Analysis of Manually Cable Pulling Process in Construction Site on the Pipe Rack with REBA (Rapid Entire Body Assessment)

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Abstract

Productivity and product quality depend on employee performance. Postures, working environment and method of statement affect the employee performance. Deficiencies in the work environment and the lack of proper postures cause a decrease in employee performance and musculoskeletal disorders. Improper working postures cause to the development of musculoskeletal disorders. Ergonomic analysis is done to evaluate improper postures in order to avoid the formation and becoming permanent of these disorders. According to health records, employees who were working at cable pulling had musculoskeletal disorders such as backache, hand and elbow pains. They have taken bill of health and not come work. Therefore, additionally healthy problems employees there were lost time and unavoidable delays in process. Rapid Entire Body Assessment (REBA) is one of the ergonomic analysis methods. It does not require advanced knowledge and experience in ergonomics. In this study, due to increment healthy problems and days of temporary incapacity who work at manually cable pulling process in construction site on the pipe rack, forces on hand are measured with a mechanical force gauges and all data are evaluated with REBA. Cable pulling process is analyzed and precautions are defined.

1.   Introduction

Each tissue such as muscle, cartilage and bone goes through many different mechanisms of differentiation. Bones, muscles, ligaments, tendons and cartilage are affected from Musculoskeletal Disorders (MSDs). Epidemiological studies have found a binding between MSDs and handling, lifting, vibration, incompatible postures (Kirkhorn , Earle-Richardson &Banks,2010) . MSDs causes disablement, rise on costs, further delay works, lost working days (Levy, Wegman,2000) . Healthy problems such as tissue injuries, pains etc. affect the daily life quality of the employee (3). MSDs are prevalently related with manual materials handling (Marras, 2000). Repetitive manual materials handling such as cable pulling process may lead to tissue injuries, contusion, tendinitis, carpal tunnel syndrome, fatigue, sprains and strains, pains (Das& Gangopadhyay ,2005). MSDs conduce to a grave problem because of economic losses, decreasing in productivity, many absences. Therefore, risk evaluation is important   to reduce hazards and taking precautions (7). REBA has a low application cost and useful to determine different ergonomic hazards and several biomechanical risk factors. Also it does not require advanced knowledge and experience in ergonomics. The REBA was found out in 2000 with investigation 600 postural examples with objective of evaluation risky postures in the development of MSDs (8-13). REBA includes systematic process to obtain whole body postural MSDs and hazards related to job tasks. There are several studies on REBA risk assessment (9-11), but there has been no study recorded on cable pulling process is found. So that the aim of this study is to investigate for reducing ailments and economic losses on manually cable pulling process at construction sites with using Rapid Entire Body Assessment (REBA) ergonomic analysis method results.

2.   Method

The risks of a working posture   or movement is expressed numerically by using REBA risk assessment method. Cable pulling process is analyzed varying in loads and postures based on the diagrams of the body part (Group A and B) from Figure 1. Trunk, neck, legs, shoulders, elbows, wrists, coupling, load and activity are considered and REBA score is obtained between 1 and 15. When REBA score is calculated, working postures are divided into A and B groups. Trunk, neck and legs are considered for A group scores. Upper arms, elbows, wrists are considered B groups scores. After load (force) and coupling adding, score C is found. Activity score added C score and final REBA score is obtained. REBA Precautions Levels is decided according to this final REBA score (McAtamney, Corlett, 1993).
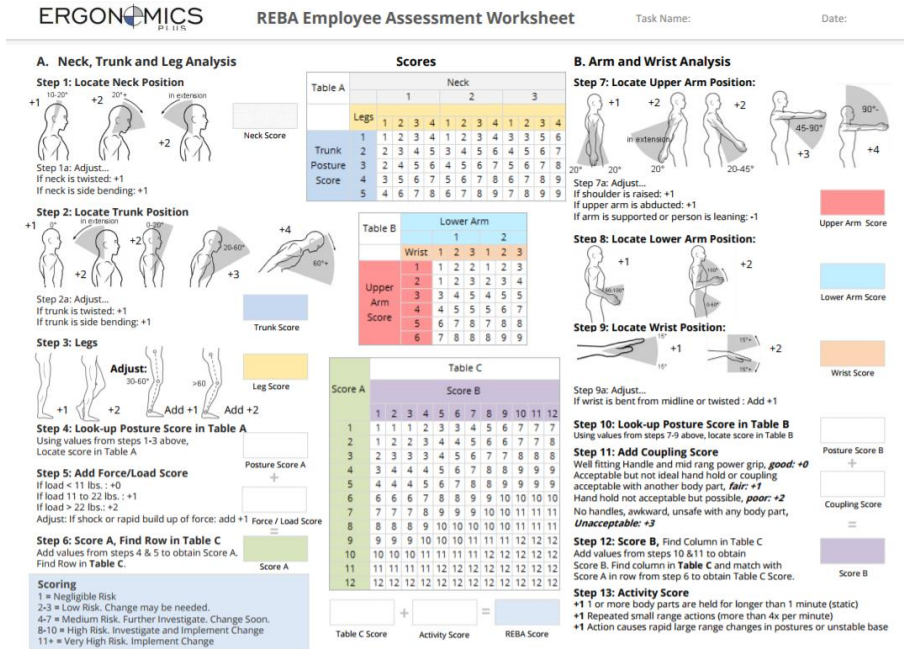
Figure 1: REBA Employee Assessment Worksheet

