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Evaluation and Correlation of the Rapid Upper Limb Assessment and Rapid Office Strain Assessment Methods for Predicting the Risk of Musculoskeletal Disorders

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ABSTRACT

Background: During the last two decades, computer use has rapidly increased. In 2000, 80% of workers stated that they use computers in their daily activities. Computer use is associated with several health risks: for example, for computer users, the incidence of musculoskeletal disorders is between 10% and 60%. In this study, we investigated the risk of musculoskeletal disorders by the Rapid Upper Limb Assessment (RULA) and the Rapid Office Strain Assessment (ROSA) methods. We surveyed the correlation of these methods and evaluated their predictive ability in the incidence of musculoskeletal disorders among office workers. **Methods:** This analytic-descriptive study was performed in 2016 at Behbahan University of Medical Sciences and the Imam Khomeini Port Office. The sample consisted of 236 office workers who were selected by the simple random sampling method. Body map questionnaires as well as RULA and ROSA checklists were used for data collection. Inclusion criteria were at least 1 year of experience working and computer use for at least 3 hours a day; exclusion criteria were having a musculoskeletal disorder unrelated to the job, having an existing job-related musculoskeletal disorder, and any other underlying disorder. Data were analyzed with SPSS software, version 22; statistical analysis was performed with the one-way analysis of variance (ANOVA) test, Pearson's correlation coefficient, and the chi-squared test. **Results:** We found that most musculoskeletal disorders were related to the trunk, neck, and back regions by 40.4%, 39.7%, and 35.4%, respectively. Mostly, distribution of risk score in ROSA method is at warning level (67.2%) and in the RULA method at high and very high levels (62%). The Pearson test showed a positive significant correlation between these methods ($P<0.05$). The chi-squared test showed a significant correlation between musculoskeletal disorders in the upper and lower limbs with the RULA method ($P<0.05$), but no significant relationship was observed with the ROSA method ($P>0.05$). The one-way ANOVA test showed a significant relationship between the risk of musculoskeletal disorders and sex ($P<0.05$); it did not, however, show a significant relationship with job experience and education ($P>0.05$). **Conclusion:** To predict the risk of musculoskeletal disorders, the RULA method is superior to the ROSA method.

BACKGROUND

During the last two decades, computer use has rapidly increased. In 2000, 80% of workers stated that they use computers in their daily activities. Computer use is associated with several health risks: for example, for computer users, the incidence of musculoskeletal disorders is between 10% and 60% (1). In developing countries, musculoskeletal disorders are a serious concern. They cause of a third of occupational injuries, which can lead to decreased worker quality and efficiency and result in substantial social and economic burdens (2). Workers with musculoskeletal disorders incur considerable medical costs (3); in fact, among Canadian workers, these disorders are the most common cause of absenteeism (4). The best way to prevent musculoskeletal disorders is to evaluate and develop an intervention for decreasing exposure to related risk factors (5). Visual methods, because of their simplicity and low cost, are the most commonly used methods in risk assessment of musculoskeletal disorders (6). In terms of ergonomics, posture assessment techniques can be highly effective. Thus, using these tech-

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niques to predict the incidence of musculoskeletal disorders would likely be effective at decreasing injuries.

In 2012, Lavatelli et al. evaluated the correlation between OCRA(occupational repetitive actions) and EAWS (ergonomics assessment worksheet) techniques in the German automobile industry. They found a good correlation (correlation coefficient=95%) between these methods (7). In another study, this one in 2010, Jones and Kumar investigated the output correlation of five different posture assessment methods—RULA, REBA, OCRA, HAL, and SI—in the Canadian woodcutting industry. Amount of agreement between methods at three classified risk levels and different working posture, was assessed at normal levels(8). In 2012, Chiasson et al. compared eight different methods—QEC(quick exposure check), REBA(rapid entire body assessment), RULA (Rapid Upper Limb Assessment), OCRA(occupational repetitive actions), JSI(job strain index), HAL(hand activity level), FIOH(finnish institute of occupational health), and EN 1005-3(European Standard)—and attempted to develop a standard method for determining risk factors related to musculoskeletal disorders. They found that, for the same job, different methods produced different analytical results. Moreover, they found that RULA and REBA, as well as JSI and HAL, were most closely correlated (2). In 2011, Shanahan et al. compared three methods— RULA, REBA, and SI—with psycho-physical scales and found that SI best predicted the risk of musculoskeletal disorders (9).

In this study, we investigated the risk of musculoskeletal disorders by the Rapid Upper Limb Assessment (RULA) and the Rapid Office Strain Assessment (ROSA) methods. We surveyed the correlation of these methods and evaluated their predictive ability in the incidence of musculoskeletal disorders among office workers.

