THE APPLICATION OF THE REVISED NIOSH LIFTING EQUATION AND REBA METHODS IN MANUAL WORK EVALUATION (A Case Study at PT. Caladi Lima Sembilan, Bandung)

Thedy Yogasara and Chrisye Fiona Wenas

Industrial Engineering Department, Industrial Technology Faculty
Parahyangan Catholic University
Jl. Ciumbuleuit 94, Bandung 40141, INDONESIA
Tel: 62-22-2032700, e-mail: thedy@home.unpar.ac.id, crefio@yahoo.com

Abstract

Manual lifting is one of manual material handling (MMH) activities that requires serious attention because the physical pressure of this particular work will affect the workers' health condition. The workers may suffer from work-related musculoskeletal disorders, especially low back pain injuries.

In its production process, PT. Caladi Lima Sembilan (PT. C59 - a garment factory in Bandung) still involves manual lifting activities. To prevent worker injury due to this particular work, manual work evaluation using The Revised NIOSH Lifting Equation (NIOSH 1991) and REBA method is conducted to several lifting activities. NIOSH 1991 is a tool for evaluating the manual lifting work comprehensively by calculating the recommended weight limit and lifting index, while REBA method is a tool for evaluating the variations of workers' physical posture as they doing their works. REBA method will produce a score for each work, which the greater the calculated score, the greater risk of the workers' injury.

The result of evaluation and analysis that have been conducted in several departments indicates that the present working condition requires improvement actions. Therefore, redesign suggestions is given to improve the present working conditions. The results are expected to be close to the ideal working conditions that are suggested by NIOSH 1991 and REBA methods.

Keywords: *manual lifting, low back pain, NIOSH 1991, REBA*

1. Introduction

Although many new technologies in industrial world have been automated in their use, the human roles in a working system cannot be disregarded. This is because human is the center of a working system that consists of production factors (5M: Man, Machine, Money, Material and Method), along with his/her complex characteristics and behavior. Work can affect human health and safety in some ways, among others through physical tasks which involve repeated use of certain body parts. Therefore special attentions are necessary to be given to human factor.

Physical activities which occupy frequent use of neck, shoulder, back and upper limb can cause work-related musculoskeletal disorders, and one of them is known as low back pain. Low back pain is the most significant problem among labors and workers. This problem tends to increase which results in high absent rate, lost incomes, increased medical compensation and incapability to work from workers. Low back pain is the second largest of the causes of lost work-hours. Because of the high level of occurrence, this problem economically will cause great cost to companies. For example, in the United States, the cost of lost productivity or lost work-hours as a result of low back pain is $50 billion annually, while the cost for reduced production output and medical compensation is $20 billion annually (Samara 2003).

Generally, it is believed that workers who perform heavy manual tasks are likely to suffer back pain compared to those whose works do not require much physical power (Pheasant 1991, p. 65). Frymoyer (Frymoyer et al. 1980, 1983 in Pheasant 1991, p.67) in his study about the

importance of varied pattern and change of posture in doing work, confirmed that works that involve lifting, carrying, pushing, pulling, bending and twisting activities can increase risk of suffering low back pain significantly.

PT. Caladi Lima Sembilan (PT. C59) is a company in Bandung, Indonesia, that produces T-shirt. In its production processes, this company still performs manual material handling activities, which take place in flow inter and within workstations. An example of those activities is lifting of T-shirt from a basket placed on the floor to folding workbench at finishing workstation. Based on preliminary observation, it is probable that manual material handling tasks in PT. Caladi Lima Sembilan have a risk of occurrence of injury and pain/disorder to its workers, so that the work condition is required to be evaluated.

In this paper, two methods will be used for evaluation of manual lifting tasks, which are the Revised NIOSH Lifting Equation (NIOSH 1991) and REBA (Rapid Entire Body Assessment). NIOSH 1991 is a tool for evaluating manual lifting tasks comprehensively by calculating recommended weight limit so that the tasks do not cause low back pain and even disability to the workers (Waters and Putz-Anderson 1999). Equation in this method can be applied to some lifting tasks at PT. Caladi Lima Sembilan shop floor. The other method, which is REBA, is a tool for assessing body postures of worker in relation to the risk of work-related musculoskeletal disorders (WRMSDs) to the workers (Bernard 2001).

