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Original

Risk of Manual Handling and Prevalence of Musculoskeletal Disorders among Rice Mill Workers in Northern Iran

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ABSTRACT

Background: Nowadays, a large proportion of work-related activities are performed manually, which has led to an increase in the prevalence of musculoskeletal disorders (MSDs). This study aims to assess the risk of manual material handling (MMH) and estimate the prevalence of MSDs among workers in rice mills in the northern part of the country. **Methods:** The study was conducted on 100 workers employed in 36 rice mills in Gilan Province using the census method. The Nordic questionnaire was used to determine the prevalence of musculoskeletal disorders, while the NIOSH equation, Snook table, KIM-LHC and MAC assessment methods were used to evaluate the risk of related activities. Data were then analysed using chi-squared test and Spss23 software. **Results:** The results of the KIM-LHC and MAC lifting methods showed a high prevalence of musculoskeletal disorders in the lower limb during lifting. Similarly, there was a statistically significant relationship (P=0.001 and P=0.002) between the Mac and Snook lifting methods. However, there was no significant relationship between the Niosh method and either the Kim-LHC or Mac-Lifting methods (P=0.10 and P=0.28). **Conclusion:** The results of the risk assessment using different methods showed a consistent and critical condition of the working environment in the rice mills studied. Therefore, it is imperative to take the necessary engineering and management control measures to improve the working conditions.

Keywords: Musculoskeletal disorders, Risk factors, Niosh, Work-related, Ergonomics.

Introduction

Musculoskeletal disorders (MSDs) refer to any type of pain, discomfort, or disorder in muscles, tendons, ligaments, peripheral nerves, joints, bones, and blood vessels that arises due to repeated stress in a period of time.[1, 2] MSDs account for 30% of total disability and 40% of partial disability in the United States.[3] Musculoskeletal disorders such as upper limb problems, neck, and back pain are the second most prevalent cause of sickness absence. According to statistics reported in the UK, a minimum of 28 million working days are lost annually, resulting in a cost of £7 billion per year.[4] Despite advancements in mechanizing work processes, most work activities are

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still manual, which increases the prevalence of work-related musculoskeletal disorders.[5, 6] One of these manual job activities is moving and carrying loads manually, which includes lifting, lowering, pulling, and pushing.[7,8] These activities are classified dangerous based on factors like load characteristics, work environment, work station, and psychological factors, such as occupational stress.[9-11] Manual transportation of goods can expose workers to unfavorable physical conditions such as forceful exertion, awkward posture, and repetitive movement leading to back pain, fractures, injuries, and waste of time and energy. Lifting heavy loads is the most important risk factor in the development of back pain.[12,13] Manual material handling (MMH)has been identified by Health, Safety, and Environment (HSE) organization of England as one of the most important causes of occupational injuries and accidents.[14,15] Ergonomic programs focus on preventing the MSD related to manual handling of loads and repetitive tasks by evaluating and checking MMH activities through methods such as Manual Handling Assessment Chart (Mac) method, NIOSH equation, the Snook tables, and the KIM_LHC method.[16] In rice mills, manual handling of loads (70 kg rice bags) is often done manually, and improper physical posture is observed among workers, leading to a high prevalence of MSDs, especially in the waist area. Studies have been conducted to improve the working posture of workers with manual handling duties in rice threshing factories. By designing an appropriate tool, the risk level of the work situations can be determined and reduced. The risk factors related to MSD can be classified into two categories: sub-risk factors (age, work experience, duration of work, work load) and main-risk factors (posture, manual handling risks). In 2015, Etmadinezhad et al. conducted a study to evaluate ergonomic conditions of rice mill workers in Sari City.[17] They investigated the working posture of rice threshing workers in Sari city using ovako working posture analyzing system (OWAS) evaluation method. The results showed that a significant portion of the workers' postures required corrective measures. The prevalence of MSD in rice mill workers is high, therefore, ergonomic intervention programs through engineering controls are recommended to control the ergonomic risk factors. Therefore, this study assesses risk assessment of MMH and the prevalence of MSD among rice mill workers in northern Iran. Furthermore, it highlights the need for ergonomic interventions to control ergonomic risk factors in the working environment of rice mills and prevent and control MSDs in workers. Moreover, the importance of evaluating permissible weight values for carrying loads was emphasized using valid evaluation methods.