METHODS

This analytic-descriptive study was performed in 2016 at Behbahan University of Medical Sciences and the Imam Khomeini Port Office. The sample comprised 236 participants (64% men and 36% women). The study had a confidence level of 95%, a test power of 0.80, and an absolute error of 25%. Participants were selected with the simple probability sampling method, but due to lack of cooperation, some were removed. Since one of the causes of occupational lower back pain is long periods of sitting, inclusion criteria were at least 1 year of experience working and computer use for at least 3 hours a day. Participants also had to have at least a diploma degree (to properly complete the checklist and questionnaire). Exclusion criteria were unwillingness to complete the questionnaire, having a musculoskeletal disorder unrelated to the job, having an existing job-related musculoskeletal disorder, and any other underlying disorder.

To assess working posture and postural stress imposed on workers, the ROSA and RULA methods were used; to obtain musculoskeletal disorders, the body map questionnaire was used. Body map is a self-reported questionnaire that uses a five-degree scale to measure pain in the limbs.

After informed consent was obtained, an ergonomic expert interviewed all participants at their workplace, familiarized themselves with the workplace itself, and gathered demographic data (age, sex, weight, stature, educational level, and job experience). Then, participants were asked to complete the Persian version of the body map musculoskeletal disorders questionnaire and rank their pain on a 1-5 scale. The printed Persian version of ROSA and RULA were completed based on the participant's body position at their computer workstation. Data were analyzed with SPSS software, version 22.

To determine correlation between RULA and ROSA, the Pearson correlation coefficient was used; to determine the association between the final scores of the RULA and ROSA methods and the results of musculoskeletal disorders, the chi-squared test was used. Finally, to determine the relationship between the final RULA and ROSA scores and job experience, sex, and education level, the one-way analysis of variance (ANOVA) test was used.

ROSA

The ROSA method was developed in 2011 by Sonne et al. (1). It was designed to quickly quantify the risks associated with computer work and to suggest how posture can be improved.

ROSA was established, based on CSA standard Z412 and EN-ISO 9241, 1997, and focusing on the activities of office workers, especially computer users. This is a quick pen-and-paper method that can determine the quantity of ergonomic risk factors and provide a report on how to redesign and optimize the workplace. It has high reliability and validity in evaluating ergonomic risk factors in office workplaces (1).

The ROSA method has three main sections. Once each section is completed and scores are determined in the 1) chair, 2) monitor and telephone, and 3) keyboard and mouse sections, the final ROSA score is calculated. The final score is between 0 and 10; scores between 3 and 5 are considered "Warning level," and scores above 5 are considered "Necessity of intervention measures level."

In our study, worker assessments were conducted by an observer, who began the ergonomic evaluation by meeting employees in the human resources departments of Behbahan University of Medical Sciences and the Imam Khomeini Port Office, to understand the different types of work performed. The analysis began with workplace observations and a brief interview with the workers, to understand the types of work performed. Pictures were taken of workers at their workplaces.

Later, the ROSA method was applied using the pen-and-paper checklist.

RULA

RULA was first developed in 1993 by McAtamney and Corel et al (10). This observational method is used to identify musculoskeletal disorder risk factors where tasks are performed in a sitting position and upper limb disorders are common. With this method, posture, force, and movement are considered. The final score is between 1 and 7, and the higher the score, the greater the risk level (11). The RULA method comprises three stages: 1) the recording of working posture; 2) the scoring system; and 3) the scale of action levels. This method analyzes two parts of the body: Part A consists of the upper and lower arm and wrist; Part B consists of the neck, trunk, and legs. RULA is based on the OWAS system. According to this methodology, posture score is calculated for each body part. Based on the total score, four action levels, indicating the level of intervention required to reduce the risk of injury, are suggested:

Action level 1: posture is acceptable;

Action level 2: further investigation is needed and changes may be needed;

Action level 3: investigation and changes are required soon; and

Action level 4: investigation and changes are required immediately (12).

In our study, after pictures were taken of different tasks, images were analyzed using ROSA and RULA software. After the final score was calculated, the risk level of each method was obtained and statistical analysis was performed using SPSS software, version 22.

RESULTS

The sample comprised 236 participants (64% men and 36% women) (Table 1). The risk assessment of the RULA method showed that the highest risk distribution was at the high and very high levels (62%); the lowest risk distribution was for the low level (3%) (Table 2). The risk assessment by the ROSA method showed that the highest risk distribution was related to warning level (67.2%); the lowest risk distribution was for the low level (0.4%) (Table 3). The highest and lowest rates of musculoskeletal disorders were found to be for the lower back (40.4%) and left leg (4.7%), respectively (Fig. 1).

Table 4 shows the relationship between musculoskeletal disorders in the upper and lower limbs and the raw scores of RULA and ROSA, demonstrating a positive significant relationship between musculoskeletal disorders in the upper and lower limbs with raw RULA score (unclassified) ($P<0.05$). However, no significant association was found between musculoskeletal disorders in the upper and lower limbs and the raw ROSA score (unclassified) ($P>0.05$).