2. Problem Identification

Based on the above description, the problems in this research can be formulated as follows:

a. What is the condition of manual lifting works at PT. Caladi Lima Sembilan based on NIOSH 1991 and REBA methods?
b. From the use of NIOSH 1991 and REBA methods in this research, are the both methods give the same evaluation results?
c. What are the proposed improvements for working condition at PT. Caladi Lima Sembilan in order to minimize the risk of injury to the workers?

3. Method

The objectives of the application of NIOSH 1991 and REBA in this research are to evaluate manual lifting tasks at PT. Caladi Lima Sembilan and to analyze characteristic of the both methods. Therefore, the selected research objects must conform to the determined criteria of the both methods. Observation is conducted in sorting and finishing departments. The task examined in sorting department is lifting of piles of T-shirt part from the floor onto a workbench, while observation in finishing department is carried out for the lifts of piles of T-shirt from a basket onto steaming workbench, folding workbench, and labeling workbench.

The collection of required data is conducted by measuring worker's postures when she is doing her tasks. The measured data for NIOSH 1991 are horizontal distance of load from the worker (H) at the origin and the destination of the lift, vertical location of the hands from the floor (V) at the origin and the destination of the lift, vertical travel distance between the origin and the destination of the lift (D), angle of asymmetry (A) at the origin and the destination of the lift, frequency (F) and duration of lifting, quality of hand-to-object coupling (C), and weight of the load. The data above are taken in a representative number and tested statistically (normality test and uniformity test).

For REBA method, the collected data are photo documentation of worker's body postures as the worker is doing the lifting activities. Body parts that are observed are neck, shoulder, trunk, upper and lower arms, wrist, and leg. Beside that, the observation also includes other factors that may affect the workers when they are performing their tasks, such as load weight, quality of hand-to-object coupling, and movement activity of the workers. The photos which are taken will be used to get the angles between worker's body segments. This is carried out with the aid of Motion Analysis Tools 1.1a (MAT) program.

4. Evaluation of Lifting Activity at Sorting Workbench by Using NIOSH 1991 and REBA

This paper will present one of four examined cases as an example, which is lifting activity of piles of T-shirt part from the floor to the operator's workbench (see figure 1).

Figure 1. Material lifting process at sorting department

The data of task variables that have been collected, are processed and recorded into job analysis worksheet (see figure 2). The data inputted are task variables which are taken from extreme posture, i.e. as the worker is lifting piles of T-shirt from the bottom of the basket/pile. This is because the posture imposes the highest risk of getting injury on worker's low back.

JOB ANALYSIS WORKSHEET

DEPARTMENT : Sortir	JOB DESCRIPTION
JOB TITLE : Proses penyortiran bahan kaos	Mengangkat tumpukan potongan bahan kaos dari
ANALYST'S NAME	lantai ke meja
DATE : 4 November 2003	

STEP 1. Measure and record task variables

Object Weight (kg)		Hand Location (cm)				Vertical Distance (cm)	Assymetric Angle (degrees)		Frequency Rate	Duration	Object Coupling
		Origin		Destination			Origin	Destination	lifts/min	(HRS)	
L (AVG)	L (Max)	H	V	H	V	D	A	A	F		C
1.18	1.5	31.63	10.7	35.74	75	64.3	64	0	0.58	> 2 tapi < 8	Fair

STEP 2. Determine the multipliers and compute the RWL's

		RWL	=	LC	x	HM	x	VM	x	DM	x	AM	x	FM	x	CM		
ORIGIN		RWL	=	23	x	0.79	x	0.81	x	0.89	x	0.8	x	0.8	x	0.95	=	7.89
DESTINATION		RWL	=	23	x		x		x		x		x		x		=	

STEP 3. Compute the LIFTING INDEX

ORIGIN LIFTING INDEX = $\frac{L}{RWL} = \frac{1.5}{7.89} = 0.19$

DESTINATION LIFTING INDEX = $\frac{L}{RWL}$

Figure 2. Job analysis worksheet for activity at sorting department

For activities at sorting department, it can be seen that at the origin of the lift, the product of six multipliers and load constant results in RWL (Recommended Weight Limit) value of **7.89 kg**. Maximum actual load weight, which is 1.5 kg is selected to be compared to the RWL value, so that lifting index value of **0.19** is obtained. The lifting index indicates that the working condition is

relatively safe. Analysis is only carried out at the origin of the lift because significant control (e.g. precision in placing object) is not required at the destination of the lift.

