

Research Article

Application of Job Difficulty Index[®] to compare work severity using P-SVR[®] method of Ergonomic analysis

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Abstract

Job Difficulty Index (JDI) using Posture-State Variation Report (P-SVR) methodology of postural analysis described here helps in evaluating the job difficulty level of work cycle quantitatively. For improving work content, the element of work with highest severity of score and with the longest duration can be highlighted. These work elements can be analyzed further and improved to simplify the work content. Posture – State Variation Report method is used for work simplification through postural analysis.

Keywords: postural severity of work element, P-SVR, JDI.

Introduction

A survey of Certified Professional Ergonomists (CPEs) was conducted by Patrick G. Dempsey, Raymond W. McGorry, et.al. (2005), to gather information on the types of basic tools, direct and observational measurement techniques, and softwares used by practitioners. The motivation for the survey was to better understand what types of tools and methods practitioners use, their opinions of these tools, and to potentially gain an understanding of the constraints or preferences that influence this selection. Reasons for using or not using a selection of tools were also surveyed. Of 578 surveys those were delivered to CPEs and Associate Ergonomics Professionals, 308 were returned for a response rate of 53%. The respondents tended to be biased towards physical ergonomics, as the survey primarily focused on this area of ergonomics. A high percentage of respondents reported using tape measures, video cameras, stopwatches and digital cameras. The frequency and type of checklists, software, and anthropometric data used were summarized. The results of this study indicated that the REBA (Rapid Entire Body Analysis) as well as RULA (Rapid Upper Limb Analysis) are the most widely used techniques for ergonomic analysis. These methods are used as a basis for P-SVR methodology.

In a handmade brick manufacturing plant the study by F.C. Trevelyan, R.A. Haslam, (2001) investigated the ergonomic issues, concentrating on the 'moulding' department, where clay is shaped into bricks. The analysis included a review of medical records and semi-structured interviews of workers; video recording to enable task, postural and force analyses; subjective discomfort survey; attitude survey; workplace analysis; and comparisons with

a sister factory. The results of the study identified both upper limb and back problems. The main task had high repetition, with a 13 seconds cycle time. Posture and force analysis found poor standing posture and undesirable wrist positions, accompanied by significant force loadings. Recommendations included task redesign to eliminate high-risk elements and workplace changes. The details of postural analysis are not mentioned in this study. In P-SVR methodology comprehensive evaluation of postural variations is done using video records.

Min K. Chung, Inseok Leeb (2003) assessed the postural load for lower limb postures based on perceived discomfort. For evaluating postural loads, leg postures are usually considered to be less important than postures in other body parts, such as arms, shoulders, and trunk. Leg postures are yet closely related to postural stability and their influence on the whole-body postural load should be fully reflected in evaluating postural stresses. In this study, 31 leg postures were evaluated based on a subjective discomfort rating. Eighteen male subjects were asked to maintain a series of leg postures for 1 min, and to report their perceived discomfort. Results showed that leg posture had a significant effect on the subjective discomfort rating. The results led to the development of a preliminary postural classification scheme, in which leg postures were classified into 6 categories (standing, knee-flexion, squatting, sitting, kneeling, and one-foot posture) followed by 10 sub-categories. A relative discomfort score on a ratio scale was assigned to each category, which was based on a normalized discomfort value for sitting. This ratio discomfort score is useful to quantitatively evaluate postural loads for a variety of leg postures, and to compare them across different leg postures. In this study only leg postures were studied. The limitation of this study is postural variations which occur under real life work

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practice are not considered. Holding a posture for 1 minute and to get the feedback from subjects can only be experimented for lab setups.

