Study of low back pain intensity and disability index among manual material handling workers of a tile and ceramic industrial unit, Iran (2016)

Fatemeh Fasih Ramandi *

- MSc Student in Occupational Health Engineering, Student Research Committee, Shahid Beheshti University of Medical Sciences, Tehran, Iran.

**Abstract**

**Background:** The revised National Institute for Occupational Safety and Health (NIOSH) lifting equation (RNLE) is commonly used for risk assessment of manual handling, and can estimate low back pain (LBP) biomechanical stressors of lifting and/or lowering of loads. The aim of this study was to evaluate manual material handling by using the RNLE, LBP, and LBP disability index (LBPD) among workers in a tile and ceramic industrial unit in Tehran, Iran.

**Materials and Methods:** A sample of 30 workers (manual workers) in a tile and ceramic production line was recruited. Low back pain prevalence and disability index were measured using body map questionnaire combined with visual analog scale and self-report Oswestry disability index (ODI), respectively. Statistical data analysis was done using SPSS software, version 22.

**Results:** According to results, composite lifting index was 14.77. Low back pain prevalence among workers was reported equal to 100%; also, Low back pain intensity was equal to 68.8 ± 17.8. The mean of Low back pain disability index among workers has been reported equal to 41.3 ± 17.1 (severe crippled).

**Conclusions:** The results show that composite lifting index value for these jobs exceeded 3, which means that there is a significant level of physical stress associated with these jobs for nearly all workers. Both strength and endurance for this job are high; therefore, job redesigning could decrease the physical demands, Low back pain prevalence, and Disability index, through modifying the job layout and work stations.

**Keywords:** Low Back Pain, Workers, Iran.

**Introduction**

Low back pain (LBP) is defined as pain and discomfort localized below the costal margin and above the inferior gluteal folds, with or without leg pain, which is one of the most prevalent forms of musculoskeletal disorders (MSDs) (1-3). LBP can affect the quality of life and has a significant economic impact (4-6). Annual LBP economic burden (direct and indirect costs) to society is estimated between 84.1 billion and 624.8 billion United States (US) dollars (6). According to annual statistics of the Health and Safety Executive (HSE), MSDs constitute three quarters of the occupational diseases, and are responsible for losing an average of about 17 work days per case (7, 8). In addition, LBP was the fifth most common reason for all office-based physician visits in the US (9). LBP risk factors include job physical factors, worker demographics, past LBP history, psychosocial factors, and hobbies and physical activities outside of work (5, 10). Low job satisfaction and work support, and high work have more association with LBP compared with other workplace psychosocial factors (11-13). Manual handling is considered as the most stressful activity, because workers involve in repeated
carrying or lifting heavy loads for a long period of time; thus, they are at risk of injury and pain (14-17). Manual handling is the second most commonly reported risk factor in workplaces (7). For risk assessment of manual handling of load, National Institute for Occupational Safety and Health (NIOSH) lifting equation can be used to estimate LBP biomechanical stressors. NIOSH lifting equation determines weight limits by using physiological, biomechanical, psychological, and epidemiologic aspects of manual load lifting, that the majority of healthy workers can lift over a period of time (up to 8 hours) without adverse effects of load handling on the back (18).

The revised NIOSH lifting equation (RNLE) combines seven biomechanical stressors including weight of the load, horizontal location (H), vertical location (V), vertical travel distance (D), asymmetry angle (A), frequency rate and duration of lifting (F), and coupling component (C), into a numerical scale to quantify biomechanical stressors. This numerical scale is called the lifting index (LI) for single task and composite LI (CLI) for multi-task.

Pain and limited movement of the spine has adverse effects on functional status, work activities, and quality of life, so it is essential that researchers use tools having acceptable validity and reliability to review the inability level and determine the consequences (19, 20). Measuring disability is an important component in the management of workers or patients with back pain, so that self-report Oswestry disability index (ODI) questionnaire is a very important evaluation tool for measuring permanent functional inability (21, 22). A significant relationship has been reported between the prevalence of LBP and manual handling (15-17, 23, 24). The present study aims to determine the prevalence of LBP and LBPDI among manual handling workers.

