International Journal of Occupational Safety and Ergonomics (*JOSE*) 2011, Vol. 17, No. 2, 139–146

Measurement Consistency Among Observational Job Analysis Methods During an Intervention Study

Caroline Joseph

Department of Industrial & Systems Engineering, University at Buffalo, The State University of New York, Buffalo, USA
Département de mathématiques et de génie industriel, École Polytechnique, Campus de l'Université de Montréal, Montréal, QC, Canada

Daniel Imbeau

Département de mathématiques et de génie industriel, École Polytechnique, Campus de l'Université de Montréal, Montréal, QC, Canada

Iuliana Nastasia

Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST), Montréal, QC, Canada

Several observational methods are available for ergonomists to evaluate the exposure to musculoskeletal disorder (MSD) risk factors associated with work. Those methods can be used to evaluate the impact of modifications done at a workstation on the exposure to risk factors. Three methods (QEC, OCRA and 4D Watbak) were used to assess the exposure to MSD risk factors before and after the implementation of changes at a saw and block opening workstation. The results from those 3 methods served to compare the methods and evaluate their consistency. Comparisons among the methods showed positive association between QEC and OCRA indices, and between the QEC back index and 4D Watbak.

observational methods OCRA QEC 4D Watbak comparison

1. INTRODUCTION

Musculoskeletal disorders (MSDs) are an important problem in industrialized countries, especially for manufacturing companies. In 2008, the USA goods-producing industries as a whole had an injury and illness incidence rate of 4.9 cases per 100 full-time workers, while service-providing industries had a rate of 3.6 cases per 100 full-time workers [1]. The incidence rate for the food manufacturing industries was 6.2 per 100 full-time workers, which is one of the goods-producing industries with the highest incidence rate [1]. Therefore, it is particularly important to implement workplace modifications that can help reduce the incidence of MSDs in goods and food producing industries.

To date, many observational methods have been published to evaluate the exposure to MSD risk factors and guide the appropriate corrective

The authors wish to thank the workers who agreed to being studied. They wish to thank Philippe-Antoine Dubé for his help with the analyses using 4D Watbak. They also wish to thank Dr. Victor L. Paquet for his comments on earlier versions of the manuscript. This project was funded in part by NSERC.

Correspondence and requests for offprints should be sent to Caroline Joseph, Department of Industrial & Systems Engineering, University at Buffalo, The State University of New York, 438 Bell Hall, Buffalo, NY 14260-2050, USA. E-mail: <cjoseph2@buffalo.edu>.

actions, e.g., RULA [2], OCRA [3] and QEC [4]. These methods can be used for exposure surveillance of risk factors such as awkward joint postures, force requirements, etc., and can be used to evaluate the reduction in the exposure to risk factors after ergonomics modifications. One difficulty faced by practitioners is that many methods have been published but there is no guideline, based on actual field testing, to inform the selection of the appropriate one according to the needs of the ergonomist. Dempsey, McGorry and Maynard published a survey of tools and methods used by certified ergonomists [5]. Their results suggested that when observational techniques were not used it was because the techniques were not necessary or ergonomists were not familiar with them. To help the practitioners become more informed about some characteristics of different methods, Imbeau, Nastasia and Farbos listed and categorized a number of those [6]. Some methods take into account a wider range of risk factors and body parts (the so-called integrated methods) and seem to better inform on the risk factors present at workstations, e.g., RULA [2], PLIBEL [7] and JSI [8]. David presented a summary and some advantages of these methods, which are classified as simple observation methods [9].

Knowing there are some differences in the exposure categories and/or measurement reliability of observational methods, a practitioner may want to know if the different methods yield comparable results for a given exposure at a workstation. There are still few studies that compare the results of different methods and those are mainly qualitative [9, 10, 11, 12, 13, 14, 15, 16, 17, 18]. Only few other studies quantify the differences and similarities [19, 20, 21, 22, 23, 24]. Some of these studies cover only exposure to the low back [16, 17, 18, 19]. However, the only comparisons between observational methods that address exposure to multiples body segments are between RULA and JSI [20], QEC and RULA [21], OWAS, RULA and REBA [22] and RULA, REBA, ACGIH TLV, SI and OCRA [23, 24]. A gap exists especially for comparisons of observational methods other than RULA.

