Ergonomic Risk Assessment of Lifting Activities; a Case Study in a Rubber Industry

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Abstract

Introduction: Manual material handling is identified as one of the musculoskeletal disorders risk factors. The aims of this study were to evaluate lifting activities by NIOSH equation and MAC method and the correlation of these two methods.

Methods and Materials: This cross-sectional study was conducted in a rubber industry. Studied subjects were 136 male workers selected from various sections by proportional-to size sampling method. Data were collected using demographic and Nordic Musculoskeletal Disorders Questionnaire (NMQ). Lifting activities were evaluated by NIOSH equation and MAC method. Statistical analyses were performed using SPSS, version 16 and some tests such as Independent sample *t* test, Chi-square (χ^2) and Bland-Atman test. The level of significance was set at <5%.

Results: The means of age and job tenure in subjects were 33.31±6.48 and 9.77±6.17 years, respectively. Prevalence of MSDs was 77.2%. The results revealed significant association between MSDs risk level evaluated by NIOSH and MAC methods and musculoskeletal disorders occurrence. The correlation of the two lifting activity evaluation methods was significant ($p<0.05$).

Conclusions: Based on the findings of the present study, the evaluated risk level by the two evaluation methods and prevalence of MSDshad significant relationship. The correlation result indicated that MAC method can be used interchangeably with NIOSH equation for ergonomic evaluation of lifting activities.

Keywords: Musculoskeletal disorders (MSDs), Ergonomic evaluation of lifting activity, NIOSH equation, MAC, MSDs risk.

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Introduction

Musculoskeletal disorders (MSDs) are common occupational injuries in industrial and developing countries (1-7). MSDs are one of the main causes of loss of work time, increased labor costs, injury of work force and the leading cause of absenteeism from work (3, 8). Low back pain (LBP) is one of the most common disorders, and considered as second leading cause of workplace absenteeism (2, 9-10).

Assessment and evaluation of musculoskeletal disorders risk factors is one of the important issues in ergonomics science (1), which Include physical and mechanical risk factors such as awkward posture, lifting and carrying loads, repeated movements (3-7, 11), vibration (6, 11), excessive force, contact pressure, low temperature and poor light (11).

Manual material handling (MMH) is a physical activity (12) and is discussed as one of the risk factors for musculoskeletal disorders (3-7, 13). A large part of the MSDS annual report in the United States is due to MMH. This can cause constant, debilitating and stressful pain to workers and impose high costs to companies (13).

Studies have shown that 42% of occurred back injuries were caused by MMH in production units that required lifting and carrying activities. This rate of back injury is three times higher than other sectors of the industry. So, back injuries are very common in manufacturing units and its assessment and analysis is more important (14). Choobineh et al. study has shown that about three-quarters of workers (73.6%) suffer from MSDs symptoms. The high prevalence included low back pain (50.2%), knee pain (48.5%) and upper extremities (38.1%). This study showed that most of the ergonomic problems are due to MMH and awkward posture (3).

According to the importance of work-related musculoskeletal disorders and the role of MMH in the incidence of MSDs, it will be needed to take preventive measures in this field.

Given the above, thepresent study was carried out at a rubber industry in the Fars province, southern of Iran, with the following objectives:

- Evaluation of lifting activities by NIOSH equation and MAC method in studied population
- Evaluation of the correlation between the results of the NIOSH equation and MAC method in the study population

Methods and Materials

Subjects

This cross-sectional study was conducted in 2010-2011. The study population was male workers of a rubber industry located in Fars province, southern of Iran. Samples were randomly selected and proportional-to size methodology was applied. Selected subjects included people who were involved in MMH and lifting activities in most of the work shift.

Given the prevalence of MSDs in Choobineh et al. study (3), the required sample size in this study were estimated 100 individuals, but in order to increase the precision and power of the study and reasons such as exclusion of subjects, 150 individuals were studied. Note that People who have a history of musculoskeletal diseases were excluded and finally 136 people were remained in study.

Data Gathering Tool

Data collection was performed using demographic features and Nordic questionnaires to determine musculoskeletal disorder symptoms (15). Evaluation of MMH and lifting activities was performed using NIOSH equation and MAC method. Note that both were observational techniques and used photography for better performance and higher accuracy in analyzing raw data.

U.S National Institute of Occupational Safety and Health (NIOSH) equation

Lifting equation is a tool that is used in evaluation of physical stress caused by lifting by two hands. Lifting equation has been presented to identify the ergonomics problems, ergonomic design evaluation and re-design issues.

In 1981, NIOSH presented the first version of lifting equation. This version was updated in 1991. The new version reflects new findings and provided methods for evaluating asymmetrical lifting tasks and lifting objects with the poor hand pairing. NIOSH believes that the 1991 version is more reliable than the 1981 equation to protect workers against the low back injury risk factors. Because this equation is an experimental method for calculating recommended weight limit, it is widely used in the occupational health field. Usefulness of this equation is in reducing the prevalence of musculoskeletal disorders, especially in the back area (16).

