The correlation between ART and OCRA methods used for posture assessment of repetitive tasks

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Abstract

*Background and Objective: Repetitive tasks are among the causes of musculoskeletal disorders. Assessment of repetitive tasks is performed through various methods with different scores and significance given to risk factors considered in these methods. Knowing the strengths and weaknesses of each method can contribute to modifying the methods and improving the correlation between them. This study aimed to investigate the correlation between ART and OCRA methods in a career with repetitive movements. **Methods:** After hierarchical task analysis in a vegetable grower job with repetitive movements, the subtasks were assessed by an assessor who mastered both ART and OCRA methods. The final score of each method was checked using the Pearson correlation coefficient in SPSS 18, after testing the normality of data. **Results:** Moderate risk levels were reported for 16 out of the 14 sub-tasks analyzed using both methods. In the ART method, 3 sub-tasks and in the OCRA method, 2 sub-tasks had high-risk levels. The Pearson correlation coefficient was 0.842 indicating a moderate correlation between the two posture assessment methods. **Conclusion:** The findings of the study showed an acceptable correlation and compatibility between the two methods considering the risk levels.*

Introduction

Work-related musculoskeletal disorders caused by occupational risk factors can result in pain or impairment of function in the nerves, tendons, muscles, arteries, and joints, and can be a reason for work disability and lost workdays (1, 2). These disorders result from unfavorable physical postures, excessive physical load and force, prolonged static postures, repetitive tasks and working fast, lack of adequate break, vibration in the workplace, personal and psychological factors, etc. (3).

The occurrence of work-related musculoskeletal disorders is common in agriculture from which many farmers suffer due to various risk factors such as bending, kneeling, crawling, turning to the sides and performing repetitive tasks so that 60% of farmers may have inappropriate working postures and 50% may carry heavy loads and perform repetitive tasks (4, 5). The results of studies have shown that farmers are exposed to whole-body vibration, inappropriate working postures, heavy loads, and repetitive tasks, which in turn cause pain and discomfort and occurrence of disorders and diseases

(6). Despite agricultural mechanization and using appropriate methods in some agricultural activities, manual vegetable cultivation with inappropriate postures and excessive bending and twisting, as well as harvesting and trimming in kneeling and squatting postures are among the causes of musculoskeletal disorders (7, 8). Therefore, the prevention of these problems and disorders requires the use of ergonomic evaluation methods as well as modification of work environments.

Using pen and paper-based methods for assessment of working postures allows achieving the desired results quickly without the use of expensive and complex equipment. ART and OCRA tools are among the paper-based methods used for the assessment of repetitive tasks of the upper limbs (9). Repetitive tasks include upper limb activities that are repeated over and over again in a short period of time and are almost identical (10).

ART method was introduced in 2009 by The Health and Safety Executive (HSE) for risk assessment of repetitive tasks leading to musculoskeletal disorders, taking into account the influential factors such as repetition of the movements, force, working posture, vibration, speed of work, duration of work, psychological factors, etc. (11, 12). Due to the efficiency and effectiveness of this method, several studies have been conducted. For instance, Rahman et al. (2017) *assessed task* repetitiveness among the workers in mold manufacturing industries. The study conducted by Zuhaidi et al. (2017) among food sellers, and the study conducted by Khandan et al. (2017), assessed exposure to risk factors of work-related musculoskeletal disorders in a manufacturing company (13-15). The OCRA method is also one of the useful methods used to analyze workers' exposure to the risk factors of upper limb musculoskeletal disorders resulting from repetitive tasks through calculating the OCRA index or determining the risk limit values using the OCRA checklist by taking into account frequency, force, posture, additional factors, duration of each repetitive task and lack of recovery time (16-18). Various studies have been conducted using this method as a standard method for assessment of the risk of upper limb musculoskeletal disorders, including the study carried out by Tosin (2019) for ergonomic design

and analysis of a car manufacturing workplace; e.g. studies conducted by Diogo Cunha dos Reis et al. (2015), Colombini et al. (2018) Dias et al. (2019) on slaughterhouse workers, and Taborri et al. (2020) (19-23). Several studies have been conducted on the relationship between the methods for assessment of musculoskeletal disorders. These include: the study carried out by Lavatelli et al. (2012) aiming at determining the relationship between OCRA and EAWS methods in the car manufacturing industry; the study conducted by Paulsen et al. (2015) aiming at determining the reliability of OCRA and Strain Index methods, risk assessment of upper Limb musculoskeletal disorders using 6 ergonomic assessment methods conducted by Sala et al. (2010); and the study conducted by Motamedzade et al. (2019) who compared four risk assessment methods (HAL-TLV, Strain Index, OCRA Checklist, and ART) (24-27). Since OCRA and ART methods are used to evaluate the risk factors associated with upper limb musculoskeletal disorders, it is important to examine the compatibility of these two methods. Hence, this study aims to investigate the correlation between ART and OCRA methods used for assessment of posture and repetitive tasks and determining their strengths and weaknesses, which can contribute to the promotion and development of similar methods.