On the basis of their individual characteristics, OCRA and QEC are interesting methods because they both allow comparisons before and after modifications at a workplace and they consider a wider range of risk factors as compared to other methods. Also, according to the literature, these two methods have not yet been compared. However, since OCRA does not consider the back, another method should be used to be able to get an overall evaluation of the exposure. Different methods are available to evaluate the back exposure. Out of those, the 4D Watbak software, developed by the University of Waterloo, Canada [25], is interesting because it considers both the peak exposure and the cumulative exposure, and also because it has not been compared to other methods.

Accordingly, the main objective of this study is to determine the level of consistency in exposure information across different methods in the context of continuous improvement.

2. METHODS

2.1. Context of the Study

The study took place at a food processing plant that specialized in the transformation of frozen fish products for the North American market (USA and Canada). Different continuous improvement tools and methods had been applied over the years at this plant and the management wanted to incorporate ergonomics to its improvement initiatives. This particular plant was consequently an interesting environment to measure the changes in levels of exposure of MSD risk factors after successive modifications made at a workstation during a continuous improvement program to compare the results from different observational techniques. The saw and block opening (sawyer) workstation was targeted for evaluation at three different stages of implementation (*Before*, *After 1* and *After 2*), since it had already been targeted in the past by CSST (the worker compensation board in the Province of Québec, Canada) inspector due to its high number of MSD injuries.

2.2. Data Collection

From a total of 24 sawyers working at the workstation, 7 (1 female and 6 males) selected randomly were observed during their work and were subsequently interviewed. Participants had a mean age of 38 (range: 27–49) and had a mean experience of 6 years at the workstation (minimum experience of 4 years).

Because of tight work schedules, it was not always possible to observe the same workers repeatedly at the three stages (*Before*: before intervention, *After 1*: after a set of intervention changes, and *After 2*: after a second set of changes). Hence, of the 7 workers observed, one participated in all three stages and two participated in the last two stages (*After 1* and *After 2*). The remaining participants were observed either before the intervention (*Before*) or after the first changes were introduced (*After 1*). For the *Before* stage, 12.5% of the workers who would normally work at the workstation over the three work shifts were observed, for the *After 1* stage 20.8% and for the *After 2* stage 12.5%.

2.3. Workstation and Task Description

At the beginning of the study (*Before*), the targeted workstation had four distinct work tasks: (a) open the box containing three blocks of frozen fish (task A), (b) take off the protective cardboard of each block (task B), (c) cut one slice of fish using a saw (task C) and (d) cut the entire block into smaller blocks, which were fed into the multi-saw (task D). The workstation had two long tables that could accommodate 28 fish blocks and fed two saws. At the second stage (*After 1*), the only modifications observed were changes in the configuration of the workstation, i.e., the tables were modified to avoid accumulation of fish blocks (maximum six blocks per table) that could result in quality problems, and workers only had to lift a block at a time instead of multiples in task B, C and D. Finally, at the last stage (*After 2*), task C was eliminated due to a new method of cutting the fish in task D. Task A was also modified to only unstuck the side of the blocks since the fish blocks (raw material) were delivered as individual blocks on a pallet instead of boxes containing three blocks.

2.4. MSD Risk Factors Assessment Methods Used

For the purpose of this study three methods were used: OCRA, QEC and 4D Watbak. The choice of methods was based on the body parts that were suspected to be affected by the changes at the workstation, but also to verify how other body parts would be affected. OCRA was chosen because it takes into account a wide array of risk factors, such as repetition, frequency, force, posture (hands, wrists, elbows and shoulders), and movement, recovery and additional factors (precision, mechanical pressure, rapid movement, etc.) [3]. OCRA considers the impact of all tasks in a work shift and separates the right and left sides of the body in two indices [3]. For this method, both the regular and the shoulder-specific indices were calculated [3]. QEC was chosen because it also includes a wide variety of risk factors, such as posture (back, shoulders and arms, wrist and hand, and neck), frequency, force, length, visual demand, and additional factors (driving a vehicle, vibrating tools, work pace and stress level) [4]. QEC was created to be used in continuous improvement situations, which corresponded with the context of this study environment; it considers each task separately and provides task-specific indices. It also provides unique indices by body part on the basis of the side of the body that yields the highest score [26]. For this method, both the indices by body part and a general index were used [21, 26]. The third method used was 4D Watbak, which gives the possibility to have an overview of the back exposure for a complete workday (all tasks) giving an overall score (low back pain reporting index, LBPRI), the peak load and the cumulative load (low back pain reporting, LBPR) at L4–L5 for all tasks combined [25]. The risk factors considered by 4D Watbak are posture, force, repetition and time [25]. Since 4D Watbak considers only the back and OCRA only considers the upper extremities, the results from 4D Watbak also make it possible to have an overview of MSD risk factors present at the workstation when combined with the results from OCRA.

