THE DEVELOPMENT OF ACTION LEVELS FOR THE 'QUICK EXPOSURE CHECK' (QEC) SYSTEM

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A preliminary study was carried out to identify an action level for the QEC system (Quick Exposure Check for the assessment of workplace risks for work-related musculoskeletal disorders). This was achieved by assessing a number of industrial tasks simultaneously using the QEC and RULA (Rapid Upper Limb Assessment) and comparing the assessment scores from both methods. The action levels of the QEC were then extracted from the corresponding RULA scores. The results suggested that a QEC score in the range of 40-49% (calculation method described in the text) could be described as equivalent to a RULA score of 3-4 (action: investigate further); similarly, a QEC score of 50-69% indicated 'investigate further and change soon' and a score of 70% or higher suggested 'investigate and change immediately'. A QEC score of less than 40% was regarded to be 'acceptable'.

Introduction

The term work-related musculoskeletal disorder (WMSD) refers to any disorder that involves the nerves, tendons, muscles and supporting structures of the body as a result of any work-related activity. There are numerous published studies which stress the 'risk factors' that are found to be associated with WMSDs. These are described as being either workplace/occupational factors, individual/personal factors (Winkel and Westgaard, 1992), or psychosocial factors (eg. Houtman et al., 1994; Theorell et al., 1991). Studies have shown that the WMSD risk associated with individual factors was small when compared with that associated with workplace exposures (Armstrong et al., 1993), and a clearer role of psychosocial factors in the development of WMSDs is still under debate (Bongers et al., 1993). A number of observational techniques have been developed since the 1970's to assess WMSD risks and these are reviewed in Li and Buckle (1999a).

The QEC system (Li and Buckle, 1999b) focuses mainly on the assessment of workplace risk factors that have been found to have a contributory role in the development of WMSDs, such as repetitive movements, force exertion, awkward postures and task duration. The tool combines the assessment of both the 'observer' and the 'worker' in its assessment outcome and indicates a risk exposure level (score) for the back, shoulder/arm, wrist/hand and the neck in relation to a particular task, and shows whether or not an ergonomic intervention proves to be effective (with decreased or increased exposure scores). However, the system is not yet able to suggest whether or not an action is needed corresponding to a particular exposure level.

The aim of the present study was to formulate action levels that may be used, in conjunction with the QEC system, to decide upon the necessity of an ergonomic intervention in the workplace.

Method

There can be different ways, in theory, to define an 'action level' or 'zone' against an exposure level assessed by such an observational tool, using epidemiological or physiological measures for example, but these may also be accompanied by issues as to what extent the measured physical workload exposures can represent a 'true' level of WMSD outcome, especially when several risk factors are presented in a combined manner.

The present study attempted to identify and use, amongst a number of tools available, an established tool with already pre-defined action limits on which to compare the scores obtained by the QEC system. Of the pen-paper based observational methods available, the RULA system (McAtamney and Corlett, 1993) was selected for this purpose. This was based on several considerations, for example, RULA is a posture based method designed for assessing the severity of postural loading; it considers the static or repetitive body movement and force exertion; it calculates assessment scores with action levels, and it is well established and widely used.

The first major hurdle to overcome was how to compare the scores obtained from QEC system, which covers individual upper body regions, with the RULA system, which uses the assessment of the upper body as a whole. This was overcome by converting the scores obtained by the QEC system for individual upper body areas into one that covered the upper body regions as a whole. The exposure level (E) is calculated as a percentage rate between the actual total exposure score X and the maximum possible total score X_{max}, using the formula: $E (\%)=X/X_{max} \, 100\%$

Where: X=Total score obtained for exposure to the (Back+Shoulder/arm+ Wrist/hand+Neck); X_{max}=Total maximum score for exposure to the (Back+Shoulder/arm +Wrist/hand+Neck). X_{max} is a constant value for a particular type of task, i.e., for manual handling, X_{maxMH}=176; for other tasks, X_{max}=162.

After the choice of which assessment tool to compare with the QEC system was made, it was necessary to decide upon the type and the number of tasks that were needed for this study. In total, 31 tasks were chosen from pre-recorded videotape. This was to provide an identical set of tasks that could be assessed by using both tools. The tasks were chosen to encompass as many and varied work activities as practicable, including repetitive tasks, manual handling, tasks with either static or dynamic natures, and tasks which were performed in either a standing or seated position. A list of the tasks used in this study is given in Appendix 1.

All of the tasks used in this study have received no previous ergonomic intervention, and have been filmed from a variety of angles to show the whole range of motions of the worker. This was to ensure that both systems were able to pick up the risk factors associated with the particular task in question.