Methods

This cross-sectional study was performed on the vegetable grower job in which all stages of the work from planting to harvesting and loading were filmed and then the task was broken down into its constituent subtasks using the hierarchical task analysis (HTA). Next, posture assessment was performed for 7 main tasks, and 14 subtasks obtained through the hierarchical task analysis, and the risk level for each subtask was determined based on the range of scores in each method. The time of activities in this job is from mid-spring to mid-autumn, with land preparation, sowing, fertilizing occurring in the middle of spring and weeding, harvest, storage and preparation from summer to mid-autumn.

The results of the assessment performed using the ART method were classified into three levels, including low-risk level (0-11), moderate risk level (12-21), and high-risk level (>22).

Also, there were 5 scoring and risk levels in the OCRA checklist: < 7.5: acceptable risk, 7.6 to 11: very low risk, 11.1-14: medium-low risk, 14.1 to 22.5: medium risk and 22.5: high risk.

In the ART method, 12 risk factors were investigated in four groups including frequency and number of movements, force, inappropriate postures (neck, back, shoulder/arm, wrist, and hand) and additional factors (including duration of work, recovery, speed of work and workplace factors). In the OCRA checklist, 5 main risk factors including breaks, repetition, force, posture, and additional factors were investigated.

The normality of the data was examined through skewness and excess kurtosis and histogram with skewness and excess kurtosis of -1.96 to +1.96 indicating a normal distribution of data. Thus, due to the normality of the data in the present study, the Pearson correlation coefficient was used to determine the correlation between the results of posture assessment for 22 sub-tasks using ART and OCRA methods (28).

Results

This study aimed to investigate the correlation between ART and OCRA methods. A total of 14 sub-tasks of the vegetable grower job were analyzed using ART and OCRA methods

Moderate risk levels were obtained for most of the 14 sub-tasks assessed by the two methods. However, in the ART method, 3 sub-tasks, and in the OCRA method, 2 sub-tasks had high-risk lev-

els. Comprehensive information about the right and left sides of the body assessed using the two methods are shown in Table 1.

Task analysis using the ART method showed that leveling vegetable beds, weeding, and harvesting vegetables with a scythe had the highest risk levels and the highest scores, while sowing had the lowest score and risk level. The scoring used in this method based on the risk factors for the right and left sides of the body is shown in Supplementary material 1.

Task analysis using the OCRA method showed that leveling vegetable beds, carrying the wheelbarrows to the farm and weeding had the highest risk levels of musculoskeletal disorders. (Supplementary material 2)

In task analysis using ART and OCRA methods, in addition to the main factors (force, posture, repetition of movements and breaks or recovery), other additional factors could have directly and indirectly affected the final score, risk level determination, and corrective actions prioritization. It should be noted that some of these cases are common in the two methods; however, their scoring levels may be different as shown below (Table 2).

In both methods, land preparation with the sub-task of leveling vegetable beds had the highest score and the highest risk level, while sowing and tying harvested vegetables into bunches had the lowest scores in the ART and OCRA methods, respectively. Different risk levels were obtained in ART and OCRA methods for 4 of the sub-tasks while the same risk levels were obtained for 10 sub-tasks.

The results of the Pearson correlation test showed a positive and statistically significant (p = 0.001) correlation (r = 0.842) between the assessment results of ART and OCRA methods.

Table1. Risk of musculoskeletal disorders related to the tasks assessed using ART and OCRA methods

Risk level	The right side		The left side		Whole body	
	OCRA	ART	OCRA	ART	OCRA	ART
High frequency (percentage)	2 (14.29%)	3 (21.42%)	1 (7.14 %)	3 (21.4 2%)	2 (14. 29 %)	3 (21.43 %)
Moderate frequency (percentage)	10 (71.44 %)	7 (50 %)	10 (71.44%)	6 (42.85%)	10 (71.44 %)	7 (50%)
Low frequency (percentage)	2 (14.29%)	4 (28.58%)	3 (21.42%)	5 (35.71%)	2 (14.29 %)	4 (28.57 %)