2.5. Analysis

The results from the three methods were compared to identify if they provided similar results. For details on the differences in exposure between stages *After 1* and *After 2*, please refer to Joseph, Imbeau and Nastasia [27].

2.5.1. Between methods analyses: QEC versus OCRA

The results from QEC and OCRA were compared for all stages confounded. Since both methods consider similar risk factors, such as posture, force, repetition/frequency and duration, and similar body parts (shoulders and arms, wrist and hand) [3, 4], both methods can be compared. Because the two methods do not provide the same kind of indices, the OCRA indices were split per task to make comparisons with QEC possible. Also, because OCRA gives two indices, left and right, only the higher of those was considered in the comparisons. To accommodate these characteristics of the methods, the following indices were used: QEC general index, QEC shoulders/arms index, QEC wrists/hands index, OCRA general index and OCRA shoulder index. The OCRA general index was compared to all three QEC indices and both shoulder indices (OCRA and QEC) were compared with each other. To verify whether the two methods had similar tendencies, two types of analyses were done: parallel-forms reliability [28] on the numeral indices (Spearman ρ correlation coefficients with $\alpha = .05$) and nonparametric correlation on the ordinal (ranked categories) indices (Kendall's τ_b with $\alpha = .05$). In addition to these comparisons, the percentage differences between stages were compared to see whether the sensitivity of both methods was comparable. Also, the way that the different risk factors were taken into account was compared.

2.5.2. Between methods analyses: QEC versus 4D Watbak

The results from QEC and 4D Watbak were also compared. Since both methods consider similar risk factors, such as posture, force, repetition and time, and both consider the back [4, 25], both methods can be compared. Because the two methods do not use the same kind of indices, the 4D Watbak indices were split per task, as done with OCRA. Also, since 4D Watbak uses many indices, only the LBPRI was taken into account in the comparisons. Thus, to accommodate these characteristics of the methods, the QEC back index and the 4D Watbak LBRPI were used. Parallel-forms reliability was verified using Spearman ρ with $\alpha = .05$. Since 4D Watbak does not categorize the index level to facilitate interpretation of the result, the nonparametric correlation was not done. In addition to that comparison, the percentage differences between stages were compared to see whether sensitivity of both methods was comparable. Also, the way that the different risk factors were taken into account was compared.

3. RESULTS

3.1. QEC versus OCRA

Of the pairs of indices compared, only one pair had a statistically significant correlation, the QEC wrists/hands index and OCRA general index ($r = .287$, $p = .040$). However, even if the association was statistically significant, it was a weak positive association. This weak association can be explained by the presence of three outliers from task A in the *After 2* stage. This task at that specific stage was considered an outlier because it had a very short cycle time which both methods seemed not to be able to take into account similarly. After removing this task from the data, all correlation coefficients were statistically significant (Table 1) and the positive associations were stronger, but still weak (Spearman $\rho < .6$).

Table 2 shows the results from the nonparametric correlations on the ordinal (ranked categories) indices both for the entire set of data and for the set of data without the outliers identified in the previous correlation analyses. The results show that in both cases, with and without outliers, the only statistically significant correlations were found between the QEC shoulders/arms and the OCRA indices. Similarly to the Spearman ρ correlation coefficients found when using the continuous scale score, Kendall's τ_b coefficients had positive but weak association (Kendall's $\tau_b < .6$). The trend of the results for the data with and without the outliers was the same except that the correlation coefficients increased when the outliers were removed.

Also, when the percentage differences were examined (Table 3), we saw that both methods agreed a little less than half of the time, but the results did not always follow the expected trend. Also, in general, the OCRA indices showed greater percentage difference than the QEC indices. An example of that was the percentage difference for the indices of task D between *After 1* and *After 2* stages. In that case the difference in the task was that the worker needed to flip the block. The indices would have been expected to either increase or stay still, not to decrease, as found. Also, in that example, the OCRA indices were more than two times greater than the QEC indices.

