EVALUATING THE AGREEMENT RESULTS OF THE MANUAL MATERIAL HANDLING METHODS (MAC, NIOSH, WASHINGTON, AND TLV)

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ABSTRACT

Some occupational factors are responsible for musculoskeletal disorders that one of them is the manual handling of unsafe loads. The present study is a case-sectional case study. The purpose of this study was to compare the internal methods and valid methods in assessing manual material handling and to evaluate the agreement results between the lifting equations of NIOSH, Washington, MAC, and TLV in an industry in Tehran. The studied population was the men workers of the studied industry who were selected by simple random sampling method. Data collection was done by the help of TLV, Washington, and MAC worksheet, and NIOSH equation calculations. Data analysis was performed using Stata software and the significance level of 0.05. Kappa coefficient and the amount of agreement were used to assess the agreement among the four methods. Evaluating the agreement between the two methods of TLV/MAC, TLV/Washington, and TLV/NIOSH showed that these two methods can be used instead of each other (respectively, kappa is equal to 0.67, 0.67, and 0.60). In addition, NIOSH and Washington methods have a good and strong correlation (kappa 1). However, there is no relationship between Washington and Mac methods and also, NIOSH and MAC methods.

Keywords: Manual Material Handling, MAC, Washington, TLV, NIOSH Equation

INTRODUCTION

There are several harmful factors at the workplace that cause fatigue, burnout, and early analysis of the body and wasting time and costs. Some occupational factors are responsible for musculoskeletal disorders that one of them is the manual handling of unsafe loads (Habibi et al., 1391). Manual handling and lifting occur frequently in most industries of Iran and even in the non-occupational affairs and each of these tasks has their own specific needs. This issue is one of the important reasons for low back pain. Hence, not only the lack of this matter causes health problems in terms of occupational health and safety of workers, but also leads to financial loss from an economic standpoint. However, the workplace can be in such a way that it helps the workers to work safely and more easily (Industrial Accident Prevention Association, 2008).

In a research study at Brock University, manual material handling has been the cause of most of the work-related low back injuries (3). Unsafe manual material handling led to the musculoskeletal disorders, including severe physical injuries as well as the strains on the low back, shoulder, and arm. Moreover, low back disorders are one of the most costly musculoskeletal injuries in the society (Marras et al., 1999). After a cold, low back pain is the second factor that has the most referrers to doctors. Orthopaedic Society
of America considers low back disorders as the most costly medical problem of the society. Medical evidence suggests that effective ergonomic interventions reduce physical needs of Manual Material Handling in the task and thereby reducing the number and severity of the injuries (3). In addition, at least 80% of adults have experienced back pain once in their lifetime and about 4-5% of the population suffers from acute back pain at one year. As mentioned, most of these back pains are related to the individual’s job and it has significantly increased the amount of workers’ compensation. For example, 16-19% of the workers are demanding compensation, but they allocated 33–41% of the total compensation to themselves.

In 1985, NIOSH gathered a special committee of experts to review the conducted researches regarding lifting loads. The results of this review were updating information from physiological biomechanics, physical-mental, and epidemiological aspects and providing revised lifting equation in 1991 (National Technical Information Service, 1991). In 1994, an equation was presented from NIOSH called material handling system aimed at reducing the rate of injuries and complications from lifting (Afshari et al., 2005). In the presented model, different variables such as horizontal and vertical distance and load displacement, trunk rotation angle, frequency and the coupling of hand on load (grip) in determining the amount of the load allowable weight (Varmazyar et al., 2011). In the conducted study by Maras in Ohio University regarding the relationship between the prevalence of musculoskeletal disorders and physical factors, the researcher concluded that regardless of biomechanical factors, the impact of no one of the studied physical factors will not reveal, thus the separation of physical and biomechanical factors is not possible (Maras, 2000).

