

# Ergonomic assessment of musculoskeletal disorders risk by rapid upper limb assessment (RULA)

## technique in a porcelain manufacturing factory

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### Introduction

Musculoskeletal disorders (MSDs) are the most common occupational injuries and one of the risk factors affecting the incidence of this type of injury is routine work activities in industrial environments [1,2]. The prevalence of these diseases can lead to decreased productivity at work, and impose direct and indirect costs on society. MSDs have resulted in lots of lost working time each year [3] and according to a report published in 1996 in Europe, 30% of

### Abstract

Musculoskeletal disorders (MSDs) are a major part of occupational diseases and one of the main causes of disability. This study aimed to determine the prevalence of MSDs and its risk factors, and assess the risk of these disorders by using RULA method in a porcelain factory in Khorasan Razavi province. This cross sectional study was conducted on 100 working women in decoration department in a porcelain factory. Data collection of the current study was done by demographic characteristics questionnaire, Nordic questionnaire and RULA checklist. Study data were analyzed by chi-square and t-tests in SPSS-16. The mean age and work history of the study population were  $28.6 \pm 14.9$  and  $2.53 \pm 1.63$  years, respectively. The prevalence rate of 81% was obtained for musculoskeletal disorders in them. They were assessed at RULA risk level 2 and 3 with 38% and 62%, respectively. Despite the low mean age and work history of the study population, the prevalence of musculoskeletal disorders was high and the relationship between the RULA risk assessment level and the prevalence rates of disorders showed that the risk of these disorders was higher in people with musculoskeletal disorders than people without these disorders.

**Keywords:** Assessment, Limb, Musculoskeletal

workers suffered from low back pain and 17% suffered from upper limb pain and 45% worked at improper physical conditions [4]. The results of a study conducted in Britain in 2005 showed that more than one million people, about 2.4% of the total workforce, suffered from work-related musculoskeletal disorders [5]. The study of Nasl Seraji et al. conducted by rapid upper limb assessment (RULA) method showed that the prevalence rates of neck, back and upper limbs' pains

are high, and a significant relationship was observed between the prevalence of MSDs and the risk level assessment [6]. The study of Miri *et al.* showed that the pain prevalence rates in different areas of body were high in Birjand hairdressers and a significant relationship was observed between the prevalence of MSDs and the risk level assessment [7]. Choobineh *et al.* also showed that the risk level obtained by using RULA method had a significant relationship with the prevalence of musculoskeletal disorders [8]. Also, another study indicated that the prevalence of MSDs was high and there was a significant relationship between the risk level and musculoskeletal disorders [9]. Studies conducted on musculoskeletal disorders in workers of different jobs in Iran have shown that these disorders have a high prevalence [10,11]. The main causes of musculoskeletal disorders injuries are repetitive movements, work stress, poor body condition or static body posture as well as continuous bending and spinning [12,16]. Thus, by identification the effective risk factors and precise ergonomic risk assessment of these disorders as well as by using appropriate methods and instruments and training the principles of ergonomics to workers the workplace can be improved and the risk of developing MSDs can be reduced.

One of the methods commonly used for risk assessment of musculoskeletal injuries in upper limbs is RULA method [17]. This pen-paper based observational method was developed by Mcatamney and Corlett [18]. Due to the fact that porcelain industry workers work in sitting posture and use the upper limbs more in static state, RULA method was used for ergonomic risk assessment as this method is used for assessing upper limbs in static state [1].

Although a lot of studies have been conducted on MSDs and the studied occupations had some similarities with decoration department in porcelain factory in terms of working posture and the kind of work, no study has been conducted specifically on decoration job in porcelain industry. Therefore, this study was conducted to determine the prevalence of MSDs, to assess the risk of developing MSDs

using RULA method and to determine the relationship between the prevalence of MSDs and the risk level obtained by using RULA method among porcelain factory workers.

### **Method**

This cross sectional study conducted in a porcelain factory in 2011. The study population was working women of a porcelain factory in Khorasan Razavi Province. Due to the low number of working women in the study population (100 women), census sampling method was.