Table 2. Risk factors of upper limb musculoskeletal disorders collected with their relative score in the ART and OCRA methods

Risk factors under investigation	ART	score	OCRA	score
Movement frequency and repetition	Arm movements Repetition (hand and arm movements, not fingers)	0 - 6	Arm activity and frequency of work periods on which the cycles are based	0 – 10* 2.5 – 4.5**
Breaks	Stopping hand and arm movements	0 - 8	work interruptions (working hours or visual checks)	0 - 10
Vibration	Hand/arm exposed to vibration	1	Vibrating tools	-
Force	Low (no special effort)	0	Medium force (3-4 Borg)	2 – 8
	Medium (force is required)	1 - 8	Strong force (5-6-7 Borg)	4 – 24
	Strong (high force)	8 – 12	maximum force (8 Borg or higher)	
	Very strong (maximum force level)	Change required		6 - 32
Posture	Head / neck (normal, bending or rotating the back during a part of the time, bending or rotating the back >50% of the time)	0 - 2	The Arm would reach *shoulder height* 50% of the time or more	1 – 24
	Back	0 - 2	Elbow (extension or sudden movements for a certain period of time)	2 - 8
	Arm (close to the body, away from the body during a part of the time, away from body for >50% of the time)	0 - 4	Wrist (maximum curvature or inappropriate posture for a certain period of time)	2 - 8
	Wrist (normal, bending or deflection during a part of the time, bending or deflection for >50% of the time)	0 - 2	Hands (grasping objects with the fingertips with contracted fingers, open hand, or hooked fingers)	2 - 8
	Hand / finger (strong grip, pinch and wide finger during a part of the time, pinch and wide finger >50% of the time)	0 - 2		
Movement uniformity or Lack of movement diversity	*Not collected*	-	*Performing* the *same movements* for 51-80% of the total time of manual handling	1.5
			Performing the *same movements* for 81-100% of the total manual handling	3
Cold	The operator is exposed to the cold or holds a cold tool in his hands	1	low *temperature*	2
Lighting	Insufficient light	1	*Not collected*	-
Lack of training	Lack of sufficient training to do the job successfully	-	*Not collected*	-
Using hands as a tool	The hands are used as a tool (e.g., as a hammer)	1	Frequent effect of hands on the task (hand used as a tool)	2
Impact of gloves	Eeffect of gloves on grip strength and manual handlings	1	Improper gloves interfere with manual handling *capability*	2

*Dynamic activities; **Static activities

Discussion

This study aimed to determine the correlation between ART and OCRA methods used for the assessment of posture and repetitive tasks in vegetable grower job and the results showed medium risk levels for most tasks which were consistent the findings of Diogo Cunha dos Reis et al. (2017) who used the OCRA checklist in their study to assess the risk factors for the upper limb musculoskeletal disorders in poultry slaughterhouses and reported medium risk levels for most cases (29). Also, Torkaman et al. (2015) who assessed the risk of musculoskeletal disorders using repetitive task analysis and ergonomic intervention programs in a manufacturing company reported medium risk levels for most cases (30).

Based on statistical analysis, a good correlation was observed between the risk levels obtained in the two methods, which can be attributed to the similar risk factors in both methods of assessment including force, repetition, and posture. In both methods, medium risk levels were reported for most cases indicating that the prevention of disorders and diseases requires further studies and control measures soon. The results of previous studies performed on different occupations are consistent with our finding; for instance, the study conducted by Kjellberg et al. (2015) which compared the results of 6 assessment methods used for evaluating repetitive tasks in various occupations and tasks such as meat cutting and meatpacking career, assembly, hairdressing, cleaning tasks and working in supermarkets. Also, Motamedzade et al. (2019) in a study entitled "Comparison of 4 methods of risk assessment of repetitive tasks in car assembly, poultry slaughterhouse, and container manufacturing industries" showed a high correlation between ART and OCRA methods (27, 31).

However, the finding of Haj Salehi's study (2018) was inconsistent with the findings of the present study and showed a difference between the results of ART and OCRA methods used for risk assessment of upper limb disorders and the results were not compatible with each other. Also, Chiasson et al. (2012) who compared the results of 8 methods of risk assessment of musculoskeletal disorders reported a high correlation between OCRA and other methods, including QEC (32).

