the human body's movement due to problems in muscles, ligaments, blood vessels and discs are called as Musculoskeletal Disorder. Repetition and Stress are the key elements resulting in Musculoskeletal Disorder.

Symptoms of MSDs can include recurrent pain, swelling dull aches and stiff joints. Factors like sitting in the same position on each day, lifting heavy weights continuously, improper posture while working and engagement to repetitive motions while working results in wear and tear of Musculoskeletal System.

The quality and productivity of the company can be improved as well as the work related risk can be eliminated by systematic study of Ergonomics.

2. PROBLEM STATEMENT

Less knowledge and awareness about ergonomics in the small scale industries affects the operator's productivity. Work station layout and Work design are the key factors which help to improve operator's work efficiency. The human factor affects technical sphere as well as realm associated with the environment and ergonomics.

Various improper postures adopted by the workers causes' discomfort. This discomfort results in musculoskeletal pain in different body parts irrespective of the age of the workers. The intensity of musculoskeletal disorder depends upon awkwardness of posture.

After taking these issues under consideration, solutions on reduction in stress and fatigue in workers, improvement in productivity, development in ergonomic designs need to be developed and hence detailed study of operator's motion during work is done here.

3. WORKING PRINCIPLE

Two postural risk assessment tools as RULA (Rapid Upper Limb Assessment) and REBA (Rapid Entire Body Assessment) are used to calculate the risk of Musculoskeletal Disorder like pain in joints, muscles or ligaments. The Data regarding postures with high risks is determined by using these tools and the necessary actions for increasing the efficiency and productivity by creating worker friendly environment to avoid injuries and provide safety are executed.

RULA is used for the quick assessment of Upper limb, Neck and Trunk and REBA is used for assessment of working posture concentrating on upper and lower arms, neck, trunk, wrist and legs.

4. RULA AND REBA SCORING SYSTEM

4.1 Arm and Wrist Analysis (RULA)

Step 01: Locate Upper Arm Position.

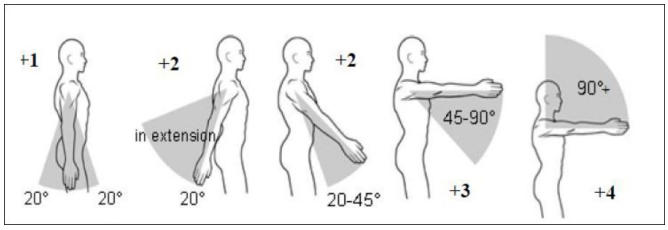

Fig -1: Locate Upper Arm Position

Step 01a: Adjust;
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1
Calculate Total Upper Arm Score.

Step 02: Locate Lower Arm Position.

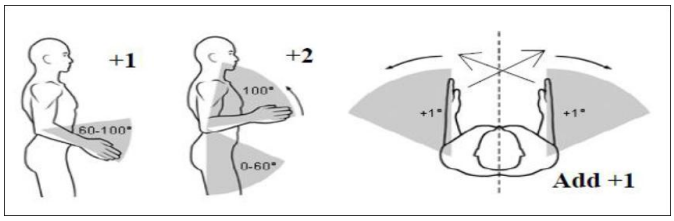

Fig -2: Locate Lower Arm Position

Step 02a: Adjust;
If either arm is working across midline or out to side of body: Add +1
Calculate Total Lower Arm Score.

Step 03: Locate Wrist Position.

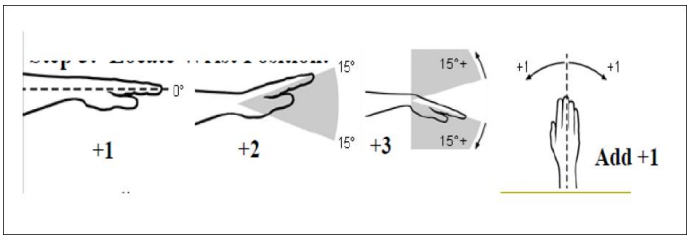

Fig -3: Locate Wrist Position.

Step 03a: If Wrist is bent from midline; Add +1
Calculate Total Wrist Score.

Step 04: Wrist Twist;
If wrist is twisted in mid-range: +1
If wrist is at or near end of range: +2
Calculate Total Wrist Twist Score.

Step 05: Look-up Posture Score in Table 1.
Using values from steps 1-4 below, locate score in table 1.

