



Applications of Quick Exposure Check in Industrial Tasks and A Proposed Improvement

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Abstract

Assessment of exposure to physical and psychosocial risk factors that contribute to musculoskeletal problems has gained importance due to severe consequences of musculoskeletal disorders and discomfort on health and productivity of the industrial workforce. Ergonomics in industrial job design also necessitates detection and mitigation of these risk factors for better worker performance. The Quick Exposure Check (QEC) is a widely used exposure assessment method which addresses work related physical and psychosocial risk factors through observational assessment and self-report. The current study reviewed several applications of the QEC in industrial tasks such as; machine sewing, rubber production, bumper tape-masking, road building, electronics manufacturing, furniture manufacturing, and assessed applicability and effectiveness of the method. Associations of the QEC with subjective musculoskeletal discomfort were also discussed. The reviewed studies mostly supported the applicability and effectiveness of the QEC in exposure assessment studies. Addition of musculoskeletal symptom data collection part was proposed as an improvement to the method. In addition, potential future applications, such as computerization of the QEC were discussed. The study would be helpful to researchers and practitioners about use of the QEC in future exposure assessment studies.

Keywords: Quick Exposure Check, Musculoskeletal Risks, Exposure Assessment

Introduction

Musculoskeletal (MS) problems substantially deteriorate health and productivity of the industrial work force [1-7]. For example, Morken et al. [5] demonstrated that MS disorders accounted for 45% of total sickness absence among aluminium industry workers in Norway. Studies have shown that MS problems among the industrial work force mostly involve the upper extremities, back and low back [2,7-11]. In the UK, for instance, Sim et al. [11] found that one-month prevalence of neck and upper limb pain was 50.5% among ceramic industry workers. In India, MS discomfort prevalence in wrist and shoulders among brass metal workers were found to be 62% and 40% respectively [9]. Such severe consequences indicated that assessment of the factors leading to MS problems is highly important from occupational health perspective.

Literature reveals that exposure to various work-related physical and psychosocial risk factors contribute to occurrence of the MS problems [2, 3, 7, 11, 12]. Common work-related physical risk factors are awkward postures, prolonged static work, repetitive movements, manual material handling, forceful exertions and vibration [3, 7, 11]. Job dissatisfaction, stress at work and time pressure comprise major psychosocial factors related to MS problems [12-14]. Assessment of exposure to these risk factors is a focal part of efforts to combat MS problems. It is further propounded in literature that the work-related physical and psychosocial risk factors interact in the work environment [12-14]. Exposure assessment results can provide a basis for planning and prioritizing workplace interventions to address prevalent MS problems, as well as changes in the level of exposure to MS risks after interventions can be monitored by repeating the assessment. Therefore, assessment methods should fit industrial work environments and industrial tasks so that levels of exposure to work-related physical and psychosocial risk factors can be effectively identified and monitored [15].

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Many exposure assessment methods are observational and include self-report [15, 16]. While observational assessment includes quantification of exposure to risk factors by experts or practitioners (e.g. assessment of awkward postures by scoring the degree of deviation from neutral posture), self-report requires use of subjective data collection tools such as surveys or questionnaires [15, 16]. It is further recommended to employ at least two methods in conjunction to perform a comprehensive and scientifically sound exposure assessment [13, 16].

The Quick Exposure Check (QEC) is an exposure assessment method which combines observational assessment and self-report. The QEC was developed at the Robens Centre for Health Ergonomics, University of Surrey [13, 17-19]. The main purpose for the development of the QEC is to equip practitioners with a scientifically valid, reliable and practical exposure assessment tool [13]. The QEC was developed and validated through extensive applications in numerous work environments and tasks such as laboratory work, computer work and warehouse jobs [18]. The first version of the QEC was published in a research report in 1999 [18]. David et al [17] further improved the usability and validity of the tool published a revised version of the QEC in 2005. The QEC addresses several physical and psychosocial risk factors. The physical risk factors include the degree of awkward postures at various body parts (i.e. neck, back, shoulder/arm and wrist/hand), repetitive movements, manual materials handling, work duration, manual force exertion, visual demand, driving and use of vibrating tools. The psychosocial risk factors include work pace and stress. While postures, repetition and deviation from neutral are assessed by the observer, other risk factors are assessed using self-report of the worker. Assessments of the observer and the worker are then quantified through a combined exposure scoring system. Exposure scores represent a hypothetical relationship between exposure levels and potential health outcomes [13]. Exposure scores for postures (i.e. of the back, shoulder/arm, wrist/hand and neck), driving, use of vibrating tools, work pace and stress are calculated separately. Predetermined ranges of exposure scores indicate Low, Medium, High, and Very High risk levels. Interactions between exposures to awkward postures, work duration, maximum manually handled weight and visual demands are also taken into consideration within scoring. Özcan et al. [20] adapted and validated the QEC in Turkish language, and the Turkish Ministry of Labour, Department of Occupational Health and Safety published a guideline for using the Turkish version of the QEC and made the tool available to industry [33].