In all risk assessment methods related to Manual Material Handling, biomechanical factors are very important. Biomechanical variables in workplace such as load weight, distance and position of work stations are effective in the prevalence of musculoskeletal disorders. Based on the conducted studies, the severity of each factor is quite variable based on the changes of each one in compressive and shear forces imposed on lumbar inter vertebral discs and the incidence and prevalence of back pain. Several methods have been developed and presented regarding the investigations related to manual material handling. Each of the assessment methods has their own strengths and weaknesses. Therefore, in this study, the four methods of Mac, NIOSH, Washington, and TLV were used to assess manual material handling and the agreement amount of methods was compared.

MATERIALS AND METHODS

Evaluation Method

The present study was conducted for evaluating the risk of biomechanical factors in a car parts manufacturing company in Tehran. After visiting the production halls and interviewing with HSE in charge of the factory, stations were identified as high-risk evaluation. In the present study, the occupational analysis of the selected jobs was initially done in each hall before evaluating manual material handling assessment. Thus, TTA table was set for each occupational task. Interviewing operators, task observation, and camera recording were used to collect information. Each station was carefully reviewed and analyzed and the results were recorded in the form of tasks and sub-tasks in specific occupational analysis tables. In the following, four assessment methods of Manual Material Handling were used as following.

NIOSH Equation

The amount of allowed load and load index were estimated using NIOSH lifting equation. This equation is a tool that is used in assessing the physical strain caused by lifting with two hands. This equation determines the allowable load by calculating Horizontal distance (HM), vertical distance (VM), perpendicular displacement (DM), back deviation angle (AM), lifting load frequency (FM), and grip type (CM) and their integration in the following equation.

\[ RWL = \text{LC} \times \text{HM} \times \text{VM} \times \text{DM} \times \text{AM} \times \text{FM} \times \text{CM} \]

Finally, considering the weight of the load and the allowable weight, load index is calculated using the following ratio.
LI=L/RWL
If the load index be greater than 1, it indicates dangerous conditions, and if it be less than 1, it shows favorable conditions.

**Washington Methods**
This method is applied to the lifting/loading activity. In this method, the required data including load weight, load handling frequency, the length of work shifts, and load handling coefficient are collected and they are calculated with the help of allowable weight and load index equations. In this method, after the determination of the weight load, the hand position is specified and graded. In addition, the coefficient of working hours, the deviation from the measured sagittal surface is obtained and finally, the allowable weight is determined.

**ACGIH (TLV) Threshold Limit Values Method**
TLV method has provided a method, which is based on environmental conditions, working conditions and the weight of the load, and it shows the risk of manual handling and determines the load limit (11).

**Manual Material Handling Assessment Chart (MAC)**
Manual material handling assessment chart is a new tool that its design has helped the health and safety inspectors to assess the risk of the factors in individual and team lifting, pulling, and carrying. This method has been developed by UK Health and Safety Committee (Health and Safety Executive, 2003) and it enables HSE authorities to assess jobs with a high risk that manual handling is one of its common activities.

All required parameters in the above methods including load weight, handling, and transport distances, frequency, and duration of work were carefully measured. For this purpose, simple tools like a tape measure were used to measure distances and stopwatch to measure the time/frequency. The exact weight of components was obtained by visiting the lab and the test site.

In order to conduct the statistical tests, all results were divided into two levels of allowed and not allowed. At the level one (allowed), the amount of carried load is less than the amount of allowed load weight and at the level two (not allowed), the amount of taken load is more than the allowed load. Data collection was done by NIOSH equation, Washington, TLV, and MAC worksheet, and data analysis was performed using Stata software at 0.05 significance level. Kappa coefficient and the amount of agreement were used in order to evaluate the agreement between all four methods.