Example of the calculation of the NIOSH 1991 multipliers as shown at the job analysis worksheet is as follows:

- LC = 23 kg
- HM = 25/H = 25/31.63 =0.79
- VM = 1-(0.003 | V-75 |) = 1-(0.003 | 10.7-75 |) = 0.81
- DM = 0.82+(4.5/D) = 0.82+(4.5/64.53) = 0.89
- AM = 1-(0.0032A) = 1-(0.0032*64) = 0.8
- FM = 0.8 (interpolation from FM table, V < 75 cm and F = 0.58 lifts/minute)
- CM = 0.95 (coupling quality is *fair* and V < 75 cm, the value is obtained from CM table)

Based on collected photo documentation, the angles between body segments that are created from lifting posture can be acquired (by using MAT program). However, those angles cannot be directly inputted to REBA software due to the difference of way in determining the angles of body segment between MAT and REBA (see figure 3). Therefore, the obtained data need to be converted prior to assessment process using REBA software. The result of data conversion for lifting posture at sorting workbench can be seen in table 1.

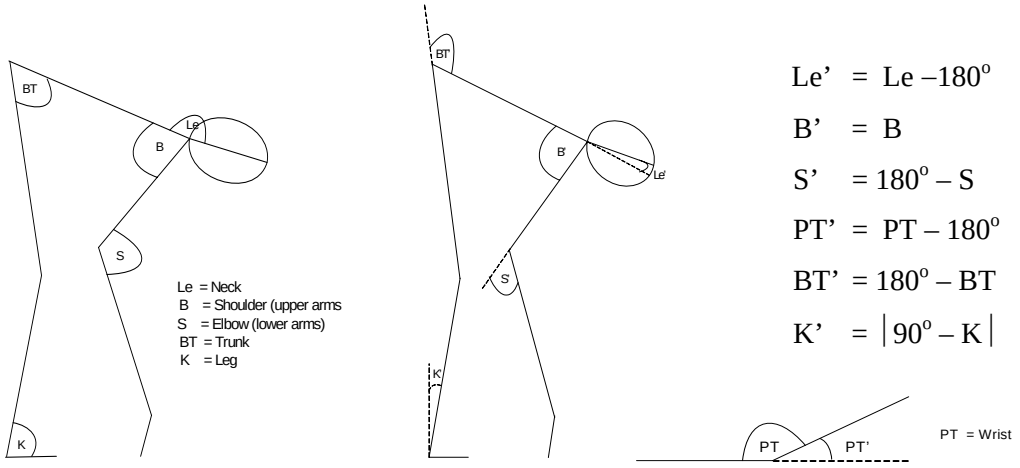


Figure 3. The calculation of body segment angles based on MAT (left) and REBA (right)

Table 1. The difference of angle values of worker's posture at sorting workbench between MAT and REBA

Angle	MAT (degree)	REBA (degree)
Neck	158.37	-21.63
Trunk	67.66	112.34
Leg	97.22	7.22
Upper Arms (Shoulder)	111.23	111.23
Lower Arms (Elbow)	167.02	12.98
Wrist	160.98	-19.02

The angle values from table 1 are inputted to REBA task information by selecting body postures that conform to the available data. The assessment result of worker's body posture for lifting activity at sorting workbench is shown at figure 4.

The REBA score as a result of the assessment is **9**. This final score point to **action level 3**, that means the current working condition is not safe for the workers because the occupied body posture while they are lifting the objects has a risk of getting injury/back pain to them. Consequently, corrective/improvement action is required soon.