Materials and Methods

This cross-sectional study was carried out in a tile and ceramic industrial unit in Tehran, Iran, in 2016. All the employed workers were enrolled in this study by census (30 workers). All workers consented to participate in this study. The criteria for inclusion in the study included the work experience less than one year, as well as lack of a history of spinal surgery and traumatic orthopedic problems such as acute back and nerve problems, inflammatory diseases such as ankylosing spondylitis involving the spine, and congenital diseases such as scoliosis and hemivertebra; due to the mentioned factors, 5 workers were excluded from the study. To evaluate manual handling risk factors in one production line (packaging unit), the RNLE was used. Moreover, to evaluate prevalence and severity of LBP, body map questionnaire combined with a visual analog scale (VAS) was used, and LBPDI was evaluated by modified version of the ODI questionnaire. In the following, used questionnaires and tools are briefly introduced.

As shown in figure 1, in this production line dimensions (25 × 40 cm), weight of tile packages (14 kg), pallet height (10 cm), and conveyor height (80 cm) were reported. Respectively, 24 and 96 tile packages were placed on each tier and on each pallet. In addition, because this job was made up of 96 single tasks (due to changes in NIOSH equation parameters), multi-task lifting analysis procedure was used. Moreover, since all tasks required the controlling and repositioning of grip at the destination, analysis was performed at the origin and destination of lifting. The workers could freely

Figure 1: Loading tile packages, from conveyor to pallet
walk on the pallet to get close to it. Workers had a continuous working model (8 hours/day). Moreover, this job did not involve a significant exposure to whole-body vibration (WBV).

To evaluate the risk factors of load lifting activities, the RNLE was used. In the first step, the packaging unit and workers’ station, parameters such as weight of tile packages, H, V, D, A, F, and C were measured for all workers. In the second step, based on the results of the first step, horizontal multiplier (HM), vertical multiplier (VM), distance multiplier (DM), asymmetry multiplier (AM), coupling multiplier (CM), and load constant (LC) were calculated. Based on the measured parameters, in each tier, one task was analyzed as the worst-case scenario (as marked in the figure, one task in each tier). Thus, frequency-independent recommended weight limit (FIRWL), single-task recommended weight limit (STRWL), frequency-independent LI (FILI), and single-task LI (STLI) at the origin and destination of lifting were calculated for these selected tasks, and at the end CLI was calculated for this lifting job according to the proposed formulas in the RNLE. It should be noted that in calculation of all mentioned parameters we used constant weight of handled tiles (not maximum or mean lifted weight).

To evaluate the prevalence of LBP, body map questionnaire was used. Moreover, to evaluate the severity of LBP, VAS was used. VAS is made up of a horizontal line with a length of 100 mm and has two labels including without discomfort and severe discomfort on both sides. To show the level of LBP, the subject specifies a point on the line that indicates the level of pain felt by him. Then, the severity of discomfort is recorded numerically from 0 to 100 using a millimeter ruler, and discomfort degree is interpreted as mild (0 to 20), moderate (21 to 40), severe (41 to 60), disabling (61 to 80), and severely disabling (81 to 100 percent). Easy management, sensitivity, and ability to respond to statistical analysis can be noted as benefits of VAS (25). Saremi determined validity and reliability of the mentioned questionnaire among Shahed university dentists (26), and it has been used in Nadri et al. studies (27, 28).

A modified version of the ODI questionnaire has a high reliability and validity for the severity of the disability caused by LBP. The questionnaire consists of 10 sections: 7 sections for the activities of daily life, 2 sections for pain, and 1 section associated with the focus. This questionnaire or index examines the degree of disability resulted from LBP and its effect on daily activities of the person. In each section, the degree of disability in performance has been scored from zero (desirable performance and without pain) to five (disability in performance due to severe pain), and the total score is recorded in percentage. Therefore, disability degree is interpreted as mild (0 to 20 percent), moderate (21 to 40 percent), severe (41 to 60 percent), disabling (61 to 80 percent) and severely disabling (81 to 100 percent).