In the task selection, one of the considerations taken into account was the use of any protective clothing that may have been worn by the workers such as gloves. Many of the gloves that were worn in the workplace were a general-purpose type, used by both sexes and were generally a 'one size fits all' arrangement. This meant that for many of the workers, the gloves used tended to be on the large side and often made it difficult to correctly assess the positions of the wrist. Work tasks selected with the use of such gloves

were kept to a minimum, and these tasks selected were recorded from various angles and were scrutinised closely to ascertain the correct positioning of the wrists during the performance of the task.

To reduce the possible learning effects of assessing the tasks by both tools, the QEC and the RULA were used in alternate sequence and the tasks were also assessed randomly. All assessments were carried out by one ergonomist over a period of 2 days. Prior to the formal assessments, the ergonomist performed a number of self-training sessions with both methods (using pilot assessment exercises on different tasks), until he felt that he had obtained sufficient knowledge/experience in both methods and could use them almost equally well when assessing a particular task.

Results

The results obtained from the assessments of the 31 tasks are shown in Table 1.

Table 1. The results of the comparison between the QEC and RULA

Task ID	RULA Score	QEC Score				
		Percentage Total (E)	Mean	SD	Range	X/X_{max}
13A*	4	45%	46.0%	1.0	45-47%	80/176
12A*		47%				82/176
3A*	5	55%	57.0%	1.1	55-58%	96/176
1A*		57%				100/176
12C		57%				92/162
8A*		58%				102/176
9A*		58%				102/176
10A*	6	61%	65.7%	2.4	61-69%	108/176
10C		63%				102/162
13C		63%				102/162
6A*		64%				112/176
7A*		64%				112/176
11A*		65%				114/176
14A*		65%				114/176
9C		65%				106/162
5A*		67%				118/176
8C		67%				108/162
15C		68%				110/162
17C		68%				110/162
18C		68%				110/162
4C		69%				112/162
5C		69%				112/162
11C	7	70%	82.3%	8.2	70-93%	114/162
6C		73%				118/162
3C*		76%				134/176
23A*		77%				136/176
16C*		83%				146/176
14C*		86%				152/176
1C*		90%				158/176
2C*		93%				164/176
7C		93%				150/162

Note: * - Manual handling tasks.

The QEC assessment data is shown in the column entitled "Percentage Total" and is presented using the equation: E (%)=X/X_{max}100% as described earlier. A maximum possible score (X_{max}) of 162 can be obtained from the QEC score table if a particular task assessed is perceived by the observer to be of a mainly static type, these may include seated or standing tasks with or without frequent repetition and where the load/force exertion is relatively low. A maximum possible score (X_{maxMH}) of 176 indicated that the particular task assessed was perceived by the observer to be of a manual handling (including lifting, pushing/pulling and carrying loads), as indicated in Table 1.

To explain how E is calculated, consider Task 10A in Table 1 as an example. The X value (score obtained from the QEC assessment) is 108 and the X_{max} is 176. Therefore: E=(108/176) x 100% = 61%. More details on how the exposure scores are differentiated in the QEC between different types of tasks are given in Li and Buckle (1998, 1999b).

Summary and discussion

This study has attempted to develop an action level for the QEC system, so that its users can have a reference that suggests whether or not an ergonomic intervention is needed for a particular task concerned. Based on the preliminary results obtained in this study, through the assessment of 31 different tasks using both the QEC and the RULA methods, the equivalent exposure levels and recommended actions are summarised in Table 2 below:

Table 2: Summary of QEC action levels

QEC score (Percentage Total)	Action	Equivalent RULA score
< 40%	Acceptable	1 - 2
40 - 49%	Investigate further	3 - 4
50 - 69%	Investigate further and change soon	5 - 6
≥ 70%	Investigate and change immediately	≥ 7

It should be noted that the present results (Percentage Total) are used to refer to the upper body as a whole. However, the nature of the design of the QEC system was to enable rapid assessment of the exposure levels (and the exposure changes following an intervention) for various body regions, so as to identify the problematic area(s). Using an overall exposure level may 'hide' a particular 'high' score of a certain body part such as the back, since this high score can be offset by a 'low' score in another body region such as the neck, leading to a suggestion that the task is safe (although it may be potentially unsafe for the back). Therefore, it is recommended that, when an overall percentage score is found to be greater than 40%, the user refers to the original QEC score table (Li and Buckle, 1998, 1999b) and checks the individual scores of each body part so as to identify where a particular high exposure lays. To this point, the action levels identified in the present study should only be regarded as a general reference which leads to further identification of particular body areas that may need ergonomic attention.

