Original Article

Evaluating the potential risk of musculoskeletal disorders among bakers according to LUBA and ACGIH-HAL indices

Beheshti MH, MSc*

- Faculty Member, Dept. of Occupational Health, Faculty of Health, Gonabad University of Medical Sciences, Gonabad, Iran.

Abstract

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Background: Bakers, due to the nature of their jobs, are at risk of musculoskeletal disorders (MSDs) caused by ergonomic factors. The purpose of this study was to evaluate the biomechanical risk factors for MSDs in bakers.

Materials and Methods: In the current study, all Sangak, Taftoon, and Lavash bread bakeries in Gonabad, Iran, were selected based on census method. Then, hierarchical task analysis (HTA) method was used for task analysis and their occupation was classified into tasks, actions, and movements. The Shater (the employee who places the bread in the oven), Chanegeer (the employee who cuts the dough), and Nangeer (the employee who removes the bread from the oven) employees were studied in this respect. Subsequently,postural loading on the upper body assessment (LUBA) and American Conference of Governmental Industrial Hygienists-Hand activity level (ACGIH-HAL) methods were implemented to identify common risk factors in repetitive tasks that can contribute to the development of MSDs of upper limbs. Analysis of the results in this study was performed using SPSS software.

Results: A LUBA score of higher than 10 was obtained by 83.33% of workers in Tafton bakeries, 100% of employees in Sangak bakeries, and 91.66% of workers inLavash bakeries. ACGIH-HAL index results of 100% of Sangak, 50.37% of Taftoon, and 50% of Lavash bakery workers were in the red (danger) zone. The LUBA score of nosubjects was below 5 (action level one).Highest relative discomfort score of Nangeer and Shater in Tafton bakeries was in the back area and of Chanegeer in the neck and shoulder area. Highest score of relative discomfort of Shater, Chanegeer, and Nangeeremployees of Lavash bakerieswas in the lumbar area and neck and ofShater and Nangeer of Sangak bakerieswas in the elbow and wrist area.

Conclusions: The results showed that the risk of MSDs due to repetitive tasks is relatively high in bakeryand ergonomic interventions required in order to redesign the job.

Keywords: Risk Factors, Ergonomics, Musculoskeletal Diseases.

Introduction

Musculoskeletal disorders (MSDs) are a major cause of work disability among workers (1). Work-related MSDs are considered as one of the most important health problems, cause of disability and absenteeism in developed countries, and the source of about one-third of health care costs (2).

Studies* in Europe show that MSDs have great effect on work absenteeism. For example, in Great Britain between 2007 and 2008, individuals who suffered from disorders of the

* **Corresponding author:** Mohammad Hossein Beheshti, Dept. of Occupational Health, Faculty of Health, Gonabad University of Medical Sciences, Gonabad, Iran.
Email: beheshtihasan8@gmail.com

upper limbs were on average absent from work 13.3 days,those who suffered from back pain 17.2days, and disorders of the lower limbs 17.2 days (3). The risk factors for MSDs include repetitive work, time on duty, vibration, awkward postures, tedious and painful actions, transportation, heavy load handling, lifting and moving patients, and prolonged walking and standing(4).Among the mentioned risk factors, the most commonis repetitive work and the most important is unfavorable body posture (5).In the industrialized world, many workers are forced to make themselvescompatible with inappropriate conditions that have been imposed by the environment and the tools.

Consequences of such confrontation could have adverse and very serious effects on the quality of life (QOL) and health of workers.In such situations, an individual is not in harmony with the work environment and tools or equipment that are used and the continuation of this situation could lead to skeletal-muscle disorders in the back area. These disorders are the most common and important factor in loss of work time, and increased labor costs and human suffering.Recent researcheshave shownthat more than half of absences from the workplace and one-third of work-related compensation requests are due to MSDs (1-6).

