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ERGONOMIC ASSESSMENT THROUGH RULA, REBA & MAN-TRA: A CASE STUDY

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Abstract

The paper presents a case study of ergonomic improvement in a tier 1 automobile company manufacturing clusters, fuel level sensors, oil pumps etc. Ergonomic assessment tools viz., RULA (Rapid upper limb assessment), REBA (Rapid entire body assessment), MAN-TRA (Manual task risk assessment) associated with the working posture are used to determine risks related with musculoskeletal disorders & work related injuries. Appropriate suggestions & improvements were effected in the form of workspace modification, provision of rotating fixture & work simplification. A comparison of work conditions before & after improvements shows considerable improvement in workers productivity.

Keywords: RULA: Rapid upper limb assessment, REBA: Rapid entire body assessment, Man-TRA: Manual task risk assessment, WMSD: Work related musculoskeletal disorders.

1. INTRODUCTION

The company manufactures oil pump & mechanical clusters averaging a monthly demand of 234000 units & 30000 units respectively. A large extent of work content is added in manual operations due to poor design of workplace leading to poor ergonomic conditions & even the risk of work related musculoskeletal disorders & work related injuries. A detailed assessment of work posture of loading pump body on cleaning fixture & packing of clusters in carton box was undertaken to make ergonomic improvements using ergonomic assessment tools like Man-TRA, REBA & RULA. The operators working on that specific workstation were facing the following problems:

- Back pain, Wrist pain
- Overall Exertion
- Overall fatigue to body
- Joints pain & other WMSD's.

2. LITERATURE REVIEW

Work-related musculoskeletal disorders (WMSDs) are a major concern in industry which can also compromise competitiveness due to costs related to worker compensation, labour turnover, absenteeism, poor quality and reduced productivity. The ramifications of WMSDs are large in terms of both health and costs.

Man-TRA—Man-TRA is a manual tasks risk assessment tool that was developed by the University of Queensland, Workplace Health and Safety Queensland and the Curtin University of Technology. User have to calculate data about the manual task. This data includes rating the physical risk factors for four body regions (neck/shoulder, arm/wrist/hand, back and lower limbs). The score for each risk factor is based on the task as a whole and for the person

performing the task. This data is used to determine action thresholds for repetition risk, exertion risk and cumulative risk. These action thresholds are presented in the results table. Further action is suggested if the thresholds are reached or exceeded. Refer figure 1 for assessment template for Man-TRA.

REBA - This ergonomic assessment tool uses a systematic process to evaluate whole body postural MSD and risks associated with job tasks. A single page worksheet is used to evaluate required or selected body posture, forceful exertions, type of movement or action, repetition, and coupling. Using the REBA worksheet, the evaluator will assign a score for each of the following body regions: wrists, forearms, elbows, shoulders, neck, trunk, back, legs and knees. After the data for each region is collected and scored, tables on the form are then used to compile the risk factor variables, generating a single score that represents the level of MSD risk. Refer figure 2 for assessment template for REBA.

RULA - The RULA Assessment Tool was developed to evaluate the exposure of individual workers to ergonomic risk factors associated with upper extremity MSD. The RULA ergonomic assessment tool considers biomechanical and postural load requirements of job tasks/demands on the neck, trunk and upper extremities Using the RULA worksheet, the evaluator will assign a score for each of the following body regions: upper arm, lower arm, wrist, neck, trunk, and legs. After the data for each region is collected and scored, tables on the form are then used to compile the risk factor variables, generating a single score that represents the level of MSD risk. Refer figure 3 for assessment template for RULA

Body Region	Total time	Duration	Task Codes	Repetition Risk	Force	Speed	Exertion Risk	Awkwardness	Vibration	CumulativeRisk
Lower Limbs										
Back										
Neck/ Shoulder										
Arm/ Wrist / Hand										

Cumulative risk is the sum of unshaded cells.