Janice D. Chen, Torbjörn Falkmer, et.al. (2013) used the Rapid Upper Limb Assessment (RULA) as an observation-based screening tool to assess postural risks of children in school settings. Studies using eye-tracking technology suggest that visual search strategies are influenced by experience in the task performed. This study investigated if experience in postural risk assessments contributed to differences in outcome scores on the RULA and the visual search strategies utilized. While wearing an eye-tracker, 16 student occupational therapists and 16 experienced occupational therapists used the RULA to assess 11 video scenarios of child using different mobile information and communication technologies (ICT) in the home environment. No significant differences in RULA outcome scores and no conclusive differences in visual search strategies between groups were found. RULA can be used as a screening tool for postural risks following a short training session regardless of the assessor’s experience in postural risk assessments. This indicates that the RULA is widely used methodology for ergonomic assessment. In this study the systematic recording system for the postural analysis is not adopted and the observer depended upon memory and perception. In P-SVR methodology this drawback is overcome by using video graphic and element by element comprehensive postural analysis.

While discussing the trouble with RULA, Peter Budnik (2013) stated that RULA has a strong focus on posture, but a weak focus on force, repetition and duration. The Ergonomics Report highlighted the importance of Duty Cycle, which is essentially the portion of task that is spent in exertion, a measure of duration of exertion. The duty cycle is important in predicting the upper extremity risk. Therefore RULA does not adequately consider duration of postural severity, let alone its weak recognition of force and repetition. In P-SVR methodology comprehensive quantification of the duty cycle is done and both the time spent in a particular severity level of postures as well as frequency of the severity level of postures is analysed.

P-SVR (Posture Variation State Report) Methodology

P-SVR (Varsha Narayan Karandikar, Shriram Madhukar Sane, 2013) methodology is about the ergonomic analysis to assess severity of manual work performed. This is achieved by devising a new methodology to find out postural variations while performing any manual task using a machine or equipment. Human effort analysis plays vital role in work simplification. Over the years, several methods are developed to study the involvement of limbs to ascertain severity of jobs done by human beings. Frequent use of limbs in work cycles performed over a day or shift creates fatigue and discomfort for an operator. This in turn leads not only to lower productivity but also causes musculoskeletal disorders for the operators in the long run.

P-SVR methodology defines the procedure involving elemental break up and analysis of video recordings of a

task to determine frequency of severity of the postures as well as the time spent in that severity of posture for that task.

The conventional techniques of postural analysis – Rapid Upper Limb Analysis (RULA) and Rapid Entire Body Analysis (REBA) based on instantaneous photographic records, either random or at certain time intervals, are used as a basis for calculating P-SVR index value.

- Video recording for manual work to be analysed is done to capture the limb movements of the operator clearly for the entire work cycle.
- The video is analysed by breaking it into work elements based upon major postural severity change.
- Postural severity index is assigned to each element using any existing method of postural severity evaluation.
- The elements are classified and grouped based upon the postural severity index.
- The analysis of frequency and duration for every level of postural severity is done to determine P-SVR index value.

Mathematical model for P-SVR Index Value

$$P - SVR \text{ index value} = \sum_{i=1}^{j=m} \sum_{i=n}^{j=m} SS_i * TT_{ij} \div \sum_{i=1}^{j=m} \sum_{j=1}^{i=n} TT_{ij}$$

SS = Severity score for work element

TT = Elapsed Time for work element

i = 1, 2, 3 n, where n is the observed highest value of the postural severity index as per the postural analysis method used

j = 1, 2, 3 m, where m is the number of work elements having particular postural severity score

Case study

This paper discusses the application of P-SVR (Postural State Variation Report) methodology to analyse different tasks, with the aim to find out relative job difficulty. It is quantified as Job Difficulty Index (JDI). A case study was conducted in a manufacturing plant and following are the results of analysis as per the P-SVR methodology. This analysis is carried out for an activity of an operator on a compressor assembly line. The time duration was 518.7 seconds during which there were major changes in posture about 50 numbers of times. It means that the posture was changing almost every 10 seconds. The P-SVR analysis is done to find out the duration of the postures as well as frequency of a particular severity.

The postural severity analysis is done on the basis of RULA scores. The table no.1 shows the postural analysis using Rapid Upper Limb Assessment (RULA) done in chronological order. The data in table no1 was further analyzed using P-SVR method. The results are shown in table no 2.

