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The Association of Manual Load Lifting Tasks with the Ergonomic Risk Factors of Musculoskeletal Disorders

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ABSTRACT

Background: Manual material handling is a high-risk task, which could lead to musculoskeletal injuries. The present study aimed to determine the association of manual load lifting tasks with the ergonomic risk factors of musculoskeletal disorders using the WISHA index and QEC method.

Methods: This descriptive-analytical study was conducted on 52 employees of the metal industry, who were surveyed by the simple census method. The WISHA index was used to assess the manual load lifting, and Nordic musculoskeletal questionnaire was used to determine the prevalence of musculoskeletal disorders. In addition, the QEC method was applied to evaluate the risk of musculoskeletal disorders. Data analysis was performed in SPSS version 21.

Results: In total, 53.8% of the workers lifted heavier loads than the allowable weight obtained by the WISHA index. The prevalence of musculoskeletal disorders was 79.9%, and the risk of musculoskeletal disorders was 36.5% at an extremely high level and 44.2% at a high level. The WISHA index was significantly correlated with the QEC scores ($P < 0.001$) and prevalence of musculoskeletal disorders ($P = 0.022$).

Conclusion: According to the results, manual material handling tasks increased the risk of musculoskeletal disorders and work absenteeism. Therefore, taking corrective actions is essential in the workplace.

1. Introduction

Musculoskeletal disorders (MSDs) are major concerns in various industries and a severe threat to workers in today's world [1]. MSDs are defined as the discomforts that affect the bones and muscles [2]. Work-related musculoskeletal disorders (WMSDs) could lead to pain, disability, drug abuse, and high costs of treatment in the patients. Therefore, employers must pay compensation for the WMSDs of workers [3, 4].

According to the reports of the British Health and Safety Executive (HSE), MSDs constitute 37% of occupational diseases, and 29% of the loss of workdays was attributed to the occupational disorders caused by MSDs in 2018-2019, which led to the loss of 6.9 million workdays in Britain [5]. In industrialized countries, the treatment costs of MSDs are more than $171.7 million annually [6, 7]. In this regard, Arghami *et al.* (2016) reported the prevalence rate of MSDs to be 98% in female workers [8], while Samadi *et al.* (2018) estimated the prevalence rate of WMSDs at 85.7% in assembly line workers [9].

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Manual material handling (MMH) significantly contributes to the incidence of MSDs, workplace accidents, and injuries [10, 11]. MMH is a high-risk task, which could lead to musculoskeletal injuries as it requires great energy and strength. If performed incorrectly, all activities could lead to inflammation in the muscles and nerves [12]. MMH involves moving or handling objects by lifting, lowering, pushing, pulling, carrying, holding or restraining [13]. The nature of such activities increases the risk of lower back pain, shoulder pain, and other musculoskeletal injuries [14].

According to Burciaga-Ortega and Santos-Reyes, MMH is the major cause of workplace accidents and injuries, with the incidence rate reported to be 24-35% [15]. On average, 27% of workplace accidents in the United Kingdom have been attributed to MMH activities over a 50-year period [16]. Furthermore, MMH activities contribute to more than half million cases of musculoskeletal injuries in the United States each year [2]. Occupational back pain is a common MSD, which is caused by risk factors such as MMH and manual load lifting [17]. According to the statistics of the HSE, approximately 40% (n = 200,000) of MSDs were associated with occupational lower back pain in 2018-2019 [5]. Similarly, the findings of Asadi *et al.* (2015) indicated that manual load lifting in workers could lead to MSDs [18].

Every organization should protect its employees against potential health risks (especially in the case of MMH) in order to prevent MSDs since WMSDs are among the most pressing occupational health concerns [19]. Today, the risk assessment of MSDs and MMH activities could be evaluated by various tools, techniques, and methods, such as psychophysical techniques, biomechanics, mental, observational, and posture analysis or a combination of these approaches, which have been exploited extensively in recent decades [6].