Codes				
Total time	1	2	3	4
0-2 hours/day	2-4 hours/day	4-6 hours/day	6-8 hours/day	> 8 hours/day
Duration of continuous performance				
1	2	3	4	5
< 10 minutes	10 min - 30 min	30 min - 1 hr	1 hr - 2 hr	> 2 hr
Cycle time				
1	2	3	4	5
> 5 minutes	1 - 5 minute	30 s - 1 min	10 s - 30 s	< 10 s
Force				
1	2	3	4	5
Minimal force		Moderate force		Maximal force
Speed				
1	2	3	4	5
Slow movements	Moderately paced	Little or no movement - static posture	Fast and smooth movements	Fast, jerky movements
Awkwardness				
1	2	3	4	5
All postures close to neutral	Moderate deviations from neutral in one direction only	Moderate deviations in more than one direction	Near end range of motion posture in one direction	Near end range of motion in more than one direction
Vibration (Whole body or Peripheral)				
1	2	3	4	5
None	Minimal	Moderate	Large amplitude	Severe amplitude

Scoring Keys for Repetition & Exertion									
Scoring key for Repetition					Scoring key for Exertion				
Cycle Time	1	2	3	4	Speed	1	2	3	4
1	1	1	2	3	1	1	1	2	3
2	1	2	3	4	2	1	2	3	4
3	2	3	4	5	3	2	3	4	5
4	2	3	4	5	4	2	3	4	5
5	3	4	5	5	5	3	4	5	5

Action may be indicated if, for any region, the Exertion risk factor is 5, the sum of exertion and awkwardness is 8 or greater, or the cumulative risk is 15 or greater

Figure 1. Man-TRA Analysis Matrix

A. Neck, Trunk and Leg Analysis

Step 1: Locate Neck Position

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

Step 2: Locate Trunk Position

Step 2a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

Step 3: Legs

Step 3a: Adjust...
If leg is twisted: +1
If leg is side bending: +1

Step 4: Look-up Posture Score in Table A

Using values from steps 1-3 above, locate scores in Table A.

Step 5: Add Force/Load Score

If load = 11 lbs: +1
If load = 11 to 22 lbs: +1
If load = 22 lbs: +2
Adjust: If shock or rapid build up of force: add +1

Step 6: Score A, Find Row in Table C

Add values from steps 4 & 5 to obtain Score A. Find Row in Table C.

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

B. Arm and Wrist Analysis

Step 7: Locate Upper Arm Position

Step 7a: Adjust...
If shoulder is twisted: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Step 8: Locate Lower Arm Position

Step 8a: Adjust...
If forearm is twisted: +1
If forearm is abducted: +1
If arm is supported or person is leaning: -1

Step 9: Locate Wrist Position

Step 9a: Adjust...
If wrist is bent from midline or twisted: Add +1

Step 10: Look-up Posture Score in Table B

Using values from steps 7-9 above, locate scores in Table B.

Step 11: Add Coupling Score

Well fitting handle and good power grip: good: +0
Acceptable but not ideal handle or coupling acceptable with another body part, fair: +1
Hand held not acceptable but possible, poor: +2
No handles, awkward, unsafe with any body part, unacceptable: +3

Step 12: Score B, Find Column in Table C

Add values from steps 10 & 11 to obtain Score B. Find Column in Table C and match with Score A in row from step 6 to obtain Table C Score.

Step 13: Activity Score

+1: 1 or more body parts are held for longer than 1 minute (static)
+1: Repeated small range motions (more than 4s per minute)
+1: Action causes rapid large range changes in posture or unstable base

Table C Score + Activity Score = Final REBA Score

A. Arm and Wrist Analysis

Step 1: Locate Upper Arm Position

Step 1a: Adjust...
If shoulder is twisted: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Step 2: Locate Lower Arm Position

Step 2a: Adjust...
If forearm is twisted: +1
If forearm is abducted: +1
If arm is supported or person is leaning: -1

Step 3: Locate Wrist Position

Step 3a: Adjust...
If wrist is bent from midline: Add +1
If wrist is at or near end of range: +1
If wrist is at or near end of range: +2

Step 4: Wrist Twist

If twist is twisted in mid-range: +1
If twist is at or near end of range: +2

Step 5: Look-up Posture Score in Table A

Using values from steps 1-4 above, locate scores in Table A.

Step 6: Add Muscle Use Score

If posture mainly static (i.e. hold 10 minutes):
If action repeated occurs < 5% per minute: +1

Step 7: Add Force/Load Score

If load = 4.4 lbs (approximately): +0
If load = 4.4 to 22 lbs (approximately): +1
If load = 4.4 to 22 lbs (static or repeated): +2
If more than 22 lbs or repeated or shocks: +3

Step 8: Find Row in Table C

Add values from steps 5-7 to obtain Wrist and Arm Score. Find row in Table C.