Numerous authors applied the QEC in variety of industrial environments and compared it with other tools and methods. For example, Chiasson et al. [29] compared eight risk assessment methods including the QEC, and suggested that the QEC was effective for initial screening and prioritizing interventions, easy and rapid to use, and it provides useful information about the root causes of risk factors. They also pointed to certain weaknesses of the tool such that the risk assessment could be biased based on workers' subjective inputs, and little guidance is provided about the target risk scores [29]. The developers of the tool have stressed that the feedback from field applications would be useful particularly to improve the applicability and effectiveness of the method especially for its scoring system [13].

In this respect, the current study reviewed the applications of the QEC in various industrial tasks and assessed the applicability and effectiveness of the method. Recommendations as to addition of MS symptom data collection part to the QEC were proposed. This review would be helpful to researchers and practitioners in using the QEC for exposure assessment studies.

Applications of the QEC in various industrial tasks

Machine sewing task

Erdoğan and Vayvay [21] applied the revised version of the QEC [13,17] to machine sewing task. The study was performed in a Turkish mid-sized apparel manufacturing company as part of a project to improve manufacturing quality through ergonomic interventions. They applied the QEC before ergonomic interventions to identify prevalent risk factors. Thirty one machine sewing operators who perform sit-sewing task participated in the study. Work postures of the operators were video recorded while they perform the task. Responses of the operators for the worker's assessment part were taken in the workplace, and the observer's assessment was completed by analysing videos afterwards. Along with the QEC, a questionnaire which addressed the ergonomic problems in the work environment was applied



[21]. The QEC scores and questionnaire responses indicated that the main risk factor was exposure to awkward postures. A set of ergonomic interventions including ergonomics training, workstation adjustments and machine tilting were implemented in two machine sewing lines. After the interventions, the QEC and the questionnaire were replicated to assess changes in exposure to previously identified risk factors. The QEC risk scores for all body parts were significantly reduced and the risk levels at shoulder/arm, wrist/hand and neck were reduced to a lower level. Overall, the QEC was found to be highly applicable and effective in the assessment of exposure to physical risk factors in the sedentary machine sewing task.

Rubber production

Choobineh et al. [22] applied the QEC in an Iranian rubber factory where tasks involved substantial physical risk factors (e.g. manual material handling) and awkward postures. The objective of their study was to determine the prevalence of MS symptoms and to assess exposure to physical risk factors. In total, 454 workers participated in the study. The Nordic Musculoskeletal Questionnaire [23] (NMQ) was used to collect MS symptom data. They video recorded the workers during their routine job activities and performed observer's assessment by analysing the videos. The results revealed that the percentages of workers with low, moderate, high and very high exposure to physical risk factors were 4.4%, 10.1%, 37.5% and 48% respectively. Comparative analysis of the QEC scores and the NMQ responses indicated an association between reported MS symptoms and exposure to physical risk factors. The authors highlighted that the QEC provided reliable findings and was effective in assessing the exposure to physical risk factors in the work environment under study.

Bumper tape-masking task

Forsman et al. [24] combined the revised version of the QEC [17] with the VIDAR, a video - based ergonomic assessment software designed for ergonomists working in the occupational health services. The VIDAR application is based on video recording workers while they perform the task, and assessment of the risk factors by analysing the recordings. The authors implemented the revised version of the QEC [17] to VIDAR by adding interfaces that included both observer's and worker's assessment questions. Using VIDAR, enabled workers to participate in the assessment of their own videos. A preliminary application was conducted in a factory where workers tape-masked bumpers. Eight workers were video-recorded during the work-cycle and the workers and the ergonomist identified eight physically demanding tasks. Subsequently, the ergonomist used the QEC-module to assess risk factors in these tasks. They concluded that the QEC-module was easy to learn and it required reasonable effort to complete the assessments. Though the application was preliminary, the study indicated that computerizing the QEC would allow for more efficient and participatory exposure assessments.

Road building industry

Roja et al. [25] applied the QEC in road building industry to assess exposure to physical risk factors. In total 450 road construction workers participated in the study. The QEC was applied to road repairing, road levelling and paving tasks. It was found that exposure to physical risks prevailed in the back, shoulder/arm and neck in road repairing tasks, and in the back and wrist/hand in paving tasks. However associations between the QEC results and other methods were not explored. They concluded that the QEC could be suitably used for exposure assessment in the road building industry.

Electronics manufacturing

Timlin and O'Sullivan [12] investigated the relationship between psychosocial risk factors, physical risk factors and occurrence of MS problems in an electronics manufacturing plant where light industrial tasks were performed in three shift cycles. They applied the QEC to assess exposure to physical and psychosocial risk factors, used the NMQ [23] to survey prevalence of MS discomfort, and used the Job Content Questionnaire [12] (JCQ) to survey job strain. In total 54 workers participated in their study. The QEC was applied in 32 tasks performed in the day shift, and 18 tasks that represented highest, medium and lowest risk tasks were selected. Subsequently, NMQ and JCQ were applied to the same group of 54 participants. The QEC stress scores and physical risk scores in the shoulder and wrist/hand were found to be significantly related. They comparatively analysed the QEC and NMQ results and found no relationship between the QEC risk levels and prevalence of MS discomfort for the neck,



shoulder, back or wrist. The QEC and JCQ results were comparatively analysed and QEC risk categories and stress scores were not found to correlate with job strain. They concluded that the QEC was quick and easy to use, and relatively low-cost for exposure assessment. The tool was found to enable practitioners to identify salient physical risk factors quickly and without much interruption to the work. The authors stated that if the QEC addressed lower limb biomechanics, factors that cause poor back and neck postures, particularly for sedentary workers, could be identified more effectively.