Data collection was performed by demographic characteristics questionnaire and Nordic questionnaire to determine the prevalence of musculoskeletal disorders in the individuals under study [19] and RULA method was used to assess workstations ergonomic condition. Nordic questionnaire is used to determine the prevalence of musculoskeletal disorders. It contains general and specific questions completed by the questioner or as self-report [17,19]. Validity and reliability of the questionnaire have been determined in various studies [6,10,11]. Fifteen minutes had passed since each sample began her work when observations were recorded and based on the RULA guidelines, the worst or the most frequent posture of the individuals were investigated [1]. After selecting body posture, the posture of forearm, arm and wrist were assessed by using RULA method diagram and then position of neck, body and legs were investigated and were scored. The combined effect of each group of limbs was calculated and then after applying the score related to muscle activity and repeated movement, the final score was determined using the relevant table for each position.

Data were analyzed in SPSS 16 software and P-value <0.05 was considered significant. The two groups with and without musculoskeletal disorders were compared for quantitative variables of age, work history, and body mass index (BMI) by using t-test, and they were compared for qualitative variables of the risk level of developing MSDs assessment by using RULA method with chi-square test.

## Results

Demographic characteristics of all workers under study and also based on the prevalence of musculoskeletal disorders are presented in Table 1. The mean age and work history of the participants were  $28.6 \pm 14.09$  and  $2.53 \pm 1.63$  years, respectively, and the mean BMI was  $22.52 \pm 4.7$  kg/m<sup>2</sup>. Reviewing the demographic

characteristics of workers under study in both groups with and without MSDs showed that the mean difference of age, work history and body mass index (BMI) were not significant between two groups ( $P > 0.05$ ). It should be noted that 12-month prevalence rates of MSDs in the industry under study was obtained 81.0%.

**Table 1** Demographic characteristics of population under study based on the prevalence of MSDs ( $n=100$ )

Demographic characteristics	Mean $\pm$ SD	Musculoskeletal disorders		P-value
		Yes ( $n=81$ )	No ( $n=19$ )	
Age (year)	$28.6 \pm 14.9$	$27.4 \pm 5.01$	$26.6 \pm 3.4$	0.074*
Work history (year)	$2.53 \pm 1.63$	$2.63 \pm 1.7$	$2.1 \pm 1.08$	0.16*
BMI (kg/m <sup>2</sup> )	$22.52 \pm 4.7$	$20.3 \pm 5.4$	$23.01 \pm 4.3$	0.61*

\*t test

Findings related to the prevalence of MSDs in each limb in the past 12 months are presented in Table 2. The results showed that the highest prevalence related to low back (77.0%) and then wrist and hand (65.0%), knee (60.0%), shoulder (49.0%), neck (45.0%), thigh (17.5%), leg (30.0%) and elbow (9.0%), respectively.

**Table 2** The prevalence of MSDs in different body parts of study population in the past 12 months ( $n=100$ )

Limb	N (%)
Neck	45 (45%)
shoulder	49 (49%)
elbow	9 (9%)
wrist and hand	65 (65%)
Low back	77 (77%)
knee	60 (60%)
leg	30 (30%)

The risk of developing MSDs by using RULA is presented in Table 3 in the study population.

**Table 3** Frequency distribution of participants' RULA score ( $n=100$ )

risk level	Frequency (%)
2	38 (38%)
3	62 (62%)

This finding shows that the participants are categorized in two risk levels 2 and 3. The findings of this study indicated that the final score in 2% of them was 3 and in 36% was 4 so they are placed in the risk level 2. The RULA final score in 39% of them was 5 and in 23%

was 6 so they are placed in the risk level 3. The relationship between the risk level of developing MSDs using RULA and its prevalence is shown in Table 4. According to the findings, although the risk of these disorders is more in people who are in group with risk level 3, this finding was not significant statistically ( $P > 0.05$ ).