TABLE 1. QEC [4] and OCRA [3] Spearman ρ Correlation Coefficient With Outliers Removed

Method	QEC General	QEC Shoulders/Arms	QEC Wrists/Hands
OCRA general	$r = .563$, $p = .001$	$r = .588$, $p = .001$	$r = .427$, $p = .021$
OCRA shoulder		$r = .481$, $p = .008$	

TABLE 2. QEC [4] and OCRA [3] Nonparametric Correlation on the Ordinal (Ranked Categories) Indices Results

Method	QEC General	QEC Shoulders/Arms	QEC Wrists/Hands
OCRA general	$\tau_b = .168$, $p = .327$	$\tau_b = .456$, $p = .007$*	$\tau_b = .180$, $p = .309$
OCRA shoulder		$\tau_b = .441$, $p = .010$*	
OCRA general (without outliers)	$\tau_b = .282$, $p = .125$	$\tau_b = .509$, $p = .004$*	$\tau_b = .204$, $p = .273$
OCRA shoulder (without outliers)		$\tau_b = .543$, $p = .002$*	

Notes. *$p < .05$.

TABLE 3. Percentage Difference of the Means Between Stages for QEC [4] and OCRA [3]

		Difference (%)					
Stages	Task	QEC Wrist/Hand	QEC Shoulder/Arm	QEC General	OCRA	OCRA Shoulder	Expected Results
Before–After 1	A	6.7	1.0	0.8	–2.5	49.3	should stay the same
	B	–0.7	–20.9	–15.2	32.4	22.9	should decrease (–)
	C	–7.7	–25.9	–20.1	–14.4	–16.5	should decrease (–)
Before–After 2	A	–6.7	–41.7	–34.4	44.5	76.1	less weight but more awkward posture and short cycles
	B	–1.1	–15.6	–14.9	–32.5	–42.0	should decrease (–)
After 1–After 2	A	–12.5	–42.3	–35.0	48.3	18.0	less weight but more awkward posture and short cycles
	B	–0.5	6.7	0.3	–49.0	–52.8	stay the same or slightly decrease (–)
	D	–13.3	–10.4	–9.8	–46.4	–29.9	should increase (+) or stay the same

TABLE 4. Percentage Difference of the Means Between Stages for QEC [4] and 4D Watbak [25]

Stages	Task	Difference (%) QEC Back	4D Watbak LBPRI	Expected Results
Before–After 1	A	–4.9	17.0	should stay the same
	B	–28.8	–9.3	should decrease (–)
	C	–29.4	–24.1	should decrease (–)
Before–After 2	A	–57.1	–11.0	should decrease (–)
	B	–33.3	–33.0	should decrease (–)
After 1–After 2	A	–54.9	–24.0	should decrease (–)
	B	–6.4	–26.1	stay the same or slightly decrease (–)
	D	–7.1	–8.4	should increase (+) or stay the same

3.2. QEC versus 4D Watbak

When the entire data set was used, there was no statistically significant correlation between the QEC and 4D Watbak indices. However, if task A of the *After 2* stage was removed, as in the comparison between the OCRA and QEC indices, we found both indices significantly correlated (r = .613, p = .002). The association between QEC back index and the 4D Watbak LBPRI was then positive.

The percentage differences (Table 4) showed agreement between both methods, but these results did not always follow the expected trend. As in the case of the comparison between QEC and OCRA, an example of this was the percentage difference of task D between *After 1* and *After 2* stages. As in the previous case, an increase or stability in the indices was expected not a decrease, as found.