Work-related MSDs occur as a result of exposure to occupational risk factors among which physical factors (such as posture, force, motion, and vibration), psychological-social factors, and individual factors can be noted (1,7).MSDs are the result of excessive mechanical load and have a significant socio-economic role because theyare one of the main causes of disability and absenteeism.These disorders are multifactorial risk factors, which in some respects are still not completely clear (8).Work-related musculoskeletal disorders is depend on working patterns and do not belong to any particular industry or occupation.Therefore, many workers are at risk of MSDs (9).In Iran, due to the diet of the majority of people (people consume bread with almost every meal),many people work in bakeries.Therefore,a large population is exposed to various risks, which are the most important risk factors for musculoskeletal and muscular disorders.Most of the operations of bread making in Iran, and in particular in Gonabad,areperformed by hand.Therefore,the incidence of risk factors, such as repetitive motions, cumulative trauma disorders (CTD), inappropriate posture, and prolonged standing, are high in this job.Furthermore, these workers are at risk for these disorders due to the large number of repetitive movements, prolonged work in standing position, inappropriate working conditions and other factors, including psychological factors and poor environmental conditions. Considering that workers are forced to hold certain postures during work, favorable or unfavorable posture,duration of holding time, and static or dynamic work, alone or in combination, play an important role in these disorders (10).As evidenced, many MSDs are preventable (11).

In fact, prevention is an effective tool in reducing disorder incidence,and actions such as screening and surveillance in the workplace are successful prevention tools.Currently, there are different ways to assess exposure to risk factors for MSDs.In evaluating the stress of body postures, observational methods are most widely used in the industry among whichOvako Working posture Assessment System (OWAS), Rapid Upper Limb Assessment (RULA), and Rapid Entire Body Assessment (REBA)can be mentioned.In observational method, scoring is based on joint discomfort in different postures and the highest score isrelated to situations in which the joints are at the greatest deviation from their normal state.Postural loading on the upper body assessment (LUBA) is an observational and macropostural technique that was developed in 2001 byKee and

Karwowski.LUBA evaluates the pressures of body posture in upper limbs (12-14).The number of risk factors evaluated by each of these techniques is varied.Some of them, like LUBA, only focus on the assessmentof posturein different body parts, while some others assess important physical factors such as energy and repetitive motion. Advantages of LUBA method is that,it shows some conceptions about working postures,perform the procedure is simple,Scoring is based on physiological data, numerical output can make decisions easier than qualitative results, and the detection of exposure requires close contact with workers.Because few ergonomics studies were performed in relation to bakery and this job is growing fast in Iran, this study seemed necessary. This study was conducted in bakeries in Gonabad city of Khorasan Province, Iran.The main objectives of this study were to determine risk factors for MSDs, provide recommendations to improve the working conditions of workers in bakeries, and determine the priority of corrective actions based on LUBA and American Conference of Governmental Industrial Hygienists-Hand activity level (ACGIH-HAL) indices.

Materials and Methods

This study was a cross-sectional analytical study.The research population of this study consisted of the workers of all bakeries in Gonabad including 8 Taftoon bakeries, 8 Lavash bakeries, and 12 Sangakbakeries. The participants were selected using census method. The Shater (the employee who places the bread in the oven), Chanegeer (the employee who cuts the dough), and Nangeer (the employee who removes the bread from the oven) employees were studied. Overall, in this study,a combination of three methods of data collection including observational method (analysis of jobs and tasks), interviews (questions about the type and complexity of work), and ergonomic assessment techniques (to determine the actual risk of and assess repetitive tasks) were used. In this study, LUBA and ACGIH-HAL techniques were used to assess the potential risk of MSDs in upper limbs.

To calculate the index, the samples were collected using filming. In this study, all tasks of workers in bakerieswere detected, and then, divided into subtasks, the subtasksinto working cycles, and working cyclesinto work activities.For the analysis of each task, according to instructions for each technique, a photo/video was prepared for a complete working cycle of working activity in any work station. In this study, to evaluate hand activity, ACGIH-HAL index was based on observationand the checklist relevant to ACGIH-HAL, normalized peak force (NPF), and their combination on a diagram.

The evaluation is based on assessment of hand activity and the level of effort for a typical posture while performing a short cycle task. The data collection Which was used by ACGIH is an adaptation that guides the gathering of information on job risk. The first step was to identify the level of hand activity on a scale of 0 to 10, where 0 is virtually no activity and 10 the highest imaginable hand activity. Hand activity accounts for the combined influences of effort repetition and effort duration in a qualitative assessment. The second step characterizes the effort level by noting the effort associated with a typically high force within the cycle of work. The NPF is the relative level of effort on a scale of 0 to 10 that a person of average strength would exert in the same posture required by the task. For assessing NPF,3 methods are suggested; noting the measured percentage of maximum voluntary contraction, a subjective report of perceived exertion (Subjective Scale),and an observational method basedon the Moore-Garg Strain Index. The third step is to locate the combination of ACGIH-HAL and

NPF on the following threshold limit value (TLV) graph.

