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The Evaluation of Manual Lifting Task by ML-Expert System:  
A Case Study of Sample Factories

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Abstract: The purposes of this research are evaluation of manual lifting task in three factories and comparison between normal work improvement method and ML-Expert program. Initially, checklist form and enterprise inspection questionnaire used for manager and supervisor interviewed, to find the problems in manual lifting task area. Then chosen the workers were evaluated by health questionnaire and interview form. After that the ergonomics principle were applied for the appropriated of work station. The study of three factories, compared between two groups of normal group (evaluation by RLE equation: NIOSH Revised Lifting Equation 1991) and ML-Expert system using group, using QCC technique for improvement every month in 5 months period. The results showed that (9 topics) Abnormal Index (AI), Lifting Index (LI), Biomechanics compressive force on L5/S1 disc, % of suggestion to be use, user satisfaction, efficiency of improvement, time usage of improvement, production efficiency and loss, quality of work life (fatigue, sickness, absence) of ML-Expert system using group are better in all factories. Especially, user satisfaction, efficiency of improvement, time usage of improvement, and production efficiency are better at 95\% significant level. Additionally, ML-Expert system can be assist in LI calculation and find a solution for improvement to faster than normal work improvement method from 12.62 (±3.35) minute to 5.38 (±1.70) minute.

Keywords: Expert System, Work Load Evaluation, Manual Lifting Task

1. INTRODUCTION

Manual lifting task, usually found in the factory, is the primary cause of back disorders, low back pain (LBP) and back injuries.(OSHA, 2004) The U.S. Department of Labor reported that there were 173,400 injuries related to manual lifting task in 2004. (U.S. Department of Labor) The Ministry of Labor and Social Welfare (Thailand) also reported that there were 4,424 injuries related to manual lifting task in 2004. (Ministry of Labor and Social Welfare, 2005) These injuries are the cause of lost work time and associated monetary costs.

Intranont K., (2005) present that ergonomics evaluation are important for improvement the work condition. (Figure 1) If the work load is fit for the worker the overall efficiency will be better. The efficiency is included productivity, physical load and mental load. Otherwise, if the work is overload the worker may be sick, injure, absent or retire. Then the productivity will be decrease. The evaluation may be combined between biomechanics, physiology, and psychophysics.
In 1981, The National Institute for Occupational Safety and Health (NIOSH) published the Work Practices Guide for Manual Lifting (NIOSH 1981). The NIOSH 1981 provided analytical procedures and lifting equation for calculating a recommended weight; and an approach for controlling the hazard of low back injuries from manual lifting. However, the NIOSH 1981 was limited applying the symmetrical lifting tasks only.

In 1985, NIOSH reviewed the current literature on lifting, including the NIOSH 1981. The literature summary prepared information on the physiological, biomechanical, psychological, and epidemiological aspects of manual lifting. NIOSH used these criteria to formulate the revised lifting equation (NIOSH Revised Lifting Equation 1991: RLE 1991). The RLE 1991 provided methods for evaluating asymmetrical lifting tasks, and lifts of objects with less than optimal couplings between the object and the workers’ hands.

In 1993, Waters et al. provided an article describe the RLE 1991 application and limitations for using the revised equation which are as follows: RLE 1991 assumes that other manual material activities, such as holding, pushing, pulling, carrying, walking, and climbing, are excluded. RLE 1991 does not include task factors to account for unpredicted conditions and environment, such as unexpectedly heavy loads, slips or falls, temperature or humidity significantly outside the range of 19 to 26 °C or 35% to 50%, respectively. RLE 1991 was not designed to assess tasks involving one-hand lifting, lifting while seated or kneeling, lifting in a constrained space, lifting people, lifting of extremely hot cold, or contaminated objects. RLE 1991 assumes that the worker/floor surface coupling provides at least 0.4 coefficient of static friction between the shoe sole and the working surface. RLE 1991 assumes that lifting and lowering tasks have the same level of risk for low back injuries.