Several methods are employed for the risk assessment of WMSD incidence. Researchers have frequently used the quick exposure check (QEC) method in various industrial environments, stating that the QEC is effective in the assessment of the physical posture during work and the initial screening and prioritization of interventions. Furthermore, the QEC method is easy and quick to use and provides beneficial data regarding the root causes of risk factors. The Washington Industrial Safety and Health Act (WISHA) index is used to perform simple ergonomic risk assessments on a wide variety of manual lifting and lowering tasks, while it is also a screening tool for the identification of lifting tasks.

The present study aimed to evaluate the association between manual load lifting tasks using the WISHA index based on the ergonomic risk factors of MSDs with the QEC method in the metal industry.

2. Materials and Methods

2.1. Study Design

This descriptive-analytical study was conducted on 52 male workers with manual lifting activity in Isfahan metal industry in 2019. The sample size was determined using the simple census method. The inclusion criteria of the study were as follows: 1) minimum work experience of one year; 2) nearly eight hours of load lifting activity per day; 3) no injuries and accidents affecting the musculoskeletal system and 4) no medication use for musculoskeletal and mental disorders.

2.2. Data Collection

At the first of data collection, data were obtained on the demographic characteristics of the subjects, including the age, tenured employment, daily work time, weekly work time, body weight, height, marital status, and education level.

At the second stage, manual load lifting was evaluated using the WISHA index, which is a simple and valid hazard evaluation tool for MMH activities. The WISHA index has been developed by Washington State Department of Labor and Industries. In the current research, the primary output of the WISHA index was the weight limit (lifting limit), which described the maximum acceptable weight that nearly all the healthy employees could lift or lower given the assessment of the task variables of the lifting duty without increasing the risk of lifting related to musculoskeletal injuries. The duty variables that were employed to calculate the weight limit and WISHA index were the actual weight of the lifted load, position of the hands (vertical hand position of the employees relative to the knees, waist, and shoulders as they began to lift, lower or place the object, horizontal hand position by measuring the distance between the projected point on the floor directly below the midpoint of the hands grasping the object and midpoint of a line between the toes), lifting frequency (average number of load lifting per minute in a shiftwork), duration of load lifting, and twisting (twisting angle as the degree of trunk and shoulder rotation required for the lifting task.).

The mentioned variables were calculated to analyze the lifting operation. The acceptable load weight was determined, and the lifted load was compared with the acceptable weight. If the weight of the lifted load by the workers was less than or equal to the WISHA index acceptable weight, the lifted load would be considered acceptable. If the weight of the lifted load by the workers was higher than the WISHA index acceptable weight, the lifted load would be considered unacceptable. Notably, the variables were calculated using a calculator, and the analysis was performed using WISHA Index calculation software [18, 20].

In the third step of data collection, the prevalence of MSDs was evaluated using the Nordic musculoskeletal questionnaire (NMQ), which was used to investigate the reported cases of MSDs in different body parts of the workers. The NMQ has been commonly employed to determine the prevalence of MSDs in epidemiological studies. In the NMQ, musculoskeletal symptoms and discomforts are reported within the past 12 months. The tool is also used to record musculoskeletal complaints in nine areas of the body, including the neck, shoulders, upper back, lower back, elbows, hands and wrists, knees,

hips, and legs [18]. The validity and reliability of the NMQ have been confirmed at the Kappa coefficient of 0.78-1.00 by 21. Marvimilan *et al.* (2019) [21].

In the fourth step, risk factor assessment was performed using workers' ergonomic quick exposure check (QEC) method. The QEC has been developed to enable health and safety practitioners to undertake the evaluation of the exposure of workers to WMSD risk factors. The method was proposed by Lee and Buckle (1999) [22]. The QEC investigates posture while working in order to estimate the risk of body posture by involving movement repetition elements, energy/burden, and work length to different body parts in a combination of observational assessment and self-report [22, 23]. In the present study, the exposure level (E) or risk level was obtained using the following formula:

$$\mathbf{E}(\%) = \frac{\textbf{Total score of the body evaluation (neck + back + shoulder, arm + twists)}}{\mathbf{X_{max} = 176}} \times \mathbf{100}$$

The score of 176 was assigned to the activities of lifting and carrying loads, the score of 162 described other activities, and the score of 176 was used to calculate the maximum total score .