Methods

This was a cross-sectional descriptive analytical study conducted in 2022 on 100 workers in 36 rice mills in Gilan province. The workers were included in the study through census and had no history of disorders affecting the musculoskeletal system, including non-occupational MSDs. The workers had a work experience of more than one year and were involved in MMH. A sample of images of MMH activities in the studied rice mill is presented in Figure1.

A written questionnaire was used to collect the data related to the desired variables. First, demographic characteristics such as gender, age, marital status, working hours, overtime, and sports activity were obtained through a demographic questionnaire. Second, the Nordic questionnaire was used to determine the prevalence of MSD among the participants. Full explanations were provided to ensure participants understood the questions. Finally, risk evaluations were carried out using the NIOSH equation, Snook tables, KIM-LHC and MAC methods for activities involving MMH, taking into account the cargo weight among other factors.

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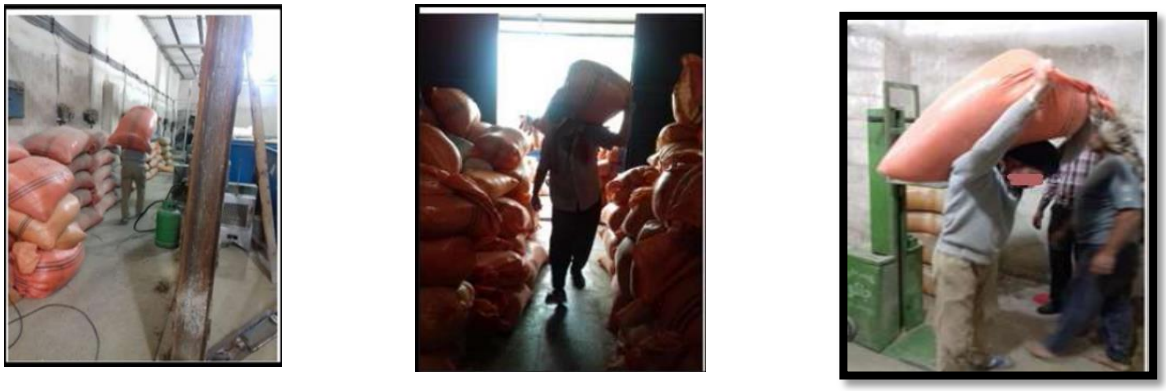

Figure1. Pictures of MMH activities in the studied rice mills

A: Nordic questionnaire

The Nordic questionnaire is a reliable measurement tool for evaluating MSD. It was first introduced in 1987 by Korina et al. and later translated, localized, and evaluated for validity and reproducibility by Mokhtarinia et al.[18] The questionnaire evaluates the presence of burning, discomfort or numbness in different parts of body including neck, shoulders, upper back, elbows, waist, wrist, thighs, hips, knees and ankles over different time periods. This tool is used to assess MSD in a wide range of occupational groups. The questionnaire was completed through an interview with rice mills, and the disorders and discomforts of 9 parts of the body were investigated. This tool is often used in screening and epidemiological investigations of MSD.[19]

B: NIOSH equation

The Niosh equation, on the other hand, is used to calculate the recommended weight for load lifting which most healthy workers could do in one work shift without suffering back problems. This equation is the result of the relationship between the 7 coefficients mentioned in equation (1). To use the NIOSH method, first, the weight of rice bags (L), the horizontal distance between the hand (while holding the load) to the center of gravity of the body (HM), the distance from the ground to the height of the load placement (the height of the starting point of lifting the load) or (VM), the amount of moving the load (the distance between the original and the destination of the load) or (DM), the amount of rotation of the trunk from the sagittal level (AM), the number of repetition of lifting the load per minute (FM) and the conditions of hand grip with the load (pair) were measured (CM). The load was specified and the numerical values of each of the required variables were determined. Then, the necessary coefficients were extracted by calculating the amount of recommended weight load (RWL) using equation land, and calculating the lifting index (LI) according to equation (2), the permissibility/non-permissibility of the load carried by rice mills and the amount of physical stress applied to the body during lifting. The load was estimated and the necessity of implementing ergonomic interventions in the work environment was investigated. Thus, in activities where LI is equal to or smaller than one, the environment is ergonomic and the implementation of ergonomic interventions is not necessary.