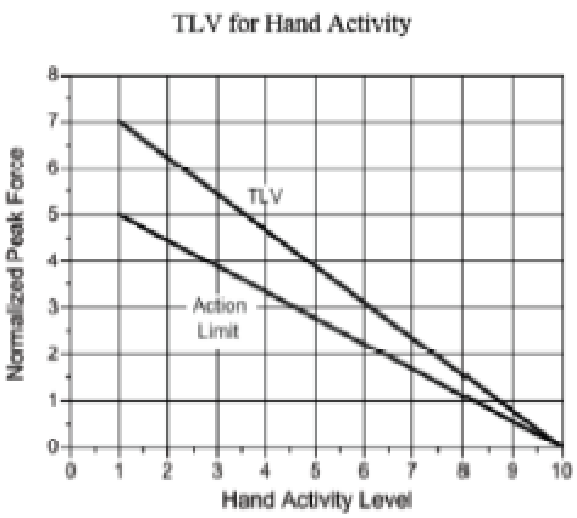

Figure1: American Conference of Governmental Industrial Hygienists-Hand activity level-Threshold limit value(ACGIH HAL-TLV) diagram (presented to assess risk levels)

LUBA method was used to determine the postural load imposed on the upper limbs and the prevalence of MSDs. LUBA is an assessment technique for postural loading on the upper body based on joint motion discomfort and maximum holding time.The proposed method is based on the newexperimental datafor the composite index of perceived discomfort (ratio values) for a set of joint motions, including the hand, arm, neck, and back, and the corresponding maximum holding times in static postures. In order to measure postural load index, thework cycle of each task was filmed using a Sony digital camera. The camera was placed at a distance of 1 meter and at an angle that would record nearly three aspects of working posture.After completing the film, according to the LUBA method, the body posture to which most working time was devoted or was performed most frequentlywas selected.Appropriate discomfort score was calculated after selecting the posture for each limb, joint movement, and joint angle.After determining the discomfort score for each limb, postural load index was calculatedas the sum of these scores according to the following formula:

$$\text{Postural load index} = \sum_{i=1}^{n} \times \sum_{i=1}^{mj} \text{Sij}$$

where I isi-th joint motion, j the j-th joint,n the number of joints to which they belong,Mj number of movements studied in j-th joint, and Sij discomfort score of i-th move from the j-th joint (if the score of relative discomfort is equal to1,Sij = 0).

Finally, based on postural loading, each person's body condition was placed in one of four levels of corrective action.

In general, the LUBA method includes 5 steps:

1. Recording of working posturesduring several cycles using video cameras;

2. Selection of postures for assessment; 3.Observationof movements of each joint in selected postures,determination of discomfort scores according to respective tables,and calculation of postural loadingthrough the sum of all discomfort scores of joints;

4. Calculation of postural loading index in selected postures according to the relevant equation in LUBA method;

5.Determination ofthe required corrective action according to the relevant table (Table 1).

The data were analyzed using SPSS 17 and Spearman correlation coefficient, independent t-test and multiple regressions.

Table 1: Corrective action groups in postural loading on the upper body assessment (LUBA) method according to postural loading

Group	Corrective action
Group 1	Postural load index of 5 or less These postures are acceptable and do not require corrective actions except in specific situations such as repetition and extended period of time and similar items.
Group 2	Postural load index of 5 to 10 These postures will require changes and corrections during the next review, but urgent corrective intervention is not necessary.
Group 3	Postural load index of 10to 15 These postures require urgent corrective action through the redesigning of the workplace or working methods.
Group 4	Postural load index of 15 This group of postures requires significant and immediate corrective action.

Results

Results of ergonomic status assessment in Bakeriesaccording to LUBA index are shown in table 2. The highest and lowest scores of relative discomfortin Nangeer of Taftoon bakeries were,respectively, in the waist and wrist areas. Moreover,the highest score of relative discomfort in Shater of Tafton bakerieswas in the lumbar area and in Chanegeer of Tafton bakerieswas in the neck and shoulder area.