Table 5 shows the relationship between demographic factors (job experience, education, and sex) and raw RULA and ROSA scores. A significant relationship was observed between raw RULA and ROSA scores and sex ($P<0.05$), but no significant relationship was found between raw RULA and ROSA scores and job experience or education level ($P>0.05$) (Table 4).

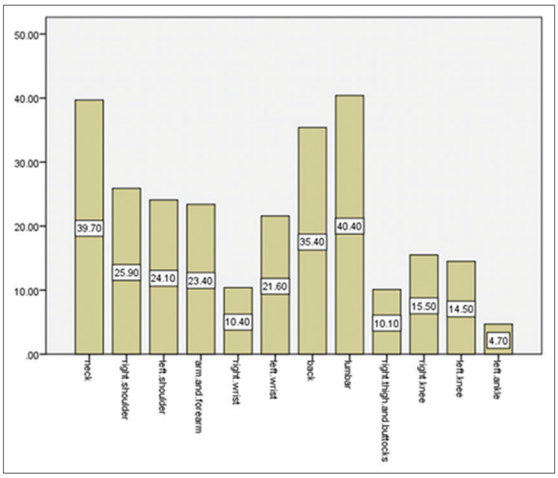

Figure 1: Prevalence of musculoskeletal disorders in body limbs

Table 1. Demographic characteristics of participants

Variable	Class	Frequency	Percent
Sex	Women	87	36
	Men	149	64
Education	Diploma	23	20.2
	Associate	21	18.4
	Licentiate	64	56.1
	Master	6	5.3
Job experience, years	1-10	108	52.9
	10-20	76	37.3
	20>	20	9.8

Table 2. Results of risk assessment by RULA (n=228)

Risk level	Risk rate	RULA final score	Frequency	Percent
1	Low	1-2	3	3
2	Medium	3-4	81	34.9
3	High	5-6	78	33.6
4	Very high	7	66	28.4

Table 3. Results of risk assessment by ROSA (n=232)

Risk level	Risk rate	ROSA final score	Frequency	Percent
1	low	<3	1	0.4
2	Warning region	3-5	156	67.2
3	Ergonomic intervention	>5	75	32.3

Table 4. Correlation between RULA and ROSA and their relation with musculoskeletal disorders in upper and lower limbs

	Upper limb disorders (Kendall)	Lower limb disorders (Kendall)	ROSA (Pearson)
RULA	P<0.05	P<0.05	P<0.05
	R=0.2	R=0. 2	R=0. 3
ROSA	P=0. 2	P=0.2	
	R=0.07	R=0.05	

Table 5: Relationship between RULA and ROSA with demographic factors (one-way ANOVA)

Demographic variable	Risk level	Score<3	3-5	>5		Mean	Standard deviation	P-value
Sex								
ROSA	Women	-	61.3	38.7		2.3	0.49	P<0. 05
	Men	0.7	73	26.3		2.2	0.45	
RULA	Risk level	1-2	3-4	5-6	7			
	Women	-	21.8	39.7	38.5	3.1	0.76	P<0.05
	Men	4.9	44.8	28.7	21.7	2.6	0.87	
	Risk level	Score<3	3-5	>5				
Education level								
ROSA	Diploma	-	60.9	39.1		2.3	0.49	P=0.1
	Associate	-	76.2	23.8		2.2	0.43	
	Licentiate	1.6	81.3	17.2		2.1	0.44	
	Master	-	83.3	16.7		2.1	0.42	
	Risk level	2-1	4-3	6-5	7			
RULA	Diploma	-	69.6	6.4	-	2.3	0.47	P=0.1
	Associate	4.8	57.1	38.1	-	2.3	0.57	
	Licentiate	9.4	73.4	17.2	-	2	0.51	
	Master	-	83.3	16.7	-	2.1	0.41	
	Risk level	Score<3	3-5	>5				
Job experience								
ROSA	<10 years	0.9	70.4	28.7		2.2	0.47	P=0.6
	10-20	-	71.1	28.9		2.2	0.45	
	20>	-	78.9	21.1		2.2	0.41	
	Risk level	2-1	4-3	6-5	7			
RULA	<10 years	5.6	42.1	31.8	20.6	2.6	0.86	P=0.2
	10-20	1.3	42.1	34.2	22.4	2.7	0.8	
	20>		20	30	5.	3.3	0.8	

DISCUSSION

The risk assessment output of the methods used in this study showed that, for the ROSA method, the lowest risk distribution was at the low-risk level (0.4%); the highest risk distribution was at the warning level (67.2%). For the RULA method, the highest and lowest risk distributions were in the high and very high levels (62%) (levels 4 and 5) and the low-risk level (3%), respectively, indicating that RULA is stricter than ROSA and items of this method are more weighty. The results of our study agree with those of Qutubuddin et al., which risk scores in the high and low level, respectively, 55/4 and 18/18 (13). Chiasson et al. found that 70% of evaluated workplaces were at the high-risk level (2).