Determination of using RLE 1991 in actual environment are the temperature and humidity equation (e.g. in Thailand), because the temperature and humidity in Thailand are usually higher than the limitation (18.6-37.4 °C; average 29.0 °C; 57%-86%; average 73%; at Bangkok, 2003). (Meteorological department, 2004) Next factor to determine is gender, because the actual tasks usually performs by male or female separately, but RLE 1991 derived from the lower criteria (female) for more safety, may be not fit for economical criteria. Another factor to determine for using RLE 1991 for different population, e.g. Thai people, should be adjusted some parameters, such as Horizontal multiplier (HM), Vertical multiplier (VM), and Frequency Multiplier (FM), because the body size and

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**Figure 1 Work Load Evaluation System (Intranont K., 2005)**

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endurance of Thai people are different from the western. However, the RLE 1991 has advantages: contained a summary of the lifting-related literature, simply using and it has recommendation for improvement the lifting condition. Therefore, this study will follow the RLE 1991, but the limitations above will be reduced for widely application. The limitation can be reduced by additional knowledge. In addition, the limitations of RLE 1991 could be reduced by another knowledge combination. There are many forms of knowledge to be combined such as the Job Stress Index (JSI; Ayoub & Mital, 1989) and another multiplier that present in mathematical or table form (Ayoub et al., 1989; Mital et al, 1997). One method to combine is to use the expert system. The expert system is the computer software that contained the rules, the inference engine and the user interface that can be easily modified or update the knowledge that change or update rapidly.

In 2004, Klomjit surveyed the manual lifting task postures and conditions. This study surveyed the manual lifting task characteristics (e.g., lifting pattern, working condition) and evaluated the manual lifting task using the RLE lifting equation. The study also investigated some difficulties underlying the application of the equation. The total of 7 factories were surveyed; auto-part manufacturing, auto-part assembly, construction material manufacturing, electric appliance manufacturing, ceramic, steel manufacturing, and furniture manufacturing. This study selects the tasks based on whether they required high degree of manual lifting. Result from the preliminary survey is 31 separated tasks. Total 81 subjects were included in the study; 78 males and 3 females. Average characteristics of the task being surveyed are weight 17.5 kg., vertical height 63.9 cm, vertical distance 37.3 cm, temperature 29.8 °C, the relative humidity 58.2 %, Recommended Weight Limit (RWL) 13.2 kg., Lifting Index (LI) 1.4. The conclusion was that most of these tasks (19 tasks) are considered as heavy manual lifting (LI over 1). The major reason is heavy load weight. Another factor is the large reaching distance, which decreases the RWL and therefore increases LI. The study also shows that these lifting required workers to work outside the limitation to appropriately use RLE equation, such as the required of short walks (30 tasks), two-persons lifting (13 tasks), exceed temperature and relative humidity.

There are some expert systems related to the evaluation of the lifting tasks such as ERGON-EXPERT (Laurig and Rombach, 1989), M-LIFTAN (Kabuka et al., 1988), a knowledge-based system for the design for repetitive manual materials handling (RMMH) tasks (Karwowski et al., 1987), a knowledge-base system for assessment of human physiological abilities in manual lifting tasks (Asfour and Genady, 1987), ERGOEX (Gilad & Karni, 1999). These expert systems were used in the limitation of alternative, flexible, and expandable. Recently, there were increasing number of literatures and the more capability of expert system shell. To increase the capability of the expert system for lifting task and to understanding the expert system roles should be determined.

The purposes of this study is to evaluate the expert system, has been developed, call ‘ML-Expert’ (Manual Lifting Task Expert System) by extend the NIOSH’s RLE 1991, incorporated specific local conditions (i.e., Thailand), and integrated of this extension for workplace evaluation and recommendations. (Klomjit P. et al, 2006) The study use three factories, compared between two groups of normal group (evaluation by RLE equation: NIOSH Revised Lifting Equation 1991) and ML-Expert system using group, using QCC technique for improvement every month in 5 months period.

The expected benefits include the following. It is the automatic evaluation of existing workplace scenarios, including task parameters, individual characteristics, and standards/requirements. In addition, the expert system will result in the set of comprehensive recommendations in order to minimize LBP.