Step 06: Add Muscle Use Score:
If posture is mainly static (i.e held > more than 10min) or if action repeated occurs 4X per minute: +1

Step 07: Add Force/Load Score:
If load < 4.4 lbs (intermittent): +0
If load 4.4 to 22 lbs (intermittent): +1
If load 4.4 to 22 lbs (static or repeated): +2
If more than 22 lbs or repeated or shocks: +3

Table -1: Wrist Posture Score

	Wrist Posture Score							
Upper	Lower	Wrist Twist		Wrist Twist		Wrist Twist		Wrist Twist	
Arm	Arm	1-- 2		1 -- 2		1 -- 2		1 -- 2	
	1	1	2	2	2	2	3	3	3
1	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
	1	2	3	3	3	3	4	4	4
2	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
	1	3	3	4	4	4	4	5	5
3	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
	1	4	4	4	4	4	5	5	5
4	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
	1	5	5	5	5	5	6	6	7
5	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
	1	7	7	7	7	7	8	8	9
6	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Step 08: Find Row in Table 2:
Add values from steps 5-7 to obtain Wrist and Arm Score.
Find row in Table 2.
Step 05 + Step 06 + Step 07 = Step 08

Table -2: Neck, Trunk and Leg Score

Wrist and Arm Score	Neck, Trunk and Leg Score							
	1	2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

4.2 Neck, Trunk and Leg Analysis (RULA)

Step 09: Locate Neck Position:

Step 09a: Adjust;
If neck is twisted: +1
If neck is side bending: +1
Calculate Total Neck Score.

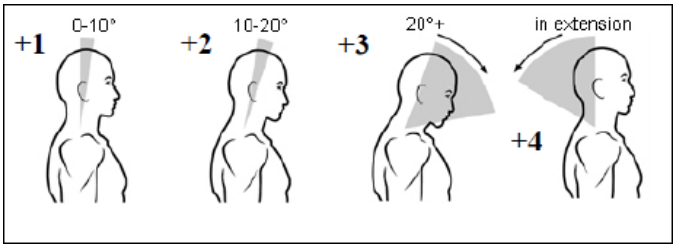

Fig -4: Locate Neck Position.

Step 10: Locate Trunk Position:

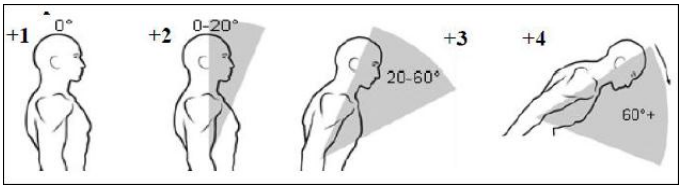

Fig -5: Locate Trunk Position.

Step 10a: Adjust;
If trunk is twisted: +1
If trunk is side bending: +1
Calculate Total Trunk Score.

Step 11: Legs;
If legs and feet are supported: +1
If not: +2
Calculate Total Leg Score.

Step 12: Look-up Posture Score in Table 3:
Using values from steps 9-11, locate score in Table 3.

Table -3: Trunk Posture Score

Neck	Trunk Posture Score											
Posture	1		2		3		4		5		6	
Score	Legs		Legs		Legs		Legs		Legs		Legs	
	1	2	1	2	1	2	1	2	1	2	1	2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	8	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Step 13: Add muscle use score;
If posture is mainly static (i.e. held>10 min) or
If action repeated occurs 4X per minute: +1

Step 14: Add Force/Load Score +
If load < 4.4 lbs (intermittent): +0
If load 4.4 to 22 lbs (intermittent): +1
If load 4.4 to 22 lbs (static or repeated): +2
If more than 22 lbs or repeated or shocks: +3

Step 15: Find Column in Table 2

Add values from steps 12-14 to obtain Neck, Trunk and Leg Score.
Find Column in Table 2
Step 12 + Step 13 + Step 14 = Step 15

Scoring: (Final score from Table 2)
1 or 2 = acceptable posture
3 or 4 = further investigation, change may be needed
5 or 6 = further investigation, change soon
7 = investigate and implement change
Calculate Final Score.

4.3 Neck, Trunk and Leg Analysis (REBA)

Step 01: Locate Neck Position:

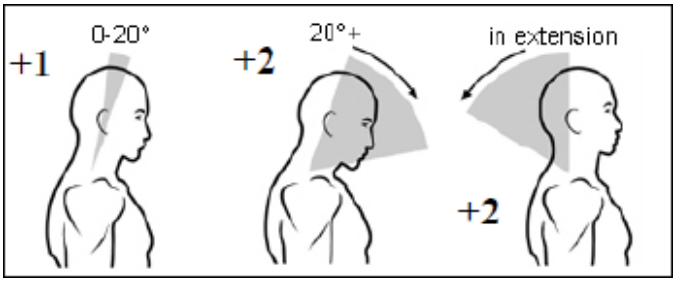

Fig -6: Locate Neck Position.

Step 01a: Adjust;
If neck is twisted: +1
If neck is side bending: +1

Step 02: Locate Trunk Position;

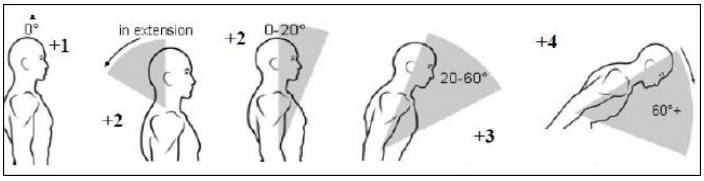

Fig -7: Locate Trunk Position.