**RESULTS AND DISCUSSION**

**Findings**
Tasks were evaluated after collecting and classifying data on the TTA table. Then, results of each evaluation were divided into two levels of allowed and not allowed. On this basis, the statistical analysis was performed using Stata software. The results are provided between different methods in Figure 1 to 4 and Table 1.
Figure 3: Diagram of the agreement results between MAC and NIOSH

Figure 4: Diagram of the agreement results between MAC and Washington

Table 1: Evaluation of simultaneous agreement between the four methods of Mac, NIOSH, Washington, and TLV

<table>
<thead>
<tr>
<th>Method</th>
<th>Mac</th>
<th>NIOSH</th>
<th>TLV</th>
<th>Washington</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mac</td>
<td></td>
<td>68.75(0.33)</td>
<td>88.24(0.67)**</td>
<td>70.59(0.35)**</td>
</tr>
<tr>
<td>NIOSH</td>
<td>68.75(0.33)</td>
<td>-</td>
<td>81.25(0.60)**</td>
<td>100(1.00)**</td>
</tr>
<tr>
<td>TLV</td>
<td>88.24(0.67)**</td>
<td>81.25(0.60)**</td>
<td>-</td>
<td>82.35(0.67)**</td>
</tr>
<tr>
<td>Washington</td>
<td>70.59(0.35)**</td>
<td>100(1.00)**</td>
<td>82.35(0.67)**</td>
<td>-</td>
</tr>
</tbody>
</table>

*They have an agreement (kappa)

**They have statistical confidence level at 0.05 significant level.

It should be noted that the amount of statistical agreement between two methods was classified for the first time by Landis and Koch 1977. So that the values less than zero were classified as the lack of agreement, values between 0 to 0.02 as low agreement, 0.21 to 0.40 as a relatively good agreement, 0.41 to 0.60 as a middle agreement, 0.61 to 0.80 as a considerable agreement and 0.80 to 1 as a strong agreement (Chobineh et al., 1390).

According to Table 1, it can be concluded that the agreement between Mac and NIOSH methods is very low and they cannot be used instead of each other. In addition, the agreement between TLV/MAC, Washington/TLV, and TLV/NIOSH showed that these two methods can be used instead of each other (kappa respectively is 0.67, 0.67, and 0.60). On the other hand, results showed NIOSH and Washington methods have a strong correlation (Kappa 1). According to the results, Washington and Mac methods have a low agreement (kappa 0.35).

Discussion and Conclusion

The results of field surveys indicate that about 80% of assessed stations with MAC and NIOSH equation methods have not allowed conditions for load carrying. According to a study in the field of tire industry by Chubineh et al., about 70% is work stations were declared not allowed by MAC method (Chobineh et al., 1390).

In addition, Washington method showed that 54% of stations have not allowed level. According to the results of the other two methods in similar stations, it can be concluded that Washington method less sensitive than NIOSH equation and MAC methods. However, due to the reduction of risk level in NIOSH equation from 3 to 2 and in MAC method from 4 to 2, it can be argued that the allowed risk level of Washington method can include the moderate risk levels of NIOSH and MAC method. However, in all not allowed stations, which mostly due to high load weight or operator waist rotation, the best solution is automating the job. In a research about improving the situation of electronic chip industry workers, after the mechanization of work related to carrying heavy objects, results showed that worker productivity has been increased by 400%.
According to the results of the agreement between MAC and Washington methods, the amount of agreement is middle and the coefficient between the two methods is significant. However, the agreement results of MAC, NIOSH in the data of this research is not significant, and these two methods cannot be replaced by each other. This result is quite different from the result of the study of Chubineh et al., in tire industry (Landis and Koch, 1977). The researchers in the mentioned study came to this conclusion that NIOSH equation and MAC methods can be used interchangeably, and there is a significant relationship between these two methods. In a study, which was performed by Amjad Sardroodi in 2011 in a tile-making company, comparing the results of Mac and NIOSH method showed that both methods have an agreement at 100% risk. The results of TLV method agreement with all 3 other methods are noticeable so that the analysis results considerably can be replaced by other methods with the help of this method. Surveying the agreement between Washington and cargo NIOSH equation has significant results and these two methods can be replaced by each other.

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