Furniture manufacturing

Mirhahomadi et al. [26] applied the first version of the QEC [18] to assess risk factors related to MS symptoms in the furniture industry. The manual tasks carried out in the factory involved substantial physical risk factors. Along with the QEC, the NMQ was applied to collect MS discomfort data. The QEC was applied in 100 workplaces where physical operations were performed. The number of participants was not reported. They classified the tasks based on action levels; the percentages of tasks at first, second, third and fourth action levels were found to be 1%, 9%, 55% and 35% respectively. They reported a significant relationship between the QEC scores and prevalence of MS discomfort at the back and neck.

Oil palm harvesting

Sukadarin et al. [28] applied the QEC to assess ergonomic risk factors in oil palm harvesting task which included repetitive manual subtasks such as cutting fresh fruit bunches (FFB) using chisel or sickle. Collecting FFB is a demanding manual handling activity. They applied the QEC to assess risk factors in harvesting FFB from tall trees with seven workers across four subtasks; harvesting, loading FFB to the truck, loading FFB from the truck to the lorry, and driving the truck. They video recorded the task and found that loading FFB to the truck involved the highest risk levels for multiple body parts. They noted that the QEC lack lower limb assessment and therefore falls short in addressing certain postural problems particular to the harvesting task. They further pointed out that when asked to estimate the force they exert manually and weight of the loads they lift, low educated harvesting workers might not be able to provide reliable responses, which could adversely affect reliability of the assessment. The authors suggested that the expert involvement or objective measurements (e.g. for load weight) in responding questions for force exertion and manual lifting.

The reviewed studies above are summarized in Table 1.

Discussion

The current study reviewed the applications of the QEC in various industrial tasks. The feedback from field applications was considered useful to examine applicability and effectiveness of the method.

The reviewed applications were carried out in machine sewing, rubber production, bumper tape-masking, road building, electronics manufacturing, furniture manufacturing and oil palm harvesting. All studied tasks and industrial environments involved physical risks, the foremost risk factor being the awkward postures. In all studies except Mirhahomadi et al. [26], and Sukadarin et al. [28], authors positively commented on the applicability and effectiveness of the QEC. Sukadarin et al. [28] supported the finding of Chiasson et al. [29] as to the potential bias on the assessment due to unreliable worker inputs, especially with low-educated workforce. Furthermore, Timlin and O'Sullivan [12] argued that the QEC should address sedentary and standing work postures separately, as lower body biomechanics can influence exposure to physical risks. This point was not mentioned in other applications and the QEC was found effective in assessing physical risk factors in both sedentary (e.g. machine sewing) and standing (e.g. rubber production) tasks. Timlin and O'Sullivan [12] also proposed that 20° – 40° of flexion of the low back should be categorized as high risk level for sedentary workers.



Table 1. The reviewed applications of the QEC in industrial tasks

Application	Industry / Task	n	Associations between the QEC and other factors	Comments on the QEC
Erdinc and Vayvay [21]	Machine sewing	31	-	Highly applicable and effective
Choobineh et al. [22]	Rubber production	454	MS discomfort (+)	Reliable results, an appropriate tool
Forsman et al. [24]	Bumper tape-masking	8	-	Suitable for computer application
Roja et al. [25]	Road building industry	450	-	Suitable
Timlin and O'Sullivan [12]	Electronics manufacturing	54	MS discomfort (-) Job strain (-)	Quick and easy, cheap, provides ability to identify salient risk factors
Mirhahomadi et al [26]	Furniture manufacturing	-	MS discomfort (+)	-
Sukadarin et al [28]	Oil palm harvesting	7	-	Inadequate for assessing oil palm harvesting task, needs expert involvement when education level of the workers is too low

Addition of MS symptom data collection part to the QEC

The main motivation to investigate exposure to workplace risk factors is that these factors could lead to MS problems, which is an important concern in occupational health. Three of the abovementioned studies explored the associations between the QEC results and the occurrence of MS discomfort among workers. While Choobineh et al. [22] and Mirhahomadi et al. [26] reported significant associations between the QEC scores and the prevalence of MS discomfort, Timlin and O'Sullivan [12] found no relationship between the QEC scores and the occurrence of MS discomfort. These three studies pointed to the fact that researchers could need to assess MS symptoms in conjunction with exposure to MS risks. Subjective data is a major information source for MS discomfort studies, and researchers widely use tools such as survey and questionnaires for collecting symptom data [12, 21, 22, 26, 30, 31, 32]. All three studies