Table A: Wrist Posture Score

Upper Arm	1	2	3	4
Low Arm	1	2	3	4
High Arm	1	2	3	4
1	1	2	3	4
2	2	3	4	5
3	3	4	5	6
4	4	5	6	7
5	5	6	7	8
6	6	7	8	9
7	7	8	9	10
8	8	9	10	11
9	9	10	11	12
10	10	11	12	13
11	11	12	13	14
12	12	13	14	15

Table B: Neck, trunk and leg score

Neck	1	2	3	4	5	6	7	8	9	10	11	12
1	1	2	3	4	5	6	7	8	9	10	11	12
2	2	3	4	5	6	7	8	9	10	11	12	13
3	3	4	5	6	7	8	9	10	11	12	13	14
4	4	5	6	7	8	9	10	11	12	13	14	15
5	5	6	7	8	9	10	11	12	13	14	15	16
6	6	7	8	9	10	11	12	13	14	15	16	17
7	7	8	9	10	11	12	13	14	15	16	17	18
8	8	9	10	11	12	13	14	15	16	17	18	19
9	9	10	11	12	13	14	15	16	17	18	19	20
10	10	11	12	13	14	15	16	17	18	19	20	21
11	11	12	13	14	15	16	17	18	19	20	21	22
12	12	13	14	15	16	17	18	19	20	21	22	23

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

B. Neck, Trunk and Leg Analysis

Step 9: Locate Neck Position

Step 9a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

Step 10: Locate Trunk Position

Step 10a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

Step 11: Legs

Step 11a: Adjust...
If legs and feet are supported: +1
If not: -1

Step 12: Look-up Posture Score in Table B

Using values from steps 9-11 above, locate scores in Table B.

Step 13: Add Muscle Use Score

If posture mainly static (i.e. hold 10 minutes):
If action repeated occurs < 5% per minute: +1

Step 14: Add Force/Load Score

If load = 4.4 lbs (approximately): +0
If load = 4.4 to 22 lbs (approximately): +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 C

Add values from steps 12-14 to obtain Neck, Trunk and Leg Score. Find Column in Table C.

Figure 2. REBA Analysis Matrix

Figure 3. RULA Analysis Matrix

3. METHODOLOGY

The following methodology was adapted for effecting improvements on the workstations

- Assessing present status of WMSD risk by different ergonomic assessment tools
- Solving the MSD risk problem through workplace & methods modification
- Implementation of proposed method & improvements.

3.1. Ergonomic Assessment to Identify WMSD Risk

A detailed ergonomic assessment using Man-TRA, RULA &

REBA is done. The scores & risk associated are illustrated below for different ergonomic assessment techniques.

Work Area 1: "Packing Workstation"

On packing station of cluster manufacturing assembly line, operator of packing station required to put the cluster in polythene bag, then pack it in cardboard box & then put it in cartoon box placed on shop floor. The repetition frequency was 1000 units/shift. Severe bending of back & raising of shoulder was present while keeping cluster in cartoon box. Man-TRA & RULA assessment was conducted to this procedure.

Table 1. Man-TRA Analysis Before Workplace Modification

Body	Task Codes									Cumulative Risk
	Total Time	Duration	Cycle time	Repetition Risk	Force	Speed	Exertion Risk	Awkwardness	Vibration	
Lower Limb	4	4	4	3	2	2	2	2	1	12
Back	4	4	4	3	4	2	4	4	1	16
Neck/Shoulder	4	4	4	3	4	2	4	4	1	16
Arm/Wrist & Hand	4	4	4	3	2	2	2	2	1	12

Table 2. Man-TRA Analysis After Workplace Modification

Body	Task Codes									Cumulative Risk
	Total Time	Duration	Cycle time	Repetition Risk	Force	Speed	Exertion Risk	Awkwardness	Vibration	
Lower Limb	4	4	4	3	2	2	2	1	1	11
Back	4	4	4	3	2	2	2	2	1	12
Neck/Shoulder	4	4	4	3	2	2	2	2	1	12
Arm/Wrist & Hand	4	4	4	3	2	2	2	2	1	12

RECOMMENDATION

After studying & analysing the initial state recommendations were made to reduce the WMSD risk at packing workstation by

increase in 50 cm height of carton box from ground to reduce bending & arm raising posture.