In addition, when LI is determined between one and three, it is necessary to design and implement ergonomic interventions. If LI is more than 3, more basic changes such as automatic methods of carrying and lifting loads should be considered in order to make the work environment ergonomic.

$$RWL=LC\times HM\times VM\times DM\times AM\times FM\times CM \quad (1)$$

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$$LI = \frac{L(kg)}{RWL(kg)} \quad (2)$$

C) Snook tables

Snook's tables are one of the most comprehensive databases for the design of carrying, lifting/lowering, pushing, and pulling tasks. They were presented in 1978 by Snook and Cyrillic with a psycho-physical approach, which include the maximum acceptable weight in lifting/lowering the load, the maximum starting force, and the holding force during the tasks. Among the advantages of these tables is the ability to separate gender groups and different percentiles. Acceptable weight in this method is approved for 90% of the working community. Snook's tables have been used in this study to evaluate the level of the activity risk related to MMH. To use this method, the tables related to (moving, lifting and lowering the load) are used for the percentile of men; for this purpose, the following parameters are measured for each task of manual load carrying:

• To lift the load: width of the load (the distance from the center of the load (where the hand grips the load) to the body), vertical distance and the range of lifting the load (floor to the fingertips, fingertips to the shoulder, and above the shoulder) the frequency and the percentage of employees lifting the load.

• To lower the load: the width of the load (the distance from the center of the load (where the hand grips the load) to the body), the vertical distance and the range of lowering the load (the floor to the fingertips, the fingertips to the shoulder and above the shoulder), the frequency and the percentage of employees lowering the load.

• To move loads: the distance, height, frequency and percentage of employees who moved load.

D) KIM-LHC method

In this study, the key indicator method, lifting, holding, carrying (KIM- LHC) method was used to evaluate the lifting tasks; this method was presented and updated in 2001 2007 by the German federal institute for occupational safety and health and has several stages: in the first stage, the time score is determined, and in the next stage, scores related to work load, posture, and working conditions are considered together. It is added and multiplied by the time score to determine the final score. Finally, to determine the corrective action, it is compared with the values of the corrective action table.[20, 21]

E) MAC method

One of the risk assessment methods for MSD is MAC method. This method is used by the HSE ergonomics laboratory department to increase safety and facilitate the inspection of companies with MMH operations. It has superiority over other methods of assessing body condition in MMH in terms of ease of use and validity (accuracy). By using this method, it is possible to evaluate three types of activities; lifting loads individually, lifting loads as a team and MMH. The validity and reliability of this method has been approved by the HSE organization.[22, 23] Also, the studies carried out in the country showed that the MAC method in assessing MSD related to MMH was consistent with the Niosh method and Iran's MMH .[22, 24] This method is an observational method focusing on the back, shoulder, upper limb, and hand areas.

To apply the MAC method, MMH assessment charts for individual lifting and manual carrying of loads were used; they included risk factors such as load weight/frequency of lifting and carrying, hand distance from the lower back, vertical lift zones, torso twisting and sideways bending or asymmetrical torso or load (carrying), postural constraints, grip on the load, floor surface, carrying distance, obstacles on route, communication, co-ordination, and control and environmental factors. In the MAC method after observing the way the activity is performed and selecting the corresponding chart, each of the

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variables is assigned color codes along with a numerical score. Finally, after summarizing the scores, the level of risk and the type of action to be taken are determine.[22] In order to evaluate the tasks of MMH, the work process of the workers was well observed. Some of the tasks were evaluated at some work stations using the checklists of the method used, and in some cases, photographs were taken. In order to evaluate the tasks, the photos were examined. In the end, the collected data were analyzed using 23. SPSS software. According to the type of variables in this study, chi squared statistical test was used to achieve the research objectives, and descriptive statistics method were used to describe the characteristics of the studied subjects.