**Table 4** The relationship between musculoskeletal level risk by using RULA method and the prevalence of MSDs in the study population ( $n=100$ )

RULA risk level	musculoskeletal disorders		P-value
	Yes ( $n=81$ )	No ( $n=19$ )	
2	28 (73.7%)	10 (26.3%)	0.190*
3	53 *(85.5%)	9 (14.5%)	

\*chi-square test

## Discussion

Musculoskeletal disorders are the most common occupational injuries [1,2]. Due to the nature of porcelain industry and its jobs, the people who work in this industry are exposed to the risk of developing MSDs, which has not been studied so far. Although the findings of this study suggest that the study population is young (the mean age  $28.6 \pm 14.09$  years) and the work history is very low ( $2.53 \pm 1.63$  years), the prevalence of MSDs was reported high as compared to that in the country's general population [14,16]. For example, the prevalence of disorders in neck and low back in the country's general population is 4.72%

and 15.27%, respectively, but this prevalence for the study population was obtained 45% and 77%, respectively (Table 2).

Reviewing the mean difference of demographic variables such as age and work history in two groups with and without MSDs showed that although the mean of these two variables is higher in people with MSDs than people without, this difference is not statistically significant. This finding indicates a good correlation with the results of a study conducted by Miri *et al.* [7], but it is inconsistent with the study of Choobineh [16]. Choobineh *et al.* showed that there is a statistically significant relationship between age, work history and the prevalence of disorders [16]. Investigating the prevalence of MSDs in different limbs showed that the prevalence of these disorders in the upper body such as neck, shoulder and hand is high, which can be due to job nature and using inappropriate posture, using excessive force and excessive use of the upper limb [16].

Reviewing the risk level of developing MSDs using RULA showed that people are at two risk levels 2 and 3. That is, 38% of people need more evaluation and require changes as well as ergonomic intervention. In addition, 62% of people are placed at risk level 3, which means they will require ergonomic interventions in working posture and their workstation status in near future [17]. The important point in findings related to final score and also the risk level obtained in this study is that because of low mean age and work history of study population, none of them were placed at the dangerous risk level 4 and also due to workstation's poor ergonomic conditions that according to researchers' observation included bad posture, using excessive force, and also exposure to static state for a long time, none of them were placed also at the acceptable risk level 1.

Evaluating the relationship between the risk level of developing MSDs obtained by using RULA method and the prevalence rate of MSDs showed that despite the high risk level and the risk of developing these disorders in group with MSDs compared to the group without, these two variables had no statistically significant difference.

Nonetheless, according to the findings of this study some appropriate decisions can be made on the ergonomic condition of this working environment. To achieve better and more comprehensive results, a study with a greater sample size that considers all individual aspects (for example, age, work history, daily and weekly working hours, marital status etc) and organizational aspects (including the kind of job and work system) governing this industry can achieve more certain results.

According to findings of the current study and observation of working conditions of the study population, it is proposed that required ergonomic solutions such as improved work methods, workstation, postures and inappropriate and undesirable physical positions as well as other ergonomic risk factors and management measures such as rest pause and work – rest recovery cycle will be performed to remove or reduce these disorders as much as possible.

### **Conclusion**

Investigating the prevalence of MSDs in workers employed in the industry under study showed that despite low age and work history of the study population, the prevalence rate of these disorders is high. Risk assessment of developing MSDs showed that people are exposed to a high risk.

Generally, the self-report questionnaire used in this study has weaknesses including difficulty in reminding, denying or malingering health complications, hence, this issue should be carefully considered. In addition, user is responsible for applying RULA method in decision making and the scoring system is hypothetical in this method. This study tried to consider the effective variables in the prevalence and incidence of musculoskeletal disorders such as demographic characteristics and to include them in regression analyses, but by conducting a wider study with larger sample volume, perhaps stronger and more certain results will be achieved.

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### Contributions

Study design: AG, MS

Data collection and analysis: AG, MS, AS, RA

Manuscript preparation: AS, RA, AG

### Conflict of interest

"The authors declare that they have no competing interests."

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