Statistical data analysis was done using SPSS (version 22.0, IBM Corporation, Armonk, NY, USA). Kolmogorov-Smirnov test (K-S test) was used to determine the normality of the data. To examine the relationship between demographic characteristics (marital status, gender, and exercise) with LBP and LBPSI, the chi-square test was used. To assess the relationship between pain intensity and disability with age, work experience, and body mass index (BMI), due to the absence of parametric conditions, the Spearman correlation coefficient was used (P < 0.05).

Results
About 86.7% of the subjects (26 workers) were married. According to the classification of BMI by health communities (33), 33.3% of the workers in this study were classified as normal weight, 60% overweight, and only 6.7% were obese. Therefore, the highest frequency of BMI belonged to the overweight class. Table 1 shows the demographic characteristics of the subjects.

Table 1: Distribution of workers’ demographic characteristics (n = 30)

| Variables               | Mean ± SD | Range   |
|-------------------------|-----------|---------|
| Age (year)              | 35.5 ± 7.3| 24.0-46.0|
| Experience (year)       | 11.3 ± 6.7| 2.0-23.0 |
| Height (cm)             | 172.1 ± 11.0| 140.0-190.0|
| Weight (kg)             | 78.5 ± 10.6| 52.0-96.0|
| BMI (kg/m²)             | 26.5 ± 2.9| 20.9-34.1|
| Regular working hours per day | 8.1 ± 0.5 | 8.0-10.0 |
As shown in table 2, CLI was equal to 14.77. FILI and STLI values exceeded 1 for all tasks (with range of 1.06 to 2.42 and 1.88 to 4.40, respectively). In addition, FIRWL and STRWL values for all tasks were less than the weight of tile packages.

Table 3: Distribution of low back pain (LBP) intensity and LBP disability index (LBPDI) among workers (n = 30)

| Variables       | Mean ± SD   | Minimum | Moderate | Severe | Crippled | Severe crippled |
|-----------------|-------------|---------|----------|--------|----------|----------------|
| LBP*            | 68.8 ± 17.8 | 20.0    | 26.7     | 40.0   | 13.3     |                |
| LBPDI**         | 41.3 ± 17.1 | 16.7    | 30.0     | 40.0   | 13.3     | -              |

* LBP: Low back pain
** LBPDI: Low back pain disability index

The prevalence of LBP was reported equal to 100% among manual handling workers. LBP and LBPDI results and their classifications are shown in table 3.

Table 4: Relationship between low back pain (LBP) intensity and LBP disability index (LBPDI) with workers demographic characteristics

| Variables   | Married (P) | Age (P) | Experience (P) | Exercise (P) | BMI*** |
|-------------|-------------|---------|----------------|--------------|--------|
| LBP*        | 0.448       | 0.405   | 0.154          | 0.628        | 0.001  |
| LBPDI**     | 0.400       | 0.390   | 0.118          | 0.583        | 0.001  |

* LBP: Low back pain
** LBPDI: Low back pain disability index
*** BMI: Body mass index

There was no significant difference in the relationship between the LBP and LBPDI with marital status, age, work experience, and exercise (P > 0.05). However, LBP and LBPDI had a strong statistical relationship with BMI (Table 4).

Table 5: Average distribution of low back pain (LBP) intensity and LBP disability index (LBPDI) among workers’ body mass index (BMI) classes

| BMI*          | Normal Mean ± SD | Overweight Mean ± SD | Obese Mean ± SD |
|---------------|------------------|----------------------|-----------------|
| LBP**         | 43.4 ± 10.1      | 66.6 ± 11.5          | 95.0 ± 7.0      |
| LBPDI***      | 24.6 ± 9.4       | 46.8 ± 10.9          | 75.0 ± 7.0      |

* BMI: Body mass index
** LBP: Low back pain
*** LBPDI: Low back pain disability index
As shown in Table 5, the mean of LBP and LBPDI in obese workers were greater than overweight and normal workers. Linear regression equation has shown that if BMI increases one unit, LBP and LBPDI have an increase equal to 5.29 and 5.01, respectively (Table 6).