P-SVR analysis using RULA

Table 1 - Postural Analysis using RULA

Postural Analysis of data based on RULA					
Serial Number	Start time	End time	Elapsed time	RULA score	Elapsed time*RULA score
1	0	31.152	31.152	3	93.456
2	31.152	41.38	10.228	1	10.228
3	41.38	48.927	7.547	4	30.188
4	48.927	53.17	4.243	4	16.972
5	53.170	63.186	10.016	4	40.064
6	63.186	83.703	20.517	3	61.551
7	83.703	97.44	13.737	3	41.211
8	97.440	123.156	25.716	2	77.148
9	123.156	135.626	12.470	3	37.410
10	135.626	157.73	22.104	3	66.312
11	157.730	161.455	3.725	1	3.725
12	161.455	168.384	6.929	3	20.787
13	168.384	187.083	18.699	3	56.097
14	187.083	219.03	31.947	3	95.841
15	219.030	237.768	18.738	3	56.214
16	237.768	272.735	34.967	3	104.901
17	272.735	285.341	12.606	2	12.606
18	285.341	318.958	33.617	3	100.851
19	318.958	342.477	23.519	1	23.519
20	342.477	347.807	5.330	6	31.98
21	347.807	352.579	4.772	1	4.772
22	352.579	356.777	4.198	6	25.188
23	356.777	361.868	5.091	1	5.091
24	361.868	365.577	3.709	6	22.254
25	365.577	372.529	6.952	7	41.712
26	372.529	377.897	5.368	1	5.368
27	377.897	382.382	4.485	6	26.910
28	382.382	389.683	7.301	6	43.806
29	389.683	401.795	12.112	1	12.112
30	401.795	404.294	2.499	6	14.994
31	404.294	406.427	2.133	6	12.798
32	406.427	414.444	8.017	7	48.102
33	414.444	415.836	1.392	6	8.352
34	415.836	428.834	12.998	1	12.998
35	428.834	429.959	1.125	6	6.750
36	429.959	433.95	3.991	2	3.991
37	433.950	435.514	1.564	4	6.256
38	435.514	437.682	2.168	5	10.840
39	437.682	440.617	2.935	1	2.935
40	440.617	442.216	1.599	5	7.995
41	442.216	448.114	5.898	1	5.898
42	448.114	451.755	3.641	1	3.641
43	451.755	452.468	0.713	6	4.278
44	452.468	463.861	11.393	1	11.393
45	463.861	504.786	40.925	7	245.550
46	504.786	509.091	4.305	1	4.305
47	509.091	510.01	0.919	5	4.595
48	510.010	518.029	8.019	2	8.019
49	518.029	518.671	0.642	7	3.852

Table 2 Data Analysis according to RULA score

Data Analysis according to RULA Score					
Serial Number	Start time	End time	Elapsed time	RULA score	Elapsed time*RU LA score
2	31.152	41.38	10.228	1	10.228
11	157.73	161.455	3.725	1	3.725
19	318.958	342.477	23.519	1	23.519
21	347.807	352.579	4.772	1	4.772
23	356.777	361.868	5.091	1	5.091