Manual handling Assessment Chart (MAC)

The Manual Handling Assessment Chart (MAC) is a new tool designed to help health and safety inspectors assess the most common risk factors in lifting (and lowering), carrying and team handling operations. Employers, safety officers, safety representatives and others may also find MAC useful to identify high-risk manual handling operations and help them complete their risk assessments. This method has been developed by the UK HSE Commission (17).

Data Analysis and Statistical Procedures

Statistical analyses were performed with SPSS, version16. The level of significance was set at .05. Independent sample *t*-test was used to assess differences in the means of age, job tenure and BMI index between two groups (with and without MSDs). Chi-square (χ^2) test was used to investigate differences in the prevalence and risk of MSDs between the two groups. Assessment of correlation between the two methods (MAC & NIOSH) is carried out using Bland-Atman test.

Results

Table 1 summarizes the subjects' personal details. As shown, the means of age and job tenure of studied subjects were 33.31±6.48 and 9.77±6.17 years, respectively. Assessment of demographic characteristics indicated that mean difference of age and job tenure between two groups is statistically significant ($p<0.05$) and the mean difference of BMI index between two groups is not statistically significant ($p>0.05$). It should be noted that the prevalence of MSDs in the industry was determined 77.2%.

The results of the evaluation of the lifting activities by NIOSH equation is presented in Table 2. The results showed that LI index in 6.6% of subjects was $LI \leq 1$, in 22.8% was $3<LI<1$ and in 70.6% was $3 \geq LI$.

The results of the assessment of the risk of musculoskeletal disorders by MAC method is presented in Table 3. The assessment showed that 7.4% were in level 1 (risk level 0-4), 46.3% in level 2 (risk level 5-12), 17.6% of the workers in level 3 (levels of 13-20) and 28.7% (risk level 21-31) were also at risk in level 4.

The relationship between MSDs prevalence and NIOSH equation is shown in Table 4. As can be seen, the difference of lifting index between the two groups (with and without MSDs) is significant. Chi-square test showed a significant increase in the prevalence of MSDs as the lifting index increased.

The relationship between MSDs prevalence and MAC method is shown in Table 5. As shown, the difference of lifting index between the two groups (with and without MSDs) was significant. Chi-square test showed that with an increase in the risk level, prevalence of MSDs significantly increased, too.

Assessment of correlation between the two methods (NIOSH and MAC) using Bland-Atman test has been presented in Figure 1. As can be observed, there is a significant relationship between MAC and the NIOSH method for the calculation and estimation of X index (the risk level of MSDs) (p=0.01).

Table 1: Individual and Demographics Data of Subjects (n=136)

Demographic Variables	Total (n=136)	MSDs		P-value†
		Yes (105)	No (31)	
Age (yr) (mean±SD)	33.31±6.48	35.0±6.28	27.58±2.85	0.001
Job tenure (yr) (mean±SD)	9.77±6.17	11.38±5.96	4.32±2.90	0.001
BMI (Kg/m^2) (mean±SD)	25.20±2.83	25.31±2.74	24.82±3.16	0.402

†independent sample t test

Table 2: Assessment of lifting activities by NIOSH equation (n=136)

Lifting index	N (%)
LI≤1	9 (6.6%)
3<LI<1	31 (22.8%)
3≥LI	96 (70.6%)

Table 3: Assessment of MSDs risk by MAC methods (n=136)

MAC index		N (%)
1	(0-4)	10 (7.4%)
2	(5-12)	63 (46.3%)
3	(13-20)	24 (17.6%)
4	(21-31)	39 (28.7%)

Table 4: relationship between MSDs prevalence and NIOSH equation (n=136)

MSDs	Lifting index			P-value†
	LI≤1	3<LI<1	3≥LI	
Yes (n (%))	3 (33.3%)	21 (67.7%)	81 (84.4%)	0.001
No (n (%))	6 (67.7%)	10 (33.3%)	15 (15.6%)	

†χ^2 test

Table 5: relationship between MSDs prevalence and MAC method (n=136)

MSDs	MAC index				P-value†
	0-4	5-12	13-20	21-31	
Yes (n (%))	3 (30.0%)	46 (73.0%)	20 (83.3%)	36 (92.3%)	0.001
No (n (%))	7 (70.0%)	17 (27.0%)	4 (16.7%)	3 (7.7%)	