Table 2: Results of a postural loading on the upper body assessment (LUBA) in bakery staff

Index coefficients		Taftoon bakery			Sangak bakery		Lavash bakery		
		Nangeer	Shater	Chanegeer	Nangeer	Shater	Nangeer	Shater	Chanegeer
Wrist score	Right hand	1.50	1.87	1.42	2.58	2.70	1.62	1.60	1.87
	Left hand	1.25	1.25	1.00	3.00	2.18	1.00	1.00	1.12
Elbow score	Right hand	3.00	2.75	1.85	2.83	3.00	2.75	1.70	3.00
	Left hand	2.25	2.62	1.00	3.00	2.27	2.50	1.50	2.50
Shoulder score	Right hand	2.50	1.50	3.00	2.00	2.00	3.00	2.50	1.75
	Left hand	1.25	1.00	1.12	2.08	3.00	1.00	1.00	1.00
Neck score	Right hand	3.00	1.25	3.00	2.16	2.17	3.00	2.75	2.00
	Left hand	3.00	1.25	3.00	2.00	1.00	3.00	2.75	2.00
Back score	Right hand	6.25	3.25	1.57	2.66	2.66	3.25	2.50	2.75
	Left hand	6.25	3.25	1.50	2.16	1.00	3.25	2.50	2.75
LUBA	Right hand	16.25	10.87	10.57	12.91	13.75	12.25	12.25	12.75
	Left hand	13.37	9.50	7.87	10.33	12.36	9.50	8.00	10.25

Results assessment of risk level of MSDs in subjects using LUBA showed thatin any job task inSangak, Taftoon, and Lavash bakeries, level exposure scorewas not lower than 5 (level priority of corrective action 2).

In any Sangak bakery workers, 16.66% of Taftoon bakery workers, and 8.33% of Lavash bakery workers,the calculated score was between 5 and 10.This score range means that further studiesshould be carried out and prompt intervention is not required (level priority of corrective action 2). Moreover, in 33.33% of Sangak, 58.33% of Taftoon, and 70.83% of Lavash bakery workers,the calculated score was between 10 and 15(level priority of corrective action3).

In 66.66% of Sangak, 25% of Taftoon, and 17.87% of Lavash bakery workers,the calculated score washigher than 15. This score means that immediate change and reform is essential(priority level of corrective action 4).

Generally, in 83.33% of Taftoon bakery workers, 100% Sangak bakery workers, and 91.66% Lavash bakery workers,the score of LUBA was higher than 10.

Results assessment of risk level of MSDs of subjects using the ACGIH-HAL index revealed thatall Sangak bakery workers, and 62.5% of Taftoonand 50% of Lavash bakery workers were in the green zone (safe, maintain conditions) (Table 3).

None of the staff of Sangak,Lavash, and Taftoon bakerieswere inthe yellow risk zone. However, 100%of Sangak bakery, 37.5% of Taftoon, and 50% of Lavash bakery workerswere in the red risk zone.

Table 3: Results of ACGIH-HAL index for different tasks of bakeries

Index coefficients		**Taftoon bakery**			**Sangak bakery**		**Lavash bakery**		
		Nangeer (%)	Shater (%)	Chanegeer (%)	Nangeer (%)	Shater (%)	Nangeer (%)	Shater (%)	Chanegeer (%)
ACGIH-HAL	Green zone	62.5	50	75	0	0	37.5	37.5	75
	Yellow zone	0.0	0	0	0	0	0.0	0.0	0
	Red zone	37.5	50	25	100	100	62.5	62.5	25

ACGIH-HAL: American Conference of Governmental Industrial Hygienists-Hand activity level

Discussion

The high prevalence of risk factors for MSDs of the neck, back, and hands, and high postural load index and 3 and 4 level ergonomic measures in 83% of bakery staff are the most important findings of this study.In this study, in order to assess posture and determine postural load index, LUBA method was used. The results of the evaluation indicated that the LUBA score of83.33% of Taftoon, 100% of Sangak, and 911.66% of Lavash bakery workers washigher than 10.The results of this study showed the high prevalence of risk factors for MSDs in bakers of Ghonabad.More than 83% of the study population was in ergonomic action levels 3 and 4 (postural load index score higher than 10). High postural load index scores indicate a high level of risk of MSDs and the need for intervention and immediate corrective action.The results showed that theACGIH-HAL index was in the red risk zone in 100%of Sangak, 37.5% of Taftoon, and 50% of Lavash bakery workers.This finding suggests a large increase in risk of MSDs and the necessity of immediateimplementationof appropriate control measures.A similar study was conducted by

Tajvret al. according to the Occupational Repetitive Actions (OCRA) index on 4 types of bakeries, including rotary Taftoon, traditional Taftoon, Sangak, and Baguette, located in the city of Kerman, Iran.They showed that the risk level of the tasks of Chanegeer and Shater in all4 types of bakeries was in the red zone (15).