26	372.529	377.897	5.368	1	5.368
29	389.683	401.795	12.112	1	12.112
34	415.836	428.834	12.998	1	12.998
39	437.682	440.617	2.935	1	2.935
41	442.216	448.114	5.898	1	5.898
42	448.114	451.755	3.641	1	3.641
44	452.468	463.861	11.393	1	11.393
46	504.786	509.091	4.305	1	4.305
8	97.44	123.156	25.716	2	77.148
17	272.735	285.341	12.606	2	12.606
36	429.959	433.95	3.991	2	3.991
48	510.01	518.029	8.019	2	8.019
1	0	31.152	31.152	3	93.456
6	63.186	83.703	20.517	3	61.551
7	83.703	97.44	13.737	3	41.211
9	123.156	135.626	12.470	3	37.410
10	135.626	157.73	22.104	3	66.312
12	161.455	168.384	6.929	3	20.787
13	168.384	187.083	18.699	3	56.097
14	187.083	219.03	31.947	3	95.841
15	219.03	237.768	18.738	3	56.214
16	237.768	272.735	34.967	3	104.901
18	285.341	318.958	33.617	3	100.851
3	41.38	48.927	7.547	4	30.188
4	48.927	53.17	4.243	4	16.972
5	53.17	63.186	10.016	4	40.064
37	433.95	435.514	1.564	4	6.256
38	435.514	437.682	2.168	5	10.840
40	440.617	442.216	1.599	5	7.995
47	509.091	510.01	0.919	5	4.595
20	342.477	347.807	5.330	6	31.98
22	352.579	356.777	4.198	6	25.188
24	361.868	365.577	3.709	6	22.254
27	377.897	382.382	4.485	6	26.910
28	382.382	389.683	7.301	6	43.806
30	401.795	404.294	2.499	6	14.994
31	404.294	406.427	2.133	6	12.798
33	414.444	415.836	1.392	6	8.352
35	428.834	429.959	1.125	6	6.750
43	451.755	452.468	0.713	6	4.278
25	365.577	372.529	6.952	7	41.712
32	406.427	414.444	8.017	7	48.102
45	463.861	504.786	40.925	7	245.550
49	518.029	518.671	0.642	7	3.852

The postural severity analysis for work elements based on RULA scores along with the frequencies and time duration for each postural severity index is calculated. The highest frequency of postural severity index, as per this analysis was 13 for the severity index 1; while the longest element during this study occurred for RULA severity score of 7 (40.925 seconds). The P-SVR Index value is 3.5.

Table 3P-SVR Analysis based on RULA

P-SVR Analysis based on RULA								Total
RULA Score	1	2	3	4	5	6	7	
Minimum elemental elapsed time	3.64	3.99	3.29	1.56	0.91	0.71	0.64	
Maximum elemental elapsed time	23.5	25.7	35	10	2.16	7.3	40.9	

Average elemental elapsed time	8.15	12.6	22.2	5.84	1.56	3.28	14.1	
Number of readings	13	4	11	4	3	10	4	49
Total Elapsed Time	106	50.3	245	23.4	4.68	32.9	56.5	518.64
Score * Number of readings	13	8	33	16	15	60	28	173
						P-SVR Index		3.5

P-SVR Index using REBA

P-SVR index calculation for the same work cycle is carried out using Rapid Entire Body Assessment (REBA). The postural severity analysis is done on the basis of REBA scores. The table no.4 shows the postural analysis using Rapid Entire Body Assessment (REBA) done in chronological order. The data in table no. 4 was further analyzed using P-SVR method. The results are shown in table no. 5.

Table 4 -Postural Analysis using REBA

REBA Analysis of a task of 518 seconds					
Sr. No.	Start Time	End Time	Elapsed time (ELT)	REBA Score	REBA Score * ELT
1	0	31.152	31.152	5	155.76
2	31.152	41.380	10.228	2	20.46
3	41.380	48.927	7.547	4	30.19
4	48.927	53.170	4.243	4	16.97
5	53.170	63.186	10.016	8	80.13
6	63.186	83.703	20.518	7	143.63
7	83.703	97.440	13.737	6	82.42
8	97.440	123.156	25.716	6	154.30
9	123.156	135.626	12.470	5	62.35
10	135.626	157.730	22.104	5	110.52
11	157.730	161.455	3.724	1	3.72
12	161.455	168.384	6.929	4	27.72
13	168.384	187.083	18.699	5	93.50
14	187.083	219.030	31.947	3	95.84
15	219.030	237.768	18.738	4	74.95
16	237.768	272.735	34.967	4	139.87
17	272.735	285.341	12.606	2	25.21
18	285.341	318.958	33.617	5	168.09
19	318.958	342.477	23.519	3	70.56
20	342.477	347.807	5.330	8	42.64
21	347.807	352.579	4.772	2	9.54
22	352.579	356.777	4.198	7	29.39
23	356.777	361.868	5.091	2	10.18
24	361.868	365.577	3.709	7	25.96
25	365.577	372.529	6.951	9	62.56
26	372.529	377.897	5.368	2	10.74
27	377.897	382.382	4.485	8	35.88
28	382.382	389.683	7.301	8	58.41
29	389.683	401.795	12.113	2	24.23
30	401.795	404.294	2.499	6	14.99
31	404.294	406.427	2.132	7	14.92
32	406.427	414.444	8.017	3	24.05
33	414.444	415.836	1.392	7	9.74
34	415.836	428.834	12.997	2	25.99
35	428.834	429.959	1.125	8	9.00
36	429.959	433.950	3.991	3	11.97