Ergonomists and other implementers use commonly REBA. This method necessitates a little knowledge, training and practice. Application of method are not required ergonomic skills (15-18). This study carried out with 135 employees in Volgograd Deep Conversion Project (Refinery construction project that is built by Tecnicas Reunidas S.A). On Figure1 REBA Employee Assessment Worksheet has seen.

3.   Results

There are totally 30 employees at 18-25 ages, 48 employees at 26-35 ages and 57 employees at over 36 ages. When we have get healthy records about cable pulling employees, we obtained table 1 data after job specification-description. It is observed that total number of employees who have healthy records are 21 mild low-back pain, 12 severe low back pain, 14 mild low hand and leg pain, 9 Severe low hand and leg pain and 17 soft tissue injury. 18 and 25 ages employees have 5 mild low-back pain, 1 severe low back pain, 2 mild low hand and leg pain, 1 severe low hand and leg pain and 5 soft tissue injury. 26 and 35 ages employees have 11 mild low-back pain, 4 severe low back pain, 5 mild low hand and leg pain, 2 Severe low hand and leg pain and 5 soft tissue injury. Over 35 age's employees

have 5 mild low-back pain, 7 severe low back pain, 7 mild low hand and leg pain, 6 Severe low hand and leg pain and 7 soft tissue injury. Also days of temporary incapacity is 448. Healthy records that is about only cable pulling employees in 6 months seen on Table 1.

Table 1: Healthy records that is about only cable pulling employees in 6 months.

Ailments	Number of employees	18-25 ages employees	26-35 ages employees	Over 35 ages employees	Days of temporary incapacity
mild low-back pain	21	5	11	5	58
severe low back pain	12	1	4	7	168
Mild low hand and leg pain	14	2	5	7	34
Severe low hand and leg pain	9	1	2	6	120
soft tissue injury	17	5	5	7	67
Total	73	14	27	32	448 lost day

According to this healthy reports we analysis cable pulling process and posture on tray. (Figure 2) At pipe rack we use Mechanical Force Gauges (Figure 3) to measurement of pulling cable on the electricity tray. For each age's groups we obtained average applied forces. The force data are changed according to pulling distance. It is between 8-10 kg.

Figure 2: Cable pulling process and posture on tray
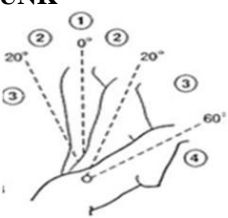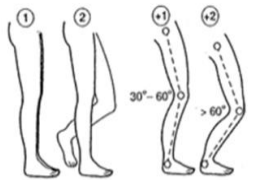

Figure 3: Mechanical Force Gauges

Group A tables (Trunk, neck and legs data's recorded on Table 2).