Table 3. RULA Analysis Previous & Present Score

No	Description	Previous Score	Previous Total Score	Current Score	Current Total Score
1	Locate upper arm position	3		3	
2	Locate lower arm position	2		2	
3	Locate wrist position	2		2	
4	Wrist twist	2		2	
5	Total Look up posture score from Table A	$3 + 2 + 2 + 2$	4	$3 + 2 + 2 + 2$	4
6	Muscle score	0		0	
7	Force score	0		0	
8	Total Wrist & arm score	$4 + 0 + 0$	4	$4 + 0 + 0$	4
9	Neck position score	3		3	
	Side Bending	1		0	
10	Trunk position score	4		3	
	Side Bending	1		0	
11	Leg position score	2		1	
12	Total Leg position score from Table B	$4 + 5 + 2$	7	$3 + 3 + 1$	4
13	Muscle score	0		0	
14	Force score	0		0	
15	Total Neck Trunk & Leg score from Table C	$7 + 0 + 0$	7	$4 + 0 + 0$	4
16	Total Final RULA score From Table C	$4 + 7$	6	$4 + 4$	4



Before

After

Fig. 4 Improvements at Packing Workstation

	Man-TRA			
	Lower Limb	Back	Neck & Shoulder	Arm/Wrist/Hand
Previous Score	12	16	16	12
Present Score	11	12	12	12

Table 4. Man-TRA Score

RULA	Arm & wrist analysis	Neck trunk & leg analysis	Table C grid	Final Score
Previous Score	4	4	7	6
Present Score	4	4	4	4

Table 5. RULA Score

Work Area 2: "Cleaning Workstation"

At cleaning workstation, it was observed that a single operator has to mount the pump body on cleaning fixture which consists of 30 casing on 1 stand; such 3 stands are used for cleaning 90 casings at a single cycle of operation in cleaning machine.

While cleaning machine is running, operator has to mount the pump body, pick the fixture, keep it on table & sit again to continue the process. The loaded fixture with pump body has a weight of 8 kilograms. This process is done about 150 a shift.

Table 6. Man-TRA Analysis Before Workplace Modification

Body	Task Codes									Cumulative Risk
	Total Time	Duration	Cycle time	Repetition Risk	Force	Speed	Exertion Risk	Awkwardness	Vibration	
Lower Limb	4	4	2	4	3	2	3	2	1	14
Back	4	4	2	4	3	2	3	3	1	15
Neck/Shoulder	4	4	2	4	2	2	2	2	1	13
Arm/ Wrist/ Hand	4	4	2	4	3	2	3	4	1	16

Table 7. Man-TRA Analysis After Workplace Modification

Body	Task Codes									Cumulative Risk
	Total Time	Duration	Cycle time	Repetition Risk	Force	Speed	Exertion Risk	Awkwardness	Vibration	
Lower Limb	4	4	2	4	1	2	1	1	1	11
Back	4	4	2	4	1	2	1	1	1	11
Neck/Shoulder	4	4	2	4	1	2	1	1	1	11
Arm/ Wrist/ Hand	4	4	2	4	2	2	2	2	1	13

Table 8. REBA analysis Previous & Present Score

No	Description	Previous Score	Previous Total Score	Current Score	Current Total score
1	Locate Neck position	2		2	
2	Locate Trunk position	4		2	
3	Leg position	4		1	
4	Look up posture score in Table A	2+4+2+2	8	5	3
5	Add force / load score	3		2	
6	Score A	8+2+1	11	7	5
7	Locate upper arm position	2		3	
8	Locate lower arm position	2		2	
9	Locate wrist position	1		1	
10	Look up posture in Table B	2+2+1	2	6	4
11	Add coupling score	2		2	
12	Score B	2+2	4	6	6
13	Score C	11+4	11	11	7
14	Activity Score + 1 If required	11+1	12		

Recommendation

After studying & analysing the initial state recommendations were made to reduce the WMSD risk at cleaning workstation by

providing new ergonomically designed rotary stand, which reduces arm/wrist/hand fatigue risk & also eliminates bending of operator.



Before

After

Fig. 2 Improvements at Cleaning Workstation

	Man-TRA			
	Lower Limb	Back	Neck & Shoulder	Arm/Wrist/Hand
Previous Score	14	15	13	16
Present Score	11	11	11	13

Table 9. Man-TRA Score

REBA	Neck trunk & leg analysis	Arm & wrist analysis	Table C grid	Activity analysis	Final score
Previous Score	11	4	11	1	12
Present Score	5	6	7	0	7

Table 10. REBA Score**4. CONCLUSION**

Ergonomics in tier 1 automobile industry is the most ignored aspect & hence more focus should be given for working posture of operator. The chances of developing work related musculoskeletal disorders are very high in operators. Ergonomic changes in current working conditions were made to reduce MSD by implementing small improvements. Use of rotating fixture & increased stand height from ground level has reduced the work related musculoskeletal disorders in operators substantially. Horizontal deployments of changes done on packing workstations at seven other assembly lines.

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