REBA Analysis of a task of 518 seconds					
Sr. No.	Start Time	End Time	Elapsed time (ELT)	REBA Score	REBA Score * ELT
37	433.950	435.514	1.564	4	6.26
38	435.514	437.682	2.168	7	15.18
39	437.682	440.617	2.935	7	20.55
40	440.617	442.216	1.599	8	12.79
41	442.216	448.114	5.898	2	11.80
42	448.114	451.755	3.642	2	7.28
43	451.755	452.468	0.713	9	6.42
44	452.468	463.861	11.393	3	34.18
45	463.861	504.786	40.925	1	40.93
46	504.786	509.091	4.305	2	8.61
47	509.091	510.010	0.919	4	3.68
48	510.010	518.029	8.019	2	16.04
49	518.029	518.671	0.641	7	4.49

Table 5 – Data Analysis according to REBA score

REBA Analysis of a task of 518 seconds sorted according to severity index				
Sr. No.	Start Time	End Time	Elapsed time (ELT)	REBA Score
11	157.73	161.455	3.724	1
45	463.861	504.786	40.925	1
2	31.152	41.38	10.228	2
17	272.735	285.341	12.606	2
21	347.807	352.579	4.772	2
23	356.777	361.868	5.091	2
26	372.529	377.897	5.368	2
29	389.683	401.795	12.113	2
34	415.836	428.834	12.997	2
41	442.216	448.114	5.898	2
42	448.114	451.755	3.642	2
46	504.786	509.091	4.305	2
48	510.01	518.029	8.019	2
14	187.083	219.03	31.947	3
19	318.958	342.477	23.519	3
32	406.427	414.444	8.017	3
36	429.959	433.95	3.991	3
44	452.468	463.861	11.393	3
3	41.38	48.927	7.547	4
4	48.927	53.17	4.243	4
12	161.455	168.384	6.929	4
15	219.03	237.768	18.738	4
16	237.768	272.735	34.967	4
37	433.95	435.514	1.564	4
47	509.091	510.01	0.919	4
1	0	31.152	31.152	5
9	123.156	135.626	12.47	5
10	135.626	157.73	22.104	5
13	168.384	187.083	18.699	5
18	285.341	318.958	33.617	5
7	83.703	97.44	13.737	6
8	97.44	123.156	25.716	6
30	401.795	404.294	2.499	6
6	63.186	83.703	20.518	7
22	352.579	356.777	4.198	7
24	361.868	365.577	3.709	7
31	404.294	406.427	2.132	7
33	414.444	415.836	1.392	7
38	435.514	437.682	2.168	7
39	437.682	440.617	2.935	7
49	518.029	518.671	0.641	7

REBA Analysis of a task of 518 seconds sorted according to severity index				
Sr. No.	Start Time	End Time	Elapsed time (ELT)	REBA Score
5	53.17	63.186	10.016	8
20	342.477	347.807	5.33	8
27	377.897	382.382	4.485	8
28	382.382	389.683	7.301	8
35	428.834	429.959	1.125	8
40	440.617	442.216	1.599	8
25	365.577	372.529	6.951	9
43	451.755	452.468	0.713	9

The postural severity analysis based on REBA scores for work elements along with the frequencies and time duration for each postural severity index is carried out. The highest frequency of postural severity index, as per this analysis was 11 for the severity index 2; while the longest element during this study occurred for REBA severity score of 4 (34.97 seconds). The P-SVR Index value is 4.7.