†χ^2 test

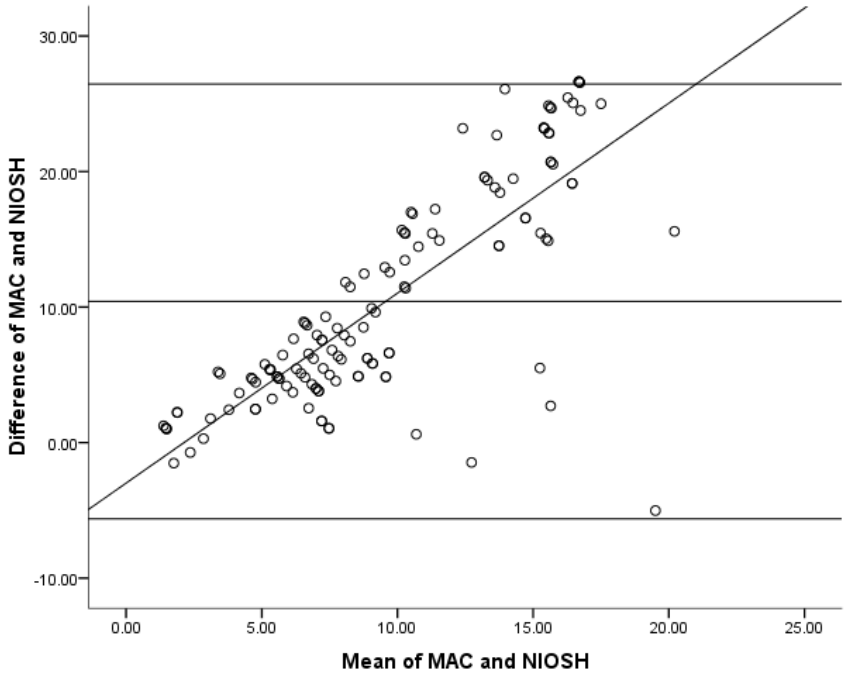

Fig. 1: Correlation between NIOSH and MAC methods

Discussion

Study of Demographic characteristics showed that the average age of workers was low (relatively young) and mean of job tenure is under 10 years. The comparison results of Demographic characteristics in two groups (with and without MSDs) indicated that the mean difference of age and job tenure between two groups were statistically significant. It should be noted that individuals with high average age and job tenure are more likely to develop MSDs. Furthermore, the results showed that the prevalence of MSDs in the industry is high (77.2%). So, based on these results, it can be predicted that work conditions can contribute in incidence of MSDs, despite the low average of age and job tenure.

Ergonomics assessment of lifting activities by NIOSH equation showed that LI index in 6.6% of cases was desired and there is no risk of back injury (LI≤1). In 22.8% of cases, probability of lumbar injury was high that control and preventive measures were needed to prevent them (3> LI> 1) and in 70.6% risk probability of lumbar injury was very high. So, in such circumstances, it is essential to implement control measures (3 ≤ LI).

However, based on the authors' researches, there wasn't any study about MAC and MSDs relationship, but ergonomics assessment of the risk of musculoskeletal disorders by MAC method revealed that 7.4% of individuals don't need to control preventive measures and in 46.3% of cases, control measures must be taken immediately. The results indicated that to prevent musculoskeletal disorders in 17.6% workers, control measures should be implemented in the near future and in 28.7% immediate actions are necessary.

Analyzing the study data showed that NIOSH equation lifting index (LI) and MSDs prevalence have a significant relationship and with the increase in LI, the prevalence of MSDs significantly increased, too. As can be seen, the difference of lifting index between the two groups (with and

without MSDs) is significant. Chi-square test showed a significant increase in the prevalence of MSDs as lifting index increased.

Furthermore, reviews of the results revealed that MAC risk level in two groups with and without MSDs were significant and with an increase in the risk level, prevalence of MSDs significantly increased, too.

With regard to the MMH and lifting causes of musculoskeletal disorders in the labor force (3-7), ergonomic assessment of this physical activity can help identify problems and provide control solutions (12). Although, several methods have been developed for risk assessment of lifting-induced MSDs (17-16), but using a quantitative or semi-quantitative, and applicable methods may help in monitoring programs to prevent and minimize the frequency of these disorders.

However, NIOSH equation is an appropriate quantitative tool for assessment of lifting activities (16), but this equation is not an easy method for some reasons such as the use of quantitative and accurate amounts and being time consuming, so to evaluate the lifting operations and activities all aspects of the procedure should be controlled, sufficiently. Therefore, by examining the correlation between this method and other methods (such as MAC) that are simpler, these methods can be used to assess the lifting activities.

The results associated with assessment of correlation between NIOSH and MAC indicated that there is a significant agreement and correlation between the two methods for the calculation and estimation of X index (the risk level of MSDs). So, According to this result, findings related to the significant relationship between the prevalence of MSDs and risk level assessed by MAC, and also the MAC method, is easier compared to NIOSH. It can be concluded that MAC as a useful, reliable and practical method can be used to assess the MMH and lifting activities and the risk of MSDs.

Conclusions

Totally, assessment of lifting activities with both MAC and NIOSH found that the risk of musculoskeletal disorders (MSDs) is high in the study population. Evaluation of correlation between the two methods showed a high correlation between them, and each of them can be used to assess the lifting activities.

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