ART addresses the effects of all risk factors and provides a final score for a task, and offers a separate assessment for each risk factor (12). Leveling vegetable beds, weeding, and harvesting with a scythe were identified as high-risk tasks in the ART assessment method while leveling vegetable beds, carrying the wheelbarrows to the farm, weeding, and carrying the bags to the vegetable transport vehicle were identified as high-risk tasks in OCRA method. The difference may be due to the type of scores assigned to the risk factors in the two methods or the way these risk factors were determined so that the way of defining the basic parameters in the methods may have affected risk assessment (33). In the ART method, the coefficient of duration multiplied by the task score might have a significant effect on the final score of exposure which was indicated by the difference between the scores of carrying the bags to the vegetable transport vehicle. Moreover, in the OCRA method, static technical actions were also considered whose scores were considered in the repetition of movements, while this was not mentioned in the ART method.

In both ART and OCRA methods, the final score was the total of the risk scores for breaks, repetition, force, posture, and additional factors; however, in the ART method, head/neck, and back postures were also assessed. Also, in the ART method, repetition of the hand movement was scored in addition to the repetition of the arm movement (34). Moreover, different scores were assigned to postures in the two methods. This is more noticeable for the arms so that a score from 1 to 24 was assigned to arm postures in the OCRA method with 5 levels, while a score from 0 to 4 assigned to arm postures in the ART method with three levels.

Also, it can be pointed out that in the OCRA method, the final score of a posture was multiplied by the score of movement uniformity of the task while in the ART method, the task score was multiplied by the duration score to get the final score of exposure. These can be the reasons for the difference between the final scores in the two methods. Also, in the OCRA method, more time was required for risk assessment compared with the ART method. The results of previous studies have also shown that the OCRA method is more complex and more time

is required for assessment of postures and risk factors (35, 36).

Also, according to the study results, a higher risk score was obtained for the right hand as compared with the left hand, since vegetable cultivation is performed by the dominant hand. Our results are consistent with the findings of Shokri et al. (2015) who assessed repetitive tasks and manual handling of loads using ART and MAC methods. Our results are also consistent with the results of the study conducted by Jafari Roodbandi et al. (2014) on the prevalence of musculoskeletal disorders and assessment of body posture in mosaicists in Kerman using ART method in which the right-handed people obtained higher scores than left-handed people (11, 37).

LIMITATIONS OF THE STUDY AND SUGGESTIONS FOR FUTURE STUDIES

A lack of similar studies on this career and analysis of different occupations are limitations of the study and future studies can compare the assessments performed using the two methods to find out if the results of the assessment performed using each method can be influenced by the type of tasks and judgment of evaluators.

CONCLUSION

Based on the results of this study, it can be concluded that despite the differences between ART and OCRA methods due to the different variables used, calculation and scoring methods and their effect on the final risk score, the compatibility of ART and OCRA methods in the assessment of repetitive upper limb tasks and postures was acceptable (0.842) with moderate risk levels for most cases.

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Supplementary material

S1. Results of vegetable grower job analysis using ART method

Task *(percentage of time spent on the task)	subtask	Arm movements	repetition	force	Head/neck	Low back	Arms	waist	Hands / fingers	breaks	Speed of working	Other factors	duration	total	Risk level
1- Land preparation (40%)	1-1. leveling vegetable beds	3	6	4	2	1	0	1	2	0	1	2	1	22	High
		3	6	4	2	1	0	1	2	0	1	2	1	22	
	1-2. breaking-up large clods of soil using a shovel	3	3	4	2	2	2	1	0	0	1	2	1	20	Moderate
		3	3	4	2	2	2	1	0	0	1	2	1	20	
2- Sowing (15%)	2-3- Sowing	3	3	0	2	0	0	2	0	0	1	1	0.75	9	Low
		0	0	0	2	0	0	1	0	0	1	1		3.75	
3- Fertilizing (50%)	3-1. filling wheelbarrows with manure using a shovel	3	3	8	1	1	0	1	0	0	1	1	1	19	Moderate
		3	3	8	1	1	0	1	0	0	1	1	1	19	
	3-2. emptying wheelbarrows	0	0	8	1	0	2	1	0	0	1	1	1	14	Moderate
		0	0	8	1	0	2	1	0	0	1	1	1	14	
	3-3. Spreading manure and soil on the seeds	3	3	8	2	2	0	1	0	0	1	1	1	21	Moderate
		3	3	8	2	2	0	1	0	0	1	1	1	21	
4- Weeding (20%)	4-1. Weeding	3	6	8	2	2	0	2	2	0	1	2	1	28	high
		3	3	8	2	2	0	1	2	0	1	2	1	24	
5- Harvest (40%)	5-1 .Harvesting vegetables with a scythe	3	6	8	2	2	0	1	1	0	1	2	1	26	High
		3	6	8	2	2	0	1	1	0	1	2	1	26	
	5-2. Tying harvested vegetables into bunches	0	3	2	1	0	0	2	1	0	1	1	0.5	5.5	Low
		0	3	2	1	0	0	2	1	0	1	1		5.5	
	5-3 .Putting vegetable bunches in bags	3	3	4	2	2	0	1	0	0	1	1	0.75	12.75	Moderate
		0	0	4	2	2	0	1	0	0	1	1		8.25	Low
6- Storage and preparation for sale (30%)	6-1. Emptying vegetable bags	0	0	8	1	1	0	1	1	0	0	1	0.75	12.75	Low
		0	0	8	1	1	0	1	1	0	0	1		8.25	
	6-2. Washing vegetables (radishes and spring onions)	3	0	8	2	2	0	1	0	0	1	1	0.5	9	Low
		3	0	8	2	2	0	1	0	0	1	1		9	
	6-4. Packaging vegetables	3	3	8	2	2	0	1	1	0	1	1	0.75	16.5	Moderate
		3	3	8	2	2	0	1	1	0	1	1		16.5	
7- Loading (10%)	7-1. Putting packages in wheelbarrows	3	0	12	1	1	2	1	0	0	1	1	0.75	16.5	Moderate
		3	0	12	1	1	2	1	0	0	1	1		16.5	