Table 6: Linear regression between low back pain (LBP) and LBP disability index (LBPDI) with body mass index (BMI)

| Variables | P      | Adjusted R² | Beta   | Constant | Equation                  |
|-----------|--------|-------------|--------|----------|---------------------------|
| LBP       | 0.001  | 0.733       | 0.861  | -79.56   | LBP = -79.56 + 5.29 BMI   |
| LBPDI     | 0.001  | 0.712       | 0.849  | -91.52   | LBPDI = -91.52 + 5.01 BMI |

* LBP: Low back pain  
** LBPDI: Low back pain disability index  
*** BMI: Body mass index

Discussion

The RNLE has been introduced as a useful tool for the estimation of LBP incidence risk due to biomechanical stressors associated with manual lifting. In RNLE, LI is a scale of biomechanical stressors for LBP caused by lifting and lowering of loads in sub-tasks, and CLI is a scale of the stressors associated with all tasks. In fact, LI and CLI have shown a significant exposure response relationship for LBP (19-22). In our study, CLI value (14.77) exceeded 3 (high-risk); this means that the load lifting was very stressful, and there was an increased risk of LBP occurrence for all workers. FIRWL reflects the compressive force and muscle strength demands for one task repetition; in this study, the FIRWL value in all tasks was less than tile packages’ weight. STLI values showed that all tasks mo...
with the results of other studies (27,36,37). Although various studies have shown the effect of different exercises on reduction of the pain (28, 38, 39), some studies have not shown any relation between LBP and exercise, and are aligned with our finding (40, 41).

LBP and LBPD1 had a strong statistical relationship with BMI. This finding was aligned with other studies that showed higher LBP and LBPD1 in subjects with a higher BMI (28, 41). Further, Youdas et al. reported higher risk of developing LBP in women weighing more than 100 kg and in men with a height greater than 180 cm (42). Obesity is considered to be a risk factor for LBP; however, only weak associations between body weight and LBP have been revealed (43, 44).

Conclusion
The results of this study support the findings of other studies and show that biomechanical stressors play an important role in the development of LBP. The LI and CLI are useful metrics for estimating exposure to biomechanical stressors, and jobs should be designed to keep both of these metrics as low as possible to reduce the LBP risk. By redesigning the workstations and correction of all multipliers involved in calculating LI and CLI, including HM, VM, DM, AM, CM, frequency multiplier (FM), and LC, the LI and CLI value will be improved. On the other hand, by training and improving the condition of the BMI, we can take a positive step toward reducing the prevalence of LBP. Studies with a larger sample size are needed to clarify the exposure–response relationship between the LI and CLI with LBP.

Acknowledgement
This study was related to the project no. 1396/46448 from Student Research Committee, Shahid Beheshti University of Medical Sciences, Tehran. We appreciate the “Student Research Committee” and “Vice Chancellor for Research and Technology” of Shahid Beheshti University of Medical Sciences for their financial support of this study.

Conflict of interest: None declared.