- ✓ Trunk score is obtained using both flexion 20-60 $^\circ$ & extension more than 20 $^\circ$ and side flexed. Score is 3+1
- ✓ Neck score is obtained using both Flexion >20 $^\circ$ & Extension >20 $^\circ$ and side flexed. Score is 3+1
- ✓ Legs score is obtained using both Unstable and Knee(s) Flexion 30-60°. Score is 2+1

Table 2: Group A scores (Trunk, neck, legs)

GROUP A SCORES			
TRUNK	**Posture /Range**	**Score**	**Additional**
	Upright	1	If back is twisted or tilted to side :+1
	Flexion:0-20º Extension: 0-20º	2	
	Flexion :20-60 $^\circ$ Extension:>20 $^\circ$	3	
	Flexion:>60 $^\circ$	4	
	Posture /Range	**Score**	**Additional**
NECK	Flexion:0-20 $^\circ$	1	If neck is twisted or tilted to side : +1
	Flexion : :>20 $^\circ$ Extension:>20 $^\circ$	2	
	Posture /Range (Bilateral Wt Bearing)	**Score**	**Additional**
LEGS	Sit	1	Knee(s) Flexion 30-60°: +1
	Unstable	2	Knee(s)Flexion >60°: +2

Group B tables (shoulders, elbows and wrists data's recorded on Table 3).

- ✓ Upper arms score is obtained using both Flexion: 20-45º & Extension: :> 20 $^\circ$ and arm abducted /rotated score. And also added arm supported score. Score is 2+1-1

- ✓ Lower arms score is obtained using Flexion: $<60^{o}$ and Flexion :$> 100^{o}$ .Score is 2
- ✓ Wrists score is obtained using both Flexion: $>15^{o}$& Extension: $>15^{o}$ and Wrist deviated/twisted score. Score is 2+1.

Using other scores tables (the data's of Load, Coupling and activity scores are shown at Table 4)
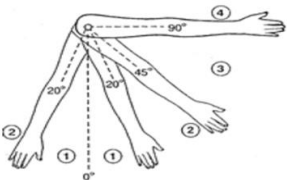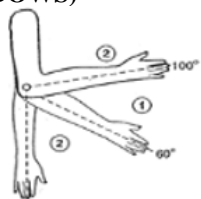
- ✓ Load/Force score equals 1+1
- ✓ Coupling is good for this process. Score is 0.
- ✓ We need activity score for final Reba score. The score is +1.

We find out Score A with using Table A. Neck, Legs and Trunk scores are intersected. Score A is 7, recorded in Table 5. We find out Score B with using Table B. Lower arm, wrist and upper arm are intersected. Score B is 4 seen at Table 5.

Score C is obtained using both Score-A and Score-B. Score is 9 founded on Table 6.
Total score is calculated 10 seen on Figure 4, this refers to a REBA action level of 3 recorded on Table 7.

Table 3: Group B scores (shoulders ,elbows and wrists)

GROUP B SCORES			
UPPER ARMS (SHOULDERS)	Posture /Range	Score	Left and Right
	Flexion:0-20º Extension: 0-20º	1	Arm Abducted /Rotated : +1
	Flexion:20-45º Extension: :>20 º	2	Shoulder Raised: +1
	Flexion: 45-90	3	Arm Supported : -1
	Flexion : >90 º	4	
	Posture /Range	Score	Left and Right
LOWER ARMS (ELBOWS)	Flexion:60-100º	1	No adjustments
	Flexion: <60 º Flexion:>100 º	2	
	Posture /Range	Score	Additional

WRISTS			
	Flexion:0-15º Extension: 0-15	1	Wrist deviated/twisted : +1
	Flexion: >15º Extension: >15º	2	

Table 4 : Load, Coupling and activity scores.

LOAD/ FORCE	Score	Additional
<5 kg <11 lb	0	
5-10 kg 11-22 lb	1	Shock or rapid build-up +1
>10 kg > 22 lb	2	
COUPLING	**Score**	**Left And Right**
Good	0	
Fair	1	No adjustments
Poor	2	
Unacceptable	3	
ACTIVITY		**Score**
One or more body parts are static for longer than 1 minute		+1
Repeat small range motions more than 4 per minute		+1
Rapid large changes in posture or unstable base		+1

Table 5: Table A and Table B scores.