The exposure levels with risk were classified as low, medium, high, and extremely high in the QEC method [22], and each posture was evaluated using the QEC software package. Notably, the workers were video-taped during their job activities, and one or more images were also captured to assess each posture. The videos and images were analyzed by the researchers.

2.3. Statistical Analysis

Data analysis was performed in SPSS version 21 using descriptive statistics and the Phi and Spearman correlation-coefficients at the significance level of 0.05.

2.4. Ethical Considerations

The research objectives and items in the questionnaires were explained to the participants prior to the study. Participation in the study was voluntary, and the personal information of the subjects remained confidential.

3. Results and Discussion

To determine the state of manual load lifting risk and its association with MSDs, 52 metal industry workers were selected as the participants. The mean age and work experience of the subjects were 32.68 ± 6.64 and 7.83 ± 4.61 years, respectively. The mean daily and weekly work hours were 10.68 ± 2.35 and 65.48 ± 5.43 hours, respectively. Table 1 shows the demographic characteristics of the studied employees.

The evaluation of the manual lifting activities based on the WISHA index showed that 53.8% of the workers lifted heavier loads than the allowable weight obtained by the WISHA index, while 46.2% of the subjects lifted lighter weights than the allowable limit. In other words, 53.8% of the workers lifted loads that were unacceptable of the weight obtained by the WISHA index. Therefore, the workers were at the higher risk of developing MSDs, which could lead to long-term health issues and diminished efficiency at work.

Table 1: Demographic characteristics of the studied employees

Demographic variables	Total (n = 52)
Age (yr) (mean ± SD)	32.68 ± 6.64
work experience (yr) (mean ± SD)	7.83 ± 4.61
Daily working hours (hr) (mean ± SD)	10.68 ± 2.35
Weekly working hours (hr) (mean ± SD)	65.48 ± 5.43
Weight (kg) (mean ± SD)	78.63 ± 8.79
Height (m) (mean ± SD)	1.763 ± 0.571
Marital status	
Single	40.38%
Married	59.62%
Education	
High school degree and diploma	39 (75%)
Associate's degree	9 (17.31%)
BSc and above	4 (7.69%)

In a study in this regard, Flocerfida *et al.* (2019) stated that all the subjects had a high lifting index based on the lifting equation of the National Institute for Occupational Safety and Health (NIOSH), which deemed these individuals high-risk [19]. On the other hand, Darvishi *et al.* (2018) assessed stone cutting workshops and reported that load weights were more than the recommended weight limit obtained from the NIOSH equation and Snook Tables [24].

In the current research, 76.9% of the workers had experienced MSDs within the past one year. According to the obtained results, symptoms in the lower back (73.07%), knees (67.3%), legs (59.61%), neck (53.84%), and shoulders (44.23%) were most prevalent among the subjects. Furthermore, lower back problems were the most common

MSDs among the subjects. Table 2 shows the frequency of the MSDs in each body part of the workers in the past one year. Notably, 61.43% of the workers were absent from work due to pain in different areas of the body.

In the present study, repeated load lifting and overweight were identified as the risk factors for lower back pain [6]. According to the previous studies in this regard, approximately 66% of backache cases are caused by MMH, with 50% reported to be due to lifting, 10% due to pushing/pulling, and 6% due to load displacement [25]. Since the proficiencies and knowledge of staff also play a key role in this regard, the training of personnel on adaptation with workplace circumstances could be a practical approach to the prevention of backache in these individuals [26].