Table 6 – P-SVR Analysis based on REBA

P-SVR Analysis based on severity index	REBA Score	Minimum elemental elapsed time	Maximum elemental elapsed time	Average elemental elapsed time	Number of readings	Total Elapsed Time	Score * Number of readings	P-SVR Index
	1	3.72	40.93	22.32	2	44.65	2	
	2	3.64	13	7.73	11	85.04	22	
	3	3.99	31.95	15.77	5	78.87	15	
	4	0.92	34.97	10.7	7	74.91	28	
	5	12.47	33.62	23.61	5	118	25	
	6	2.5	25.72	13.98	3	41.95	18	
	7	0.64	20.52	4.71	8	37.69	56	
	8	1.13	10.02	4.98	6	29.86	48	
	9	0.71	6.95	3.83	2	7.66	18	
				49	518.7	232	4.7	

Job Difficulty Index (JDI)

Quantitative measure for job difficulty level due to postural severity of work elements of a process was not available till date by any ergonomic evaluation method. There was a need to quantify Job difficulty level value on a common evaluation scale. The postural severity values for processes or work elements are assigned by various postural evaluation methods which have different scales of assigning postural severity values. In order to overcome this limitation of postural evaluation, Job difficulty index arising out of postural severity of work elements is established. The same index can also be used to evaluate relative difficulty of different jobs on the basis of postural severity evaluation.

Formulation for Job difficulty Index[©]

This is the index invented to arrive at a value to evaluate postural difficulty level for any job. This index is defined as the ratio between the P-SVR index value and the maximum severity index value of the base method used for P-SVR analysis.

Job Difficulty Index

$$= \frac{\text{P – SVR index value}}{\text{Maximum value for the base method of postural analysis}} * 100$$

Job Difficulty Index (JDI) Decision Table

Table 7 - Job Difficulty Index value and action required

Job Difficulty Index	Action required
< 50	Postural severity level of the process is satisfactory.
> 50 = 75	Process needs to be simplified for work elements with high postural difficulty index value.
> 75 = 85	Immediate action needed to have major change in the process for work elements with high postural difficulty index value.
> 85	Entire process is required to be revamped to lower the JDI.

Benefits of Job Difficulty Index

- Job Difficulty Index provides basis for comparison of difficulty level arising out of postural severity of work elements for different jobs and processes in an organization, on a common job difficulty evaluation scale.
- This index clearly indicates job difficulty level for any job or for a process irrespective of methods used for postural severity evaluation having different postural severity evaluation scales and ranges.

Results and Discussion

The P-SVR Index value was 3.53 for RULA and 4.73 for REBA.

Based on these figures the Job Difficulty Index value for RULA is calculated as –

$$\text{Job Difficulty Index}_{RULA} = (3.53 / 7) * 100 = 54$$

$$\text{Job Difficulty Index}_{REBA} = (4.73 / 14) * 100 = 34$$

These values indicate that the Job Difficulty for the work cycle is higher for Upper Body than the Entire body. This highlights the fact that the organization should concentrate on improving the work content involving upper body of the operator.

Conclusion

The P-SVR methodology analyses a job comprehensively through application of postural severity analysis. This methodology has overcome the shortcomings of the earlier methods of postural analysis. Since the duration of time spent in different severity of postures is also accounted for in this method, the P-SVR Index is a better method to analyse of work contents for any task. The P-SVR methodology also highlights the exact work element where postural improvement is required.

The JDI (Job Difficulty Index) is the index which can be used to find out either relative difficulty of different jobs, or it can also be used to evaluate relative difficulty of a job when different methods of postural analysis are used to evaluate the postural severities, having different scales, as discussed in the above mentioned case study.

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