References
1. Masiero S, Carraro E, Celia A, Sarto D, Ermani M. Prevalence of nonspecific low back pain in schoolchildren aged between 13 and 15 years. Acta Paediatr 2008; 97(2):212-6.
2. Bell JA, Burnett A. Exercise for the primary, secondary and tertiary prevention of low back pain in the workplace: a systematic review. J Occup Rehabil 2009; 19(1):8-24.
3. Hong J, Reed C, Novick D, Happich M. Costs associated with treatment of chronic low back pain: an analysis of the UK General Practice Research Database. Spine 2013; 38(1):75-82.
4. Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya K, Adair-Rohani H, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012; 380(9859):2224-60.
5. Hayden JA, Chou R, Hogg-Johnson S, Bombardier C. Systematic reviews of low back pain prognosis had variable methods and results: guidance for future prognosis reviews. J Clin Epidemiol 2009; 62(8):781-96.
6. Dagenais S, Caro J, Haldeman S. A systematic review of low back pain cost of illness studies in the United States and internationally. Spine J 2008; 8(1):8-20.
7. Health and Safety Executive. Health and Safety Statistics: Annual Report for Great Britain. London, Britain; Health and Safety Executive, National Statistics, Health and Safety Statistics; 2013/14. Available from: http://www.hse.gov.uk/statistics/overall/hssh1314.pdf
8. Health and Safety Executive. Health and Safety Statistics: Annual release for Great Britain. London, Britain; Health and Safety Executive, National Statistics, Health and Safety Statistics; 2014/15. Available from: http://www.hse.gov.uk/statistics/overall/hssh1415.pdf
9. Chou R, Qaseem A, Snow V, Casey D, Cross JT Jr, Shekelle P, et al. Diagnosis and treatment of low back pain: a joint clinical practice guideline from the American College of Physicians and the American Pain Society. Ann Intern Med 2007; 147(7):478-91.
10. Manchikanti L. Epidemiology of low back pain. Pain Physician 2000; 3(2):167-92.
11. Matsudaika K, Konishi H, Miyoshi K, Isomura T, Takeshita K, Hara N, et al. Potential risk factors for new onset of back pain disability in Japanese workers: findings from the Japan epidemiological research of occupation-related back pain study. Spine 2012; 37(15):1324-33.
12. Van Nieuwenhuyse A, Fathuddinova L, Verbeke G, Pirenne D, Johannik K, Sormville PR, et al. Risk factors for first-ever low back pain among workers in their first employment. Occup Med 2004; 54(8):513-19.
13. Macfarlane GJ, Palievawte N, Paudyal P, Blyth FM, Coggon D, Crombez G, et al. Evaluation of work-related psychosocial factors and regional musculoskeletal pain: results from a EULAR Task Force. Ann Rheum Dis 2009; 68(8):885-91.
14. Marras WS. Occupational low back disorder causation and control. Ergonomics 2000; 43(7):880-902.
15. Battevi N, Pandolfi M, Cortinovis I. Variable Lifting Index for manual-lifting risk assessment: a preliminary validation study. Hum Factors 2016; 58(5):712-25.
16. Garg A, Kapellusch JM. The Cumulative Lifting Index (CULI) for the revised NIOSH lifting equation quantifying risk for workers with job rotation. Hum Factors 2016; 58(5):583-94.
17. Sarkar K, Dev S, Das T, Chakraborty S, Gangopadhyay S. Examination of postures and frequency of musculoskeletal disorders among manual workers in Calcutta, India. Int J Occup Environ Health 2016; 22(2):151-8.
Low back pain in manual material handling workers

18. Waters TR, Putz-Anderson V, Garg A. Applications manual for the revised NIOSH lifting equation. Cincinnati (OH): U.S. Department of Health and Human Services Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Division of Biomedical and Behavioral Science; 1994 Jan. 168 p. Report No.: 94-110.

19. Bombardier C. Outcome assessments in the evaluation of treatment of spinal disorders: summary and general recommendations. Spine 2000; 25(24):3100-3.

20. Jackowski D, Guyatt G. A guide to health measurement. Clin Orthop Relat Res 2003; (413):80-9.

21. Fairbank JC, Pynsent PB. The Oswestry Disability Index. Spine 2000; 25(22):2940-52.

22. Ostelo RW, De Vet HC. Clinically important outcomes in low back pain. Best Pract Res Clin Rheumatol 2005; 19(4):593-607.

23. Marras WS, Karwowski W. Fundamentals and assessment tools for occupational ergonomics. 2nd ed. Boca Raton, Florida, United States: CRC Press, Taylor & Francis 2006.

24. Harkness EF, Macfarlane GJ, Nashi ES, Silman AJ, McBeth J. Risk factors for new-onset low back pain amongst cohorts of newly employed workers. Rheumatology 2003; 42(8):959-68.

25. Karwowski W, Marras WS. Occupational ergonomics: engineering and administrative controls. 1st ed. United States: CRC Press, Taylor & Francis; 2003.