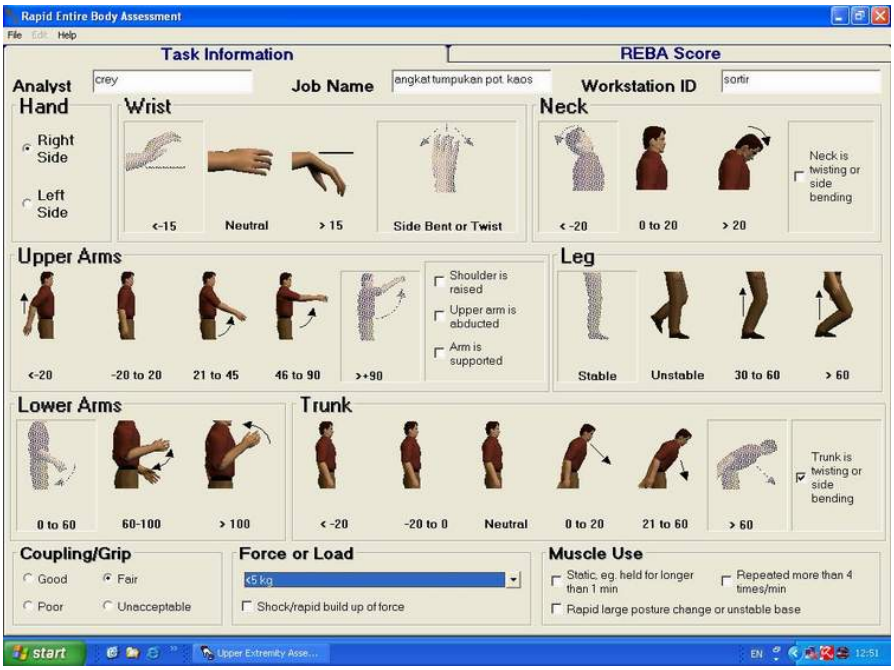


Figure 4. The REBA assessment of worker's body posture at sorting workbench

The workers' body posture will be ideal if in performing their activities, the workers are under these conditions: trunk is in neutral position, neck moves in the range of 0^o - 20^o , leg is in straight position, upper arms create -20^o – 20^o angle, lower arms move in the range of 60^o – 100^o, and wrist is in neutral position. In addition, factors that may affect directly to workers' activity should not be in such condition that they may cause injury/pain to the workers. This condition will be achieved if coupling quality is good, the weight of the load is less than 5 kg, and the workers perform their activities normally (there is no overexertion).

5. Comparative Analysis between the Result of NIOSH 1991 and REBA Assessment

The lifting index for activity at sorting workbench is 0.19. This value is obtained by dividing the maximum load weight by the RWL (7.89 kg). It indicates that the actual load weight is less than the recommended weight limit, thus it can be concluded that the current working condition is relatively safe for the workers. On the other hand, the assessment result from REBA is different. REBA final score shows action level 3 indicator, that means working condition at sorting workbench has a high risk of causing injury/pain so that improvement action is required soon.

The difference in the assessment results is caused by the difference of focus of analysis in each method. REBA method put emphasis on evaluation of overall body posture, hence the bent posture of the worker while she is taking the load on the floor will give bad evaluation result from REBA. Moreover, the bent posture due to large vertical distance to the object also causes the other body parts are far from the ideal condition (upper and lower arms need to reach maximally, and there is bending at the neck as well), so that this will worsen the assessment result.

Whereas, NIOSH 1991 emphasizes the evaluation on object weight, lifting distances, asymmetry angle and lifting frequency/duration, nevertheless it does not give attention to body posture in detail. Beside that, indicator of the goodness or badness of working condition is seen from the comparison of actual load weight and recommended weight. Thus, based on NIOSH 1991 method, the lifting activity at sorting workbench is in safe condition because the object lifted by the worker is lightweight, so that the worker can perform her work safely although in lifting the object from the floor, angle of asymmetry and great vertical distance are occurred.

Table 2 shows the comparison of evaluation result of all observed working condition based on REBA and NIOSH 1991 methods. While table 3 generally presents the characteristic comparison between NIOSH 1991 and REBA methods.