Results

In total, 100 workers from rice mills were included in the study, and their mean age and daily working hours were reported as (48.41 ± 12) and (10.48 ± 1.93) hours, respectively. Additional demographic characteristics of the studied workers were presented in Table 1.

Table 2 presents the prevalence of MSD among rice mill workers in the current study, as determined by the Nordic questionnaire. Results show that within the last year, 49% of workers experienced pain, discomfort, burning or numbness in one of their nine organs at least once. Within the last week, 45% experienced the same symptoms. The back (49%), knee (44%), and ankle (40%) were the organs with the highest frequency of symptoms.

The result of the evaluation of the lifting activity

Table 3 displays the results of the evaluation of load lifting activity in different ways. According to the LHC-KIM method, 26% of workers lifted loads (bags of rice) above permissible limits, as the risk level was ranked as "4". Using the MAC lifting method, 85% of workers were ranked as having a very high-risk level of lifting loads. Snook lifting method evaluation showed that the maximum weight of the load workers should lift is 22 kg. However, only 21% of workers were allowed to lift loads under current conditions. A chi square test indicated no significant relationship between the Niosh method and the two methods of Kim-LHC and Mac lifting (P=0.10 and P=0.28).

The results of the evaluation of lowering and carrying load

Table 4 presents results of the activities of lowering and carrying loads. Using carrying MAC evaluation method, 70% of the workers were ranked as having a very high-risk level of carrying loads. Carrying-Snook table demonstrated that only 21% of the workers were allowed to carry the maximum weight of 22 kg under current conditions.

Table 1. Demographic characteristics of workers

Demographic variable		Abundance	Percent
Marital Status	Single	4	4%
	Married	96	96%
Overtime hours	Yes	53	53%
	No	47	47%
Sport activity	Yes	8	8%
	No	92	92%

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Table 2. Prevalence of MSD in different parts of the body during the last 12 month in the rice mill

Body Area	Have you had this problem in the last 12 months?	Have you experienced this problem in the last 1 week?
	Abundance	Abundance
	Percent (%)	Percent (%)
Neck	20 20	18 18
Shoulders	36 36	18 18
Upper back area	34 34	31 31
Elbows	16 16	16 16
Wrist, hand	20 20	19 19
Waist area	49 49	32 32
Pelvis, thighs	23 23	20 20
Knees	44 44	45 45
Wrist, legs	40 40	36 36

Table 3. The result of load lifting evaluation using KIM-LHC, Snook, MAC, and NIOSH methods

	Methods	Range of risk	Number	Percent(%)
KIM-LHC	The load has increased greatly (50 to 25)	3	4	4
	Heavy load (50 ≤)	4	96	96
NIOSH	(LI ≤ 1)	-	94	94
	(1<LI < 3)	-	6	6
MAC	13≤MAC≤ 20	High	15	15
	21≤MAC ≤ 31	Very high	85	85
	Snook			
	Maximum acceptable weight (Kg)		Percent of population	
	22		21	

Table 4. Evaluation results of lowering and carrying loads using evaluation tools, Snook-lowering, Snook-carrying, and MAC-carrying.

Method		Range of risk	Number	Percent(%)
MAC-carrying	13≤MAC ≤ 20	high	30	30
	21≤MAC ≤ 31	Very high	70	70
Method		Maximum acceptable weight (Kg)	Percent of population	
Snook carrying		22	21	
Snook lowering		19	16	

Results from the lowering Snook table showed that only 16% of workers were allowed to lower the maximum weight of 19 kg under current conditions. A chi square test revealed a significant relationship between the MAC-carrying and Snook-carrying methods (P=0.001 and P=0.002).

Discussion

The goal of the present research was investigating the risk of MMH and prevalence of MSD between employed workers in rice mill in north of the country. A high prevalence of MSD was observed among them.49% of the workers in the past year, and 45% of them in the last week experienced pain, discomfort, burning, and numbness at least once in nine organs. The highest frequencies were related to waist, knee, and ankle areas respectively.