4. DISCUSSION

The main goal of this study was to compare the results obtained with the different methods. The two analyses, parallel-forms reliability on the numeral indices (Spearman ρ) and nonparametric correlation on the ordinal (ranked categories) indices (Kendall's τ_b), showed a trend in the same direction, indicating a positive association between the results of OCRA and QEC methods when the outliers were removed. This association was at its highest between the OCRA general index and the QEC shoulders/arms index. This can be due to the fact that the OCRA general index took into account the movement of the elbow and that the QEC shoulders/arms index considered both shoulders and arms together while sharing similar risk factors such as force exerted and the time at the task. However, the way those risk factors were taken into account was different and OCRA also took into account additional risk factors. For both methods, intervals were used to characterize the different risk factors which were later combined to get overall indices [26, 29]. The addition of certain risk factors for OCRA compared to QEC can then explain the differences between the results. Secondly, for the comparison of QEC and 4D Watbak, results (parallel-forms reliability analyses only) similar to the comparisons between OCRA and QEC indices were found, which was a positive association between back indices when the outliers were removed. Both methods (QEC and 4D Watbak) considered back posture, force exerted and the time at the task. However, the way those risk factors were taken into account was different. QEC considered intervals for all the different risk factors which were later combined to get overall back results [26]. In the case of 4D Watbak, the software considered the exact posture input, the duration the posture was held in the cycle, the amount of time the task was done during a day and the force at the hands. The different postures of the worker for the task then needed to be input in the software and the software combined the results of all postures to give an overall back index. The latter should then be closer to the reality if the information input in the software were accurate. In the parallel-forms reliability analyses, when considering that task A at the last stage (*After 2*) changed the level of correlation for the different comparisons, the unexpected high correlations between some of the indices might be related to the presence of multiples tasks and comparison of the methods by task might be necessary. This was not done in the current study because of the small sample size. A larger sample size might also help minimize the influence of the difference between tasks or at least know if differences between tasks really existed. The difference in the results might be related to the way the risk factors, e.g., task length and task pace, were taken into account by the methods but also to the risk factors that were considered. The comparison results added to the results already present in the literature where only RULA was compared to other methods (JSI: Drinkaus, Sesek, Bloswick, et al. [20], QEC: Brown and Li [21], OWAS and REBA: Kee and Karwowski [22], REBA, ACGIH TLV, SI and OCRA: Jones and Kumar [23, 24]). With this study we added the comparison between OCRA and QEC. This study also added quantitative information on the comparison of methods to evaluate the back as compared to the previous literature [19]. Finally, since the results from the different methods were generally similar, QEC might be a method to prefer when evaluating modifications to workstations because its results were more often in the expected direction and this method seemed to react more effectively than the other methods especially for the back index. In addition, QEC was easier to use than the other methods.

5. CONCLUSION

From our results, we found that different methods such as OCRA, QEC and 4D Watbak seemed to be fairly consistent in describing exposure to risk factors for the kind of tasks done at this workstation. However, the fact that outliers in the data influenced that trend should indicate that further comparisons for those same methods should be done for different kinds of tasks, but also with a larger sample. The sensitivity of the methods to characterize some risk factors can then influence those results.

REFERENCES

1. Bureau of Labor Statistics. U.S. Department of Labor. Workplace injuries and illnesses—2009. Retrieved February 1, 2011, from: http://www.bls.gov/news.release/pdf/osh.pdf
2. McAtamney L, Corlett EN. RULA: a survey method for the investigation of work-related upper limb disorders. Appl Ergon. 1993;24:91–9.
3. Occhipinti E. OCRA: a concise index for assessment of exposure to repetitive movements of the upper limbs. Ergonomics. 1998;41:1290–311.
4. Li G, Buckle P. Evaluating change in exposure to risk for musculoskeletal disorders—a practical tool (HSE Contract report 251/1999). Sudbury, Suffolk, UK: HSE Books; 1999.
5. Dempsey PG, McGorry RW, Maynard WS. A survey of tools and methods used by certified professional ergonomists. Appl Ergon. 2005;36:489–503.
6. Imbeau D, Nastasia I, Farbos B. Troubles musculo-squelettiques: évaluation et conception du travail [Musculoskeletal disorders: assessment and design of work]. In: Manuel d'hygiène du travail: du diagnostic à la maîtrise des facteurs de risque [Textbook of occupational hygiene: from diagnosis to the control of risk factors]. Modulo-Griffon, QC, Canada: Mont-Royal; 2004. p. 321–62.
7. Kemmlert K. A method assigned for the identification of ergonomic hazard—PLIBEL. Appl Ergon. 1995;26:199–211.
8. Moore JS, Garg A. The strain index: a proposed method to analyze jobs for risk of distal upper extremity disorders. Am Ind Hyg Assoc J. 1995;56:443–58.
9. David GC. Ergonomic methods for assessing exposure to risk factors for work-related musculoskeletal disorders. Occup Med (Lond). 2005;55:190–9 (DOI:10.1093/occmed/kqi082). Retrieved February 14, 2011, from: http://occmed.oxfordjournals.org/content/55/3/190.full.pdf+html
10. Coyle A. Comparison of the rapid entire body assessment and the New Zealand manual handling "hazard control record", for assessment of manual handling hazard

in the supermarket industry. Work. 2005; 24:111–6.