Table 2. The comparison of evaluation result of current working condition based on NIOSH 1991 and REBA methods

Lifting Activity at Workbench	NIOSH 1991		REBA		
	LI	Improvement Action	Final Score	Action Level	Improvement Action
Sorting	0.19	Not required	9	3	Required
Steaming	1.11	Required	8	3	Required
Folding	1.27	Required	7	2	Required
Labeling	0.83	Not required	8	3	Required

Table 3. The comparison of characteristic between NIOSH 1991 and REBA methods

NIOSH 1991	**REBA**
o Offers recommended load weight that is safe for a certain lifting/lowering condition. o Considers the distance of worker to object, vertical distance and vertical travel distance at the origin and the destination of the lift, angle of asymmetry, frequency and duration of lifting. o Considers biomechanical, physiological and psychophysical aspects in developing the lifting equation. o Limited to many conditions, e.g. this method can only be used for lifting/lowering that occupies both hands, the equation does not apply for lifting/lowering while seated or kneeling, etc. o Evaluation only focus on injury/pain at lower back, and less attention on other body parts.	o Provides information of worker's body posture in detail. o Requires information of angle values on trunk, neck, leg, upper arms, lower arms and wrist of worker's body posture. o Can be applied for estimating injury indication on skeletal system generally. o Does not consider distances between the worker and the object while performing lifting/lowering. o Assessment result is highly dependent on worker's body posture. o Assessment result is not sensitive to little change of angle values, because the method works based on range, not on specific value.

6. Proposed Improvement for Lifting Activity at Sorting Workbench

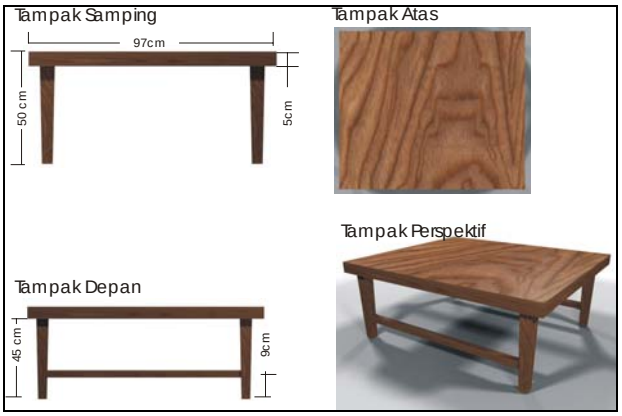
Improvement will be carried out for working condition at sorting workbench, despite the both evaluation methods give different assessment results. This is done for the sake of minimizing the risk, and the improvement is carried out until the both evaluation methods indicate a safe condition. Specifically, the improvement will be focused on body parts that have bad posture at the time of lifting (prioritized for improving the REBA score).

The proposed improvements for lifting activity at sorting workbench are as follows:

- Change of the way of lifting by using leg lifting technique (see figure 5a), so that horizontal distance between worker and object can be decreased and there is no bending posture.
- Change of worker's posture movement as the worker is taking the object from the floor.
- The use of aid table with certain height that can minimize horizontal and vertical distances of the lifting (see figure 5b).

The improvements for working condition at steaming, folding and labeling workbench are generally carried out by the change of the way of lifting that can result in better postures, and by using aid tables. Based on the proposed improvements, it can be evaluated whether the improvements have given good contribution to current working conditions. This can be seen if there is a decreased indication of injury/pain risk to the workers. The comparison of NIOSH 1991 lifting index and REBA score/action level between current and proposed working condition is presented in table 4.

From table 4, it can be seen that the proposed improvements result in NIOSH 1991 lifting index less than 1 for all observed working conditions, and from REBA method, final score 3 and action level 1 are obtained. This indicates that the proposed working conditions are relatively safe for the workers without the risk of being injured or getting pain.