Using of lifting equation, Niosh method, and

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Snook Tables on workers in stone cutting workshops, Dervish et al. found that 48% of workers experienced MSD within the last year, primarily related to back discomfort.[25] Similarly, research on carpet retail workers revealed that 37.8% experienced pain in one of their nine organs, with the most common discomfort being related to their waists.[26] In Etmadinezhad et al.'s study on the ergonomics of rice mill workers, 74% of the workers experienced MSD within the last year, primarily on their waists.[17] And also the study by Adedeji et al on furniture company in Nigeria showed that 25.9% of workers had back pain.[27]

Therefore, in addition to load carrying with an excess weight, inappropriate posture is one of the risk factors due to skeleton and muscles problems specially backache. According to Snook tables, 21, 21 and 16 percent of the workers are respectively suitable for lifting, carrying and putting down the cargo; the limited cargo's weight must be reduced almost to a third of the bag's weight for workers. Evaluation of lifting with KIM- LHC indicated that cargo's weight was high for 96 percent of the workers and additional physical load may occur, which necessitates a redesign in the working place of rice mill workers. Moreover, for 4 percent of workers, the amount of cargo was increased and extra physical load might be a problem for normal people and redesigning of workplace is necessary. According to a research by Esksndari et al, in the Kashan automotive industry Saypa, 3 workers were at risk level of 1, 40, at risk level 2, 38, at risk level 3, and 3 workers were at risk level of 4.[28] Based on MAC method, in lifting the load, 85 percent of the workers were at high risk level, and doing corrective actions were essential. In 15 percent of the workers, corrective actions had to be done immediately. In Mohammadi et al. 's research, through the mean of carrying things with hand by MAC method in a tile company, the risk level of lifting and carrying cargo in a team in mould unit was considered to be high (risk level 3); it needs immediate corrective actions .Jari et al.'s study also showed that MAC method can be used to plan educational interventions against the risk of Work-related Musculoskeletal Disorders risk in MSDs.[29]

The risk level was investigated in part 2 of casting unit for lifting and carrying of an average worker (risk level 2). In part 1 of the casting unit where lifting cargo was done alone, the risk level was average (risk level 2).[22]

Chi square test showed there was a significant relationship between MAC and KIM-LHC methods (p=0.001). Based on NIOSH method, the LI for 94 percent of employed workers was less than 1; so, the load's weight was appropriate, and the activity could be performed safely.

In this study, the results of method NIOSH do not have any correlation with method KIM-LHC and MAC lifting. In Panjali et al.'s research reported that there was a significant relationship between Iran's adherence to MAC method and NIOSH; however, there was no significant relationship between NIOSH and MAC.[30] B on the MAC-carrying method, the risk level of load carrying was very high for 70 percent of workers, which requires corrective actions immediately.

Chi square test results according to MAC carryingand Snook carryingindicated a significant relationship between these two methods (p=0.002) which can be an alternative to other evaluation methods.

It is necessary that ergonomic interventions be done in line with manual handling in rice mill in north of the country to reach the minimum physical burden possible.

Conclusion

The prevalence of MSD is high among workers in rice mills. The results investigating occupational hazards were consistent across various methods, indicating that the workplace conditions in rice mills are hazardous and require further study. Among the

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methods used in this research, the results obtained from the NIOSH method differed from other methods, suggesting that it may not be suitable for investigating risks in the northern part of the country. Therefore, it is crucial to prioritize the health of managerial workers by improving the conditions of workplace. It is imperative that MSD be prevented to boost workers' performance. One of the limitations of this study was lack of access to biomechanical tools such as electromyography (EMG) to evaluate skeletal and muscular problems. Future studies should consider the use of such tools to assess MSD in different areas.

Conflict of interest

The authors declared no conflict of interest.

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Authors' Contribution

N.S. Kh designed the research. N.S. Kh, M.B.M collected data, M.R analyzed data, and N.S. Kh, M.B.M, and M.R wrote and edited the manuscript.

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