11. Juul-Kristensen B, Fallentin N, Ekdahl C. Criteria for classification of posture in repetitive work by observation methods: a review. Int J Ind Ergon. 1997;19:397–411.
12. Jones T, Kumar S. Comparison of ergonomic risk assessment output in a repetive sawmill occupation: trim-saw operator. Work. 2008;31(4):367–76.
13. Takala EP, Pehkonen I, Forsman M, Hansson GA, Mathiassen SE, Neumann WP, et al. Systematic evaluation of observational methods assessing biomechanical exposures at work. Scand J Work Environ Health. 2010; 36(1):3–24.
14. Village J, Backman CL, Lacaille D. Evaluation of selected ergonomic assessment tools for use in providing job accommodation for people with inflammatory arthritis. Work. 2008;31(2):145–57.
15. Li G, Buckle P. Current techniques for assessing physical exposure to work-related musculoskeletal risks, with emphasis on posture-based methods. Ergonomics. 1999; 42:675–95.
16. Marklin RW, Wilzbacher JR. Four assessment tools of ergonomics intervention: case study at an electric utility's warehouse system. Am Ind Hyg Assoc J. 1999; 60:777–84.
17. van der Beek AJ, Erik Mathiassen S, Windhorst J, Burdorf A. An evaluation of methods assessing the physical demands of manual lifting in scaffolding. Appl Ergon. 2005;36(2):213–22.
18. Waters TR, Putz-Anderson V, Baron S. Methods for assessing the physical demands of manual lifting: a review and case study from warehousing. Am Ind Hyg Assoc J. 1998;59(12):871–81.
19. Russell SJ, Winnemuller L, Camp JE, Johnson PW. Comparing the results of five lifting analysis tools. Appl Ergon. 2007;38(1):91–7.
20. Drinkaus P, Sesek R, Bloswick D, Bernard T, Walton B, Joseph B, et al. Comparison of ergonomic risk assessment outputs from rapid upper limb assessment and the strain index for tasks in automotive assembly plants. Work. 2003;21:165–72.
21. Brown R, Li G. The development of action levels for the "quick exposure check" (QEC) system. In: McCabe PT, editor. Contemporary ergonomics. London, UK: Taylor & Francis; 2003. p. 41–6.
22. Kee D, Karwowski W. A comparison of three observational techniques for assessing postural loads in industry. International Journal of Occupational Safety and Ergonomics (JOSE). 2007;13(1):3–14. Retrieved February 14, 2011, from: http://www.ciop.pl/21103
23. Jones T, Kumar S. Comparison of ergonomic risk assessment output in four sawmill jobs. International Journal of Occupational Safety and Ergonomics (JOSE). 2010;16(1): 105–11. Retrieved February 14, 2011, from: http://www.ciop.pl/35544
24. Jones T, Kumar S. Comparison of ergonomic risk assessments in a repetitive high-risk sawmill occupation: saw-filer. Int J Ind Ergon. 2007;37(9–10):744–53.
25. Neumann WP, Wells RP, Norman RW. 4D WATBAK: adapting research tools and epidemiological findings to software for easy application by industrial personnel. In: Proceedings of the International Conference on Computer-Aided Ergonomics and Safety, Barcelona, Spain. 1999.
26. The Robens Centre for Health Ergonomics. Quick Exposure Check (QEC) report and toolkit. Available on request from: <ergonomics@rebesinsitute.com>.
27. Joseph C, Imbeau D, Nastasia I. Impact of externally and internally driven modifications to a workstation: a case study in the fish processing industry. In: Proceeding of the Human Factors and Ergonomics Society 53nd Annual Meeting. 2009. Santa Monica, CA, USA: Human Factors and Ergonomics Society; 2009. p. 922–4.
28. Huck SW. Reading statistics and research. 3rd ed. New York, NY, USA: Addison Wesley Longman; 2000.
29. Colombini D, Occhipinti E, Grieco A. risk assessment and management of repetitive movements and exertions of upper limbs: job analysis, OCRA risk indices, prevention strategies and design principles. Oxford, UK: Elsevier; 2002.