It also needs to be pointed out that the preliminary action levels identified in the present study were based on equivalent actions recommended by RULA. Although

RULA has been widely used, the validity of the method, especially the predictive value of its assessment scores for quantifying the actual risk of WMSDs, has not yet been validated. There is also an issue about the differences in the design and application purposes of the two methods used, which may limit the value of the present results. Further studies are required to validate the relationships between the QEC assessment outcome (scores) and corresponding action levels using more sophisticated approaches.

More information on the QEC system is available at: http://www.geocities.com/qecuk/

Acknowledgement

References

Armstrong, T.J., Buckle, P., Fine, L.J., Hagberg, M., Jonsson, B., Kilbom, Å., Kuorinka, I.A.A., Silverstein, B.A., Sjogaard, G., Viikari-Juntura, E.R.A., 1993, A conceptual model for work-related neck and upper-limb musculoskeletal disorders. Scandinavian Journal of Work, Environment and Health, 19, 2, 73-84.

Bongers, P.M., de Winter, C.R., Kompier, M.A.J. and Hildebrandt, V.H., 1993, Psychosocial factors at work and musculoskeletal disease [review]. Scandinavian Journal of Work, Environment and Health, 19, 297-312.

Brown, R., 2001, Further evaluation of the Quick Exposure Check (QEC), with particular attention to the scoring system. Unpublished MSc Thesis, University of Sunderland.

Houtman, I.L.D., Bongers, P.M., Smulders, P.G.W. and Kompier, M.A.J., 1994, Psychosocial stressors at work and musculoskeletal problems. Scandinavian Journal of Work, Environment and Health, 20, 2, 139-145.

Li, G. and Buckle, P., 1998, A practical method for the assessment of work-related musculoskeletal risks - Quick Exposure Check (QEC). In: Proceedings of the Human Factors and Ergonomics Society 42nd Annual Meeting, October 5-9, Chicago, Human Factors and Ergonomics Society: 1351-1355.

Li, G. and Buckle, P., 1999a, Current techniques for assessing physical exposure to work-related musculoskeletal risks, with emphasis on posture-based methods. Ergonomics, 42, 5, 674-695.

Li, G. and Buckle, P., 1999b, Evaluating change in exposure to risk for musculoskeletal disorders – a practical tool. HSE Contract Report 251/1999, HSE Books ISBN 0 7176 1722 X.

McAtamney, L. and Corlett, E. N., 1993, RULA: a survey based method for the investigation of work related upper limb disorders. Applied Ergonomics, 24, 91-99.

Theorell, T., Harms-Ringdahl, K., Ahlberg-Hultén, G. and Westin, B., 1991, Psychosocial job factors and symptoms from the locomotor system - A multicausal analysis. Scandinavian Journal of Rehabilitation Medicine, 23, 165-173.

Winkel, J. and Westgaard, R., 1992, Occupational and individual risk factors for shoulder-neck complaints: Part II - The scientific basis (literature review) for the guide. International Journal of Industrial Ergonomics, 10, 85-104.

Appendix 1. List of tasks used during the assessment

Task ID	Task description
1A.	The manufacture of plastic plates.
3A.	The manufacture of an electric wall fan housing.
5A.	Measuring a quantity of plastic dough.
6A.	Placing the plastic dough in to a mould.
7A.	Removal of a plastic drain inspection cover from a mould.
8A.	Removal of a plastic vacuum cleaner cylinder from a mould.
9A.	The manufacture of plastic milk crates.
10A.	Removal of a plastic barrel from a blow moulding machine.
11A.	Removal of excess plastic from a plastic barrel.
12A.	Placing plastic granules in to a rotation casting machine.
13A.	The closure of a rotation casting machine.
14A.	Manufacturing plastic baths.
23A.	Disposal of excess material after the manufacture of a crankshaft.
1C.	Moving empty oil drums by hand.
2C.	Emptying bags of chemicals in to a hopper.
3C.	Loading of a delivery van.
4C.	Packing small packets of food.
5C.	Checkout operator.
6C.	Addition of parts to an engine whilst on a production line.
7C.	Placement of stacked boxes on to a production line.
8C.	A worker, checking small objects before being packed in to a box.
9C.	Placing objects on to spikes on a moving production line.
10C.	Checking small objects mounted in a box.
11C.	Poultry worker.
12C.	A forklift driver.
13C.	The packaging of poultry in to bags.
14C.	Removal of aluminium casks from an underground cellar.
15C.	Seated worker, packing small plastic tubs.
16C.	Changing a large paper roll over on a printing machine.
17C.	Packing large plastic bottles.
18C.	Making individual bricks by hand.