2. METHOD AND EQUIPMENT

2.1 Equipment

The equipment are included: “ML- Expert” Program (Figure 2), computer, camera, VDO camera, measuring tape, Checklist (Intranont K., 2005), Interview form (Intranont K., 2005), and Satisfaction evaluation form,
2.2 Method

The study performs in three factories, sanitary factory, paper core factory and furniture factory. The researcher collects the data and evaluates the manual lifting task by ML-Expert and other method with the following procedure:

1) Survey the overall section in the factory. Collect the sickness and injuries data and then select the section that has a height level of problem in manual lifting task.
2) Collect the detail data by checklist, Interview form
3) Select two sample groups: Group 1; improve the manual lifting task by normal method (NIOSH Equation), Group 2; improve the manual lifting task by ML-Expert System
4) Train the improvement method. (Introduction ML-Expert system to group 2)
5) Train the sample groups to use the QCC technique for improvement
6) Biomechanics Analyze by working picture, and interview the result of each group
7) Analyze the result of each improvement method
8) Compare with Ergo EASER program [13] and 3DSSPP program [14]
9) Conclusion

3. RESULT

The background of subject data of 12 males at casting section in the factory are following: age 27.17 (±1.64) years, working time 2.38 (±1.53) years, and Low Back Pain Experience Ratio 54%
3.1 Abnormal Index

The result of AI (Abnormal Index) (Intranont K., 2005) of all factories, are totally decreased. (Figure 3) Factory 1: Group 1 and Group 2 decrease 4.55% and 13.59%, Factory 2: Group 1 and Group 2 decrease 41.14% and 61.45%, Factory 3: group 1 and Group 2 decrease 26.78% and 23.70%, respectively.

3.2 Biomechanics Analysis

The result of biomechanics compressive force on L5/S1 disc of Group 1: at the “open mould” operation 15.95% and at the “open base” operation 24.57%, Group 2: at the “open side mould” operation 4.58% and the “moving object” operation 5.44%

3.3 NIOSH 1991

The result of LI (Lifting Index) at origin and destination of two groups decreased. Group 1: at the “move object” operation decrease 49.12% and 42.94%, and at the “release load” operation decrease 47.14% and 43.10%, Group 2: at the “open mould operation” decrease 14.68% and 13.51%, respectively.

3.4 Ratio (%) of Implementation

The result showed that the ratio (%) of implementation of ML-Expert is better than normal evaluation by RLE method. (Figure 4)
3.5 The Satisfaction of ML-Expert System

The result showed that the user satisfactions are better than other method, especially, in the “Recommendation” Part (Figure 5) Factory 1: Group 1 and Group 2 decrease 4.55% and 13.59%, Factory 2: Group 1 and Group 2 decrease 41.14% and 61.45%, Factory 3: group 1 and Group 2 decrease 26.78% and 23.70%, respectively.

![Figure 5 the user satisfactions](image)

3.6 Improvement Efficiency

The result showed that the efficiency of improvement is better than other method, especially, in the “Recommendation” Part. (Figure 6)

![Figure 6 The improvement efficiency of each method](image)

3.7 Calculation and Improvement Time

The performance of each system was measured in term of calculation and improvement time. The average time result of NIOSH, ErgoEASER, 3DSSPP, and ML-Expert are 12.62 minutes, 12.02 minutes, 9.78 minutes and 5.38 minutes, respectively. The time usage of improvement of ML-Expert is better than calculation by NIOSH equation at 95% significant level. (Figure 7)


3.8 Production Efficiency

The production efficiency defined in term of efficiency and loss. The result showed that efficiency of “ML-Expert” Group is better than normal method (Figure 8). This result may be from the “ML-Expert” was reduce the step or time of improvement to the easy way.

3.9 Quality of Work Life

The result showed that the quality of work life (general fatigue, sickness and absence ratio) after improvement every group is better than before improvement. However the general fatigue ratio of the “ML-Expert group” is better than other group. (Figure 9)
4. CONCLUSION

The study of three factories, compared between two groups of normal group (evaluation by RLE equation: NIOSH Revised Lifting Equation 1991) and ML-Expert system using group, using QCC technique for improvement every month in 5 months period. The results showed that (9 topics) Abnormal Index (AI), Lifting Index (LI), Biomechanics compressive force on L5/S1 disc, % of suggestion to be use, user satisfaction, efficiency of improvement, time usage of improvement, production efficiency and loss, quality of work life (fatigue, sickness, absence) of ML-Expert system using group are better in all factories. Especially, user satisfaction, efficiency of improvement, time usage of improvement, and production efficiency are better at 95% significant level. Additionally, ML-Expert system can be assist in LI calculation and find a solution for improvement to faster than normal work improvement method from 12.62 (+3.35) minute to 5.38 (+1.70) minute.

5. ACKNOWLEDGEMENT

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6. REFERENCE


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