26. Saremi M. Assessment of musculoskeletal disorders among dentistry of Shahed University, using REBA method and provide appropriate corrective methods. [MSc thesis]. Tehran: Tarbiat Modarres University; 2003.

27. Nadri H, Nadri A, Rohani B, Fasih Ramandi F, Amin Sobhani M, Naseh I. Assessment of musculoskeletal disorders prevalence and body discomfort among dentists by visual analog discomfort scale. Journal of Mashhad Dental School 2015; 39(4):363-72.

28. Nadri H, Fasih-Ramandi F. Low back and neck pain intensity and relationship with disability index among dentists. Journal of Occupational Health and Epidemiology 2016; 5(4):218-25.

29. Chung MK, Kee D. Evaluation of lifting tasks frequently performed during fire brick manufacturing processes using NIOSH lifting equations. Int J Ind Ergon 2000; 25(4):423-33.

30. Okimoto MLR, Teixeira ER. Proposed procedures for measuring the lifting task variables required by the Revised NIOSH Lifting Equation—A case study. Int J Ind Ergon 2009; 39(1):15-22.

31. Dormohammadi A, Amjad-Sardudi H, Motamedzadeh M, Dormohammadi R, Musavi S. Ergonomics intervention in a tile industry - case of manual material handling. J Res Health Sci 2012; 12(2):109-13.

32. Torres Y, Viña S. Evaluation and redesign of manual material handling in a vaccine production centre's warehouse. Work 2012; 41(1):2487-91.

33. Waters TR, Lu ML, Piacentii LA, Werren D, Deddens JA. Efficacy of the revised NIOSH lifting equation to predict low back pain due to manual lifting: expanded cross-sectional analysis. J Occup Environ Med 2011; 53(9):1061-7.

34. Boda S, Garg A, Campbell-Kyureghyan N. Can the revised NIOSH lifting equation predict low back pain incidence in a “90-day-pain-free-cohort”? Proc Hum Factors Ergon Soc Annu Meet 2016; 56(1):1178-82.

35. Roland M, Fairbank J. The Roland–Morris Disability Questionnaire and the Oswestry Disability Questionnaire. Spine 2000; 25(24):3115-24.

36. Yip VY. New low back pain in nurses: work activities, work stress and sedentary lifestyle. J Adv Nurs 2004; 46(4):430-40.

37. Marshall SJ, Gorely T, Biddle SJ. A descriptive epidemiology of screen-based media use in youth: a review and critique. J Adolesc 2006; 29(3):333-49.

38. O’Sullivan PB, Mitchell T, Bulich P, Waller R, Holte J. The relationship between posture and back muscle endurance in industrial workers with flexion-related low back pain. Man Ther 2006; 11(4):264-71.

39. Farahpour N, Marvi Esfahani M. Postural deviations from chronic low back pain and correction through exercise therapy. Tehran University Medical Journal 2008; 65(2):69-77.

40. Waling K, Järvelin M, Sundelin G. Effects of training on female trapezius myalgia: an intervention study with a 3-year follow-up period. Spine 2002; 27(8):789-96.

41. Eftekhar Sadat B, Babaei-Ghazani A, Azizi R, Parizad M. Prevalence and risk factors of neck and shoulder pain in medical students of Tabriz University of Medical Sciences. Medical Journal of Tabriz University of Medical Sciences and Health Services. 2013; 35(3):12-17.

42. Youdas JW, Garrett TR, Egan KS, Therneau TM. Lumbar lordosis and pelvic inclination in adults with chronic low back pain. Phys Ther 2000; 80(3):161-75.

43. Lebeouf-Yde C. Body weight and low back pain. A systematic literature review of 56 journal articles reporting on 65 epidemiologic studies. Spine 2000; 25(2):226-37.

44. Shiri R, Karppinen J, Leino-Arjas P, Solovieva S, Viikari-Juntura E. The association between obesity and low back pain: a meta-analysis. Am J Epidemiol 2009; 171(2):135-54.