In the present study, the workers performed their tasks either by prolonged standing or continuous walking in the workplace, which may be a major cause of knee and foot discomfort. In addition, the MSDs within the past 12 months caused 61.43% of the workers to be absent from work. The resulting MSDs also led to significant

Table 2: Frequency of musculoskeletal disorders in various body parts of workers in past one year

Body area	Frequency (%)
Lower back	38 (73.07%)
Neck	28 (53.84%)
Elbow	19 (36.53%)
Shoulder	23 (44.23%)
Knee	31 (67.3%)
Leg	35 (59.61%)
Hip	5 (9.61%)
Hand/wrists	20 (38.46%)
Upper back	17 (32.69%)

consequences in their professional life in terms of human suffering, as well as the direct and indirect costs imposed by the loss of workdays, reduced efficiency and productivity, and increased medical costs [27]. The findings of the QEC evaluation are presented in Table 3. Accordingly, 36.5% of the workers were classified as level four (extremely high), and 44.2% were in level three of the QEC (high).

The mean score of the QEC in the investigated individuals was 107.27 ± 25.6, which indicated that they were at a high risk of MSD incidence.

The QEC evaluation indicated that 80.7% of the workers were at the extremely high and high risk of MSDs. In this regard, the findings of Choobineh *et al.* (2007) demonstrated that 37.5% and 48% of the workers had high and extremely high exposure to ergonomic risk factors [28]. According to another study by Deros *et al.* (2015) the RULA scores showed the high risk level of all the workers who performed load lifting activities, and ergonomic changes were required as quickly as possible [29].

The evaluation of the manual load lifting using the WISHA index in the current research showed a significant correlation with the final score of the QEC ($P < 0.001$). In other words, manual lifting load increased the risk of MSD incidence. Furthermore, the WISHA index had a significant association with the prevalence of MSDs ($P = 0.022$) and work absenteeism in the workers ($P = 0.031$). Table 4 shows the correlations of the WISHA index with the QEC score, MSD incidence, and work absenteeism.

In a similar research, Lei *et al.* (2005) reported that the prevalence of MSDs was significantly correlated with MMH in Chinese foundry workers [11]. In addition, Marras reported that MMH is associated with the prevalence of MSDs (particularly lower back pain) in industrially developing countries [10].

In industrialized countries, MMH activities contribute to the increased symptoms of WMSDs, and load lifting in the workplace is the most common example of MMH activities [6]. In a research in this regard, Bültmann *et al.* (2007) stated that MMH is an important risk factor for the incidence of occupational injuries and accidents [30]. Load lifting and MMH in the workplace cause injuries and disabilities in different parts of the musculoskeletal system, and the increased number of workers with MSDs leads to increased work absenteeism [31, 32]. In this regard, the findings of Arghami *et al.* (2016) indicated that factors such as improper workstations, awkward postures, and selecting unfit workers lead to the increased prevalence of WMSDs, even in the workers with limited work experience [8]. From an ergonomic perspective, manual material transfer is a high-risk task that could cause musculoskeletal injuries [29].

Table 3: Results of QEC assessment in the studied subjects

Level	Risk	Frequency (%)
1	Low	0
2	Moderate	10 (19.2%)
3	High	23 (44.2%)
4	Very high	19 (36.5%)

Table 4: Correlation of WISHA index with QEC Score, MSD incidence, and work absenteeism

Variables	*P* value	Correlation coefficient
QEC score	< 0.001	0.654
developing MSDs	0.022	0.467
absence from work	0.031	0.394

4. Conclusions

According to the QEC observations of the workers and manual load lifting assessment, the WISHA index had a significant correlation with the QEC score. In other words, manual lifting load increased the risk of MSD incidence, and immediate ergonomic changes should be applied. The findings of this research also indicated that manual load lifting in an unauthorized range is a major risk factor for MSD incidence. Therefore, some of the recommended measures in this regard are the correction of the posture during work, modifying the workstation, performing tasks between standing and sitting, performing interventions such as load handling, and training on the correct principles of load lifting and handling.

Since the present study was performed in an industrial factory and only on male workers, it is suggested that further investigations be conducted on larger sample sizes of industrial factory workers (both male and female).

Authors' Contributions

B.M., and S.B., designed the study; B.M., collected the data and conducted the statistical analysis; S.B., drafted the manuscript. All the authors revised and approved the final manuscript.

Conflict of interest

The Authors declare that there is no conflict of interest.

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