(a) (b)

Figure 5. Leg lifting technique and aid table for proposed improvements

Tabel 4. Comparison of NIOSH 1991 lifting index and REBA score/action level between current and proposed working condition

Lifting Activities at Workbench	LI value from NIOSH 1991		Score (Action Level) from REBA	
	Current Condition	Proposed Condition	Current Condition	Proposed Condition
Sorting	0.19	*Leg lifting:* 0.12 Support table: 0.10	9 (3)	*Leg Lifting:* 3 (1) Support table: 3 (1)
Steaming	1.11	0.36	8 (3)	3 (1)
Folding	1.27	0.41	7 (2)	3 (1)
Labeling	0.83	0.48	8 (3)	3 (1)

7. Conclusions

Based on this research, several conclusions that can be drawn are as follows:

a. There are differences of characteristic between NIOSH 1991 and REBA methods, particularly on the emphasis of evaluation from the both methods. This differences may cause each method gives different evaluation result for the same working condition.
b. Evaluation by using NIOSH 1991 indicates risk potency to the workers at folding and steaming workbench, while evaluation result that is obtained by using REBA shows a high risk potency for all observed working conditions, except for working condition at folding workbench (medium level of risk).
c. The proposed improvements that can be given to the current work conditions in order to minimize the risk of being injured or suffering pain to the workers are changes in the way of lifting object and the use of aid tables. The evaluation of the proposed improvements shows that the proposed lifting activities are better than the current ones (this can be seen from the values of NIOSH 1991 lifting index and REBA score/action level), so that the workers are relatively safe to perform their tasks.

8. References

1. Bernard, Thomas E. (2001), *Rapid Entire Body Assessment*, [online], Available: http://hsc.usf.edu/~tbernard/HollowHills/REBA_M11.pdf [2003, September 18].
2. Bridger, R.S. (1995), *Introduction to Ergonomics*, McGraw-Hill, Inc., Singapore.
3. Gunawan, Indra (2004), *Analisis dan Perancangan Sistem Kerja Penanganan Material Secara Manual dengan Menggunakan Mannequin Pro 7.1 serta Pembuatan Panduan Program Mannequin Pro 7.1 (Studi Kasus di Hidup Baru Garment & Printing).* Thesis. Department of Industrial Engineering, Parahyangan Catholic University , Bandung.

4. Hignett, S. & McAtamney, L. (2000), 'Rapid Entire Body Assessment (REBA)' in *Applied Ergonomics*. 31: 201-205.
5. Kroemer, K.H.E., Kroemer, H.B., and Kroemer-Elbert, K.E. (2001), *Ergonomics How to Design for Ease and Efficiency*, 2nd ed., Prentice Hall International, Inc., New Jersey.
6. Pheasant, S.T. (1991), *Ergonomics, Work and Health*. Aspen, Gaithersburg, MD.
7. Pulat, B.M. (1996), *Fundamentals of Industrial Ergonomics, Waveland Press*, Inc., USA.
8. Salvendy, G. (1997), *Handbook of Human Factors and Ergonomics*, John Wiley & Sons, Inc., Canada.
9. Samara, Diana (2003), *Nyeri Pinggang Bawah Pada Pekerja Dapat Ganggu Produktivitas Kerja*, [online], Available: http://www.kompas.com/kompas%2Dcetak/0302/26/ilpeng/ 149555.htm [2003, July 19].
10. Sutalaksana, Iftikar Z.; Anggawisastra; Tjakraatmadja (1979), *Teknik Tata Cara Kerja*, Bandung Institute of Technology.
11. Waters, T.R., and Putz-Anderson, V. (1999), 'Revised NIOSH Lifting Equation' in *The Occupational Ergonomics Handbook*, eds. W. Karwowski & W.S. Marras, CRC Press, New York.
12. [online] (2003), *Keluhan Nyeri Tanda Penyakit Berbahaya*, Available: http://www.kompas.com/kompas%2Dcetak/0305/12/jateng/307198.htm [2003, July 19].
13. [online] (2002), *Nyeri Punggung: Membungkuk, Lalu Aduh…*, Available: http://www.kompas.com/kesehatan/news/0208/13/193825.htm [2003, July 19].
14. [online] (2002), *Nyeri Pinggang Bawah Banyak Ditemukan di Tempat Kerja*, Available: http://www.kompas.com/kompas%2Dcetak/0206/11/iptek/nyer10.htm [2003, July 19].