TABLE A			Trunk				
			1	2	3	4	5
Neck	1	**Legs**					
		1	1	2	2	3	4
		2	2	3	4	5	6
		3	3	4	5	6	7
		4	4	5	6	7	8
	2	**Legs**					
		1	1	3	4	5	6
		2	2	4	5	6	7
		3	3	5	6	7	8
		4	4	6	7	8	9
	3	**Legs**					
		1	1	4	5	6	7
		2	2	5	6	7	8

		3	3	6	7	8	9
		4	4	7	8	9	9

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

Table 6: Table C score for cable pulling process

TABLE C		SCORE A											
		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
SCORE B	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
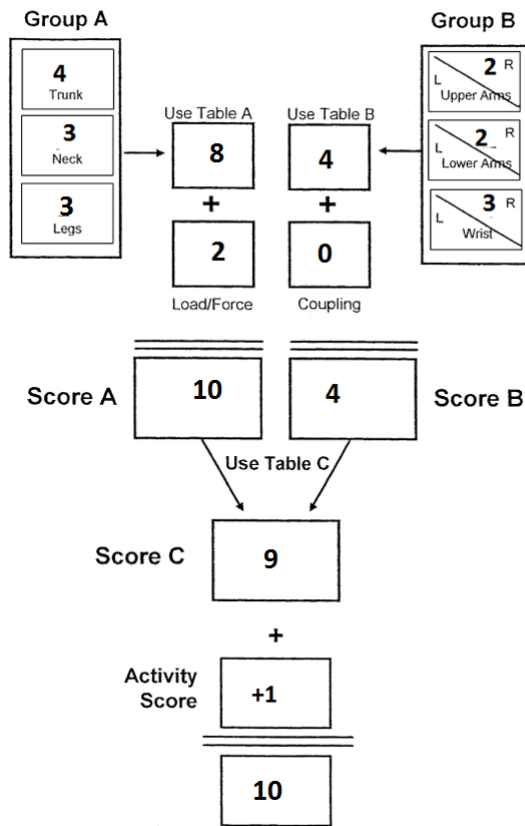
Figure 4: REBA Final Score

Table 7: REBA Precautions Levels

Action level	REBA score	Risk level	Action (Including further assessment)
0	1	Negligible	None necessary
1	2-3	Low	May be necessary
2	4-7	Medium	Necessary
3	8-10	High	Necessary soon
4	11-15	Very high	Necessary now

4.   Discussion

MSDs are a costly and prevalent problem for employees and companies all around the world. MSDs have big ratio in the workplace injuries and absenteeism. MSDs **affect** the human body's movement or musculoskeletal system such as tendons, ligaments, nerves, discs, muscles etc. After examination of healthy records, it is seen that manually cable pulling works cause MSDs. Employees start to fatigue and develop a musculoskeletal imbalance. Finally, fatigue causes musculoskeletal disorder develops cause of repeat tasks by the time. Therefore, manually cable pulling process are analyzed using REBA ergonomic risk assessment method.

The REBA is a tool that scores the tasks for biomechanical risk factors and where employees might be exposed (19-20). According to total REBA score, REBA action level of 3 is obtained indicating a high risk of injury to the manually cable pulling process employees. This REBA score corresponds to necessary soon. Therefore, some precautions are taken immediately.

✓   Training about true postures provided to employees.
✓   Electric/hydraulic cable pulling equipment's supplied.
✓   Increased number of portable pulleys.
✓   Done rotation and shorten working periods.
✓   Increased rest break times.

Healthy records   that is about only cable pulling employees in 6 months after improvements are shown table 8. Due to this data it is clearly seen decreasing on employees who have healthy problems. After improvements, total number of employees who have healthy records are 16. (% 64,38 decreasing) .18 and 25 ages employees have 2 mild low-back pain and 3 soft tissue injury. At this ages % 64,28 decrease is seen. 26 and 35 ages employees have 2 mild low-back pain and 2 soft tissue injury. At this ages % 85,18 decrease is seen. Over 35 age's employees have 3 mild low-back pain, 1 severe low back pain, 1 mild low hand and leg pain, 1 severe low hand and leg pain and 1 soft tissue injury. At this ages % 78,12 decrease is seen. Also days of temporary incapacity is 47. Lost working days at the cable pulling works decreased %89,5.

Table 8: Healthy records that is about only cable pulling employee's in 6 months after improvements.

Ailments	Number of employees	18-25 ages employees	26-35 ages employees	Over 35 ages employees	Days of temporary incapacity
mild low-back pain	7	2	2	3	14
severe low-back pain	1	-	-	1	5
Mild low hand and leg pain	1	-	-	1	3
Severe low hand and leg pain	1	-	-	1	2
soft tissue injury	6	3	2	1	23
Total	16	5	4	7	47 lost day

In conclusion we have taken healthy records and analyzed process with using REBA. Due to high risk level, we applied some precautions. After taken precautions, it is find out high level progress.

Disclosure statement

No potential conflict of interest was reported by the authors.

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