Step 02a: Adjust;
If trunk is twisted: +1
If trunk is side bending: +1

Step 03: Legs;

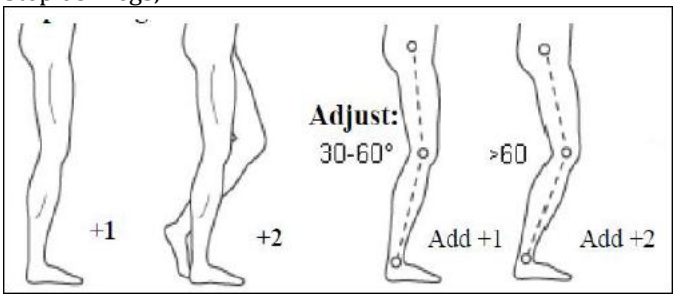

Fig -8: Locate Leg Position.

Step 04: Look-up Posture Score in Table 4
Using values from steps 1-3, locate score in Table 4.

Table -4: Neck Posture Score

		Neck											
		1				2				3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
	1	1	2	3	4	1	2	3	4	3	3	5	6
Trunk	2	2	3	4	5	3	4	5	6	4	5	6	7
Posture	3	2	4	5	6	4	5	6	7	5	6	7	8
Score	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

Step 05: Add Force/Load Score
If load < 11 lbs : +0
If load 11 to 22 lbs : +1
If load > 22 lbs: +2
Adjust: If shock or rapid buildup of force: add +1

Step 06: Score A,
Find Row in Table 6
Add values from steps 4 and 5 to obtain Score A.
Find row in Table 6.
Step 04 + Step 05 = Step 06

4.4 Arm and Wrist Analysis (REBA)

Step 07: Locate Upper Arm Position;

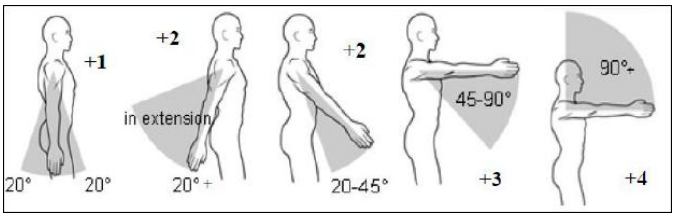

Fig -9: Locate Upper Arm Position.

Step 07a: Adjust;
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Step 08: Locate Lower Arm Position;

Fig -10: Locate Lower Arm Position.

Step 09: Locate Wrist Position;

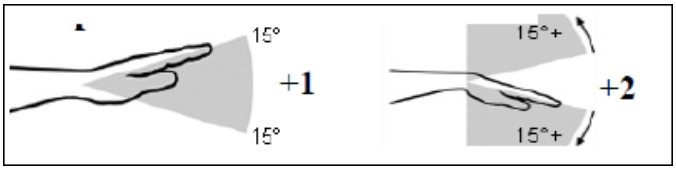

Fig -11: Locate Wrist Position.

Step 09a: Adjust;
If wrist is bent from midline or twisted: Add +1

Step 10: Look-up Posture Score in Table 5. Using values from steps 7-9, locate score in Table 5.

Table -5: Arm Posture Score

		Lower Arm					
		1			2		
	Wrist	1	2	3	1	2	3
	1	1	2	2	1	2	3
Upper	2	1	2	3	2	3	4
Arm	3	3	4	5	4	5	5
Score	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
	6	7	8	8	8	9	9

Step 11: Add Coupling Score;
Well-fitting handle and mid rang power grip, good: +0
Acceptable but not ideal hand hold or coupling in Table 5 acceptable with another body part, fair: +1
Hand hold not acceptable but possible, poor: +2
No handles, awkward, unsafe with any body part, unacceptable: +3

Step 12: Score B,
Find Column in Table 6
Add values from steps 10 & 11 to obtain Score B. Find column in Table 6 and match with Score A in row from step 6 to obtain Table 6 Score.
Step 10 + Step 11 = Step 12

Table -6: Score A and Score B

Score A												
Table A +	Score B											
load/force	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

Step 13: Activity Score;
1 or more body parts are held for longer than 1 minute (static): +1
Repeated small range actions (more than 4x per minute): +1
Action causes rapid large range changes in postures or unstable base: +1

Table 6 score + Activity Score = Final REBA score.

Scoring:
1 = negligible risk.
2 or 3 = low risk, change may be needed.
4 to 7 = medium risk, further investigation, change soon.
8 to 10 = high risk, investigate and implement change.
11+ = very high risk, implement change.

5. CONCLUSIONS

From the above study, conclusions drawn are;

1. The efficiency of workers can be measured as well as improved by using multiple assessment tools and providing a user friendly environment.
2. By using a scoring system with the ergonomic assessment tools such as Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA), the Risk Factor can be calculated and then the preventive majors can be taken by the organization in the sake of betterment of work environment.

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