* Percentages are a amount of time that takes to complete a task in during a shift.

S2. Results of vegetable grower job analysis using OCRA checklist

Task * (percentage of time spent on the task)	subtask	Breaks	Repetition	force	Arm	Elbow	Wrist	Hand	uniformity	**Posture	Additional factors	The sum score	Risk level
1- Land preparation (40%)	1-1. leveling vegetable beds	0	1	8	12	–	–	–	3	15	2	26	High
		0	1	8	12				3	15	2	26	High
	1-2. breaking-up large clods of soil using a shovel	0	1	6	–	8	–	–	3	11	2	20	Moderate
		0	1	6		8			3	11	2	20	Moderate
2- Sowing (15%)	2-1. Sowing	0	0	2	--		8	–	1.5	9.5	2	13.5	Low
		0	0	2			8		1.5	9.5	2	13.5	Low
3- Fertilizing (50%)	3-1.vfilling wheel-barrows with ma-nure using a shovel	0	0	8	–	–	8	–	1.5	9.5	2	19.5	Moderate
		0	0	8			8		1.5	9.5	2	19.5	Moderate
	3-2. emptying wheelbarrows	0	2.5	6	–	–	–	8	1.5	9.5	2	20	Moderate
		0	2.5	6				8	1.5	9.5	2	20	Moderate
	3-3. Spreading manure and soil on the seeds	0	0	8	--	8	–	–	3	11	2	21	Moderate
		0	0	8		8			3	11	2	21	Moderate
4- Weeding (20%)	4-1. Weeding	0	3	8	–	–	8	–	3	11	2	24	High
		0	1	8			8		3	11	2	22	Moderate
5- Harvest (40%)	5-1. Harvesting vegetables with a scythe	0	1	8	–	–	8	–	3	11	2	22	Moderate
		0	1	8			3		3	11	2	22	Moderate
	5-2. Tying harvested vegetables into bunches	0	0	4	–	–	4	–	1.5	5.5	2	11.5	Low
		0	0	4			4		1.5	5.5	2	11.5	Low
	5-3. Putting vegetable bunches in the bags	0	1	6	–	–	4	–	3	7	2	16	Moderate
		0	0	6				4	1.5	5.5	2	13.5	Low
6- Storage and prepara-tion for sale (30%)	6-1. Emptying vegetable bags	0	2.5	6	–	–	–	4	1.5	5.5	2	16	Moderate
		0	2.5	6				4	1.5	5.5	2	16	Moderate
	6-2. Washing vegetables (radishes and spring onions)	0	1	6	–	–	8	–	3	11	2	20	Moderate
		0	1	6			8		3	11	2	20	Moderate
	6-4. Packaging vegetables	0	3	6	–	8	–	–	1.5	9.5	2	20.5	Moderate
		0	3	6		8			1.5	9.5	2	20.5	Moderate
7- Loading (10%)	7-1. Putting packages in wheelbarrows	0	0	8	–	8	–	–	1.5	9.5	2	19.5	Moderate
		0	0	8		8			1.5	9.5	2	19.5	Moderate

*Percentages are amount of time that takes to complete a task in during a shift.
** The posture score is the sum of the highest score of the relevant organs with the score of non-diversity and uniformity.