This finding corresponds with the results of the present study.The results of LUBA Index showed that most of the relative discomfort scores of Nangeer and Shater of Taftoon bakeries werein the lumbar area and the lowest score was in the wrist area.Furthermorethe relative discomfort scores of Chanegeer of Taftoon bakeries were in the neck and shoulder area.The highest score of relative discomfort ofShater, Chanegeer, and Nangeer of Lavash bakeries were in the neck and lumbar areas. The highest score of relative discomfort ofShater and Nangeer of Sangak bakeries were in the elbow and wrist areas.In another study conducted by Tajvret al.on bakers, about 298 cumulative traumatic disorders (CTD) were observed in the neck, shoulder, hand/wrist, and waist areas (15).Among these cases, 91 cases were related to Chanegeer, 149 cases to Shater, 10 cases to bread Gouging, 6 cases to bread sellers, and42 cases to bread Gouging / sellers (16).Accordingly, it is recommended that their work practices be improvedthrough redesigningof their work conditions.The study by Ghamariet al. revealed that, inthe upper extremity, thehighest prevalence of disorders (8.55%)was observed in the back and the frequency of shoulder and back disorders in Shater is higher than other occupational groups(16).A major cause of stress and pressure on joints is the force exerted on them.To reduce the pressure of excessive force when there is no possibility of downsizing and equipment weight reduction,employeescan be rotatedto different tasks or more people can be employed so that work pressure is divided between workers (21).Through providing breaks for the workers to rest,the involved muscles have the opportunity to rest and return to normal(17).To reduce Repetitive actionper minute and low movement speed in stations with high frequency, more people can be used or the production process can be automated (21).The results of this study suggest that inappropriate hand/wrist posture can be one of the risk factors for MSDs.According to the findings, most work tasks were in the medium and high risk levels.Thus, further evaluation, control, and preventive measures to improve working conditions are necessary,because if the workers who perform these tasks continue in this way,they are at risk forMSDs.Moreover, it is important totake actionimmediately to reduce or eliminate the impact of these factors on workstations,because MSDs areamong the most common and important diseases and occupational injuries, and the leading cause of disability among workers (18).Ergonomics is the best way to control MSDs, is considered as the most important part of any control program, and its impact on reducing the rate of work-related MSDs has also been demonstrated (13, 19).

In addition, it is recommended that the following items be pursued in order to reduce musculoskeletal complicationsin bakery workers.

1. Redesigningof working posts in various bakery tasks is recommended so that workers can perform their activities without any additional movement and danger, and with ease.
2. To prevent excessive bending, and bending and twisting along the trunk byShater and Chonegeer,the shortening of access to dough and tools is suggested.
3. It is suggested that workers sit whileperforming differentactivities to prevent discomfort in the lower back and knees from standing; seats such as saddle bullseatsare suggested (18).
4. For preventing shoulder disorders caused by

arm movement, especially among Chonegeer and Shater, it is necessary that the height of the tape device be slightly lower than shoulder height.

5. Reduction of work time and implementation of the work and restprogram are recommended, so that workers have more rest at specified intervals.
6. The workers have low level of knowledge in the field of ergonomics.Hence, training workers and informing them about the correct way to work, appropriate postures, the importance of rest intervals, and handlingcan have a significant impact on preventing injuriesin workers.Job examinations for early diagnosis and treatment of MSDs and suitable exercise are also recommended.Many studies have shown that combinations of these methods have resulted in better outcomes (20). Therefore, it is suggested that a combination of these methods be implemented in bakeriesin order to improve the working environment.

Posture caused by pressure (postural loading), according to LUBA method, is a risk factor that causes MSDs or predisposesindividuals to MSDs in the long term.The limitations of this study included supervisors who were difficult to satisfy, people to do the filming in bakeries, and low cooperation of some subjects due to stress and high workload. Moreover, in some cases, because of the limited space in which each task was performed, there was no suitable angle of view for filming.

Conclusion

In summary, with respect to the content provided, most of the risk factors evaluated wereat an undesirable risk level and, based on the results of ACGIH-HAL and LUBA indices, bakery workers were at high risk of musculoskeletal injuries.Throughergonomic interventions and implementing ergonomic principles with the use of standard equipment, making changes to perform activities correctly, and modifying tools and tasks,activitiescan be made more efficient and damage to the musculoskeletal system reduced.Therefore, many injuries and their costs, and absences from workcan be prevented.

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