In our analysis of the results obtained from both ROSA and RULA, a significant relationship was observed between the final scores of these methods. Because of computer users who performed their tasks using mostly the upper limbs in doing static tasks and mostly, back, neck and shoulders are involved, Furthermore, these two methods focuses on static jobs and upper extremity deviations from a favorable position, so achieving these result was rational. Like other studies, our study indicated a positive direct and significant relationship between these methods. In addition, in terms of the correlation between RULA and the other posture assessment methods examined by Jones and Kumar, Chiasson et al., and Shanahan et al., their results are in agreement with ours (2, 8, 9). But because of the weak correlation between RULA and ROSA (R=0.3), one method cannot be used as an alternative to the other.

Statistical tests showed a significant relationship between RULA results and the prevalence of musculoskeletal disorders in the upper and lower limbs. In this regard, Dalkilinic et al. evaluated the status of musculoskeletal disorders by RULA and showed that with an increase in RULA score, the prevalence of musculoskeletal disorders increases (14). In addition, Oyewole et al. showed that with improved workstations and worker posture, musculoskeletal disorders significantly decreased (15). According to these findings, RULA is the best method to assess the risk factors of office activities and identify risk factors related to musculoskeletal disorders. It can also be used to identify design deficiencies in a workstation.

In our study, we did not find a significant relationship between ROSA risk level and musculoskeletal disorders, suggesting that this method does not have sufficient ability to predict musculoskeletal disorders. There is a disagreement between the results of this portion of the study and another study in this field (16, 17), which can be due to evaluator skill differences, differences in measuring devices (determination angles and distances), and differences in the assessment procedure of pen-and-paper-based observational methods (observational or videotaping).

Our findings confirmed the effect of sex on the final RULA score and musculoskeletal disorders. This is owing to the smaller body size and muscles of women compared to men and to the fact that women are exposed to more risk factors in the workplace than men (18). Also, most workplaces have been designed for the anthropometric dimensions of men. Furthermore, women have a different physical and physiological status, and studies have confirmed sex as a risk factor for musculoskeletal disorders. In short, women are more likely than men to develop symptoms of musculoskeletal disorders (18, 19).

We found no significant relationship between job experience and the risk of musculoskeletal disorders. Although some studies have shown that personnel with more job experience have a higher risk of musculoskeletal disorders, our study is in agreement with Oha et al.'s study of 202 office workers in Estonia and Marshal et al.'s study of dentists, both of which concluded that age and job experience were not effective predictive factors for musculoskeletal disorders (20, 21).

Studies that surveyed the prevalence of musculoskeletal disorders among office workers showed that the highest rates were related to the neck, back, and trunk. In a study of 750 office workers, a high rate of musculoskeletal disorders was observed, and the highest rates were in the neck, trunk, and shoulder (22). Similarly, Kristensen et al. reported that the most common areas of discomfort were in the neck, trunk, and shoulder regions, which was in agreement with other studies of office workers (23). This trend is possibly caused by the improper design of workstations. Office work often requires that workers assume a static position in chairs for long periods of time; according to a study by Aazari et al., this is the primary risk factor for neck pain (24).

The combination of sitting for long periods of time and awkward posture in the workstation can lead to long-term static contraction of the muscles, which can cause increased pressure on intervertebral discs, stress on ligaments and muscles, decreased tissue flexibility, and alteration of the curvature of the vertebral column. This can lead to increased risk of musculoskeletal discomfort in the vertebral column (18). Limitations of these studies include the lack of a videotaping assessment method and counterfeit ergonomic behavior during the course of participant assessment. To obtain more accurate results, we recommend using a combination of methods (i.e., pen-and-paper observational methods as well as videotaping observational methods). These assessments should be repeated several times throughout the work day.

CONCLUSION

We found that, considering the high prevalence of musculoskeletal disorders among office workers, most workers do not have proper workplaces in terms of ergonomics and that reforms to workplaces are essential. Since no significant correlation was observed between the RULA and ROSA methods, one cannot be used as an alternative to the other. RULA is an accurate predictor of risk factors related to musculoskeletal disorders. Conversely, based on our findings, ROSA is not an accurate predictor of risk factors related to musculoskeletal disorders.

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AUTHOR CONTRIBUTIONS

Study concept, study design, manuscript editing, and manuscript review: Amirhossein Davudian; statistical analysis: Gholamreza Azari; manuscript preparation and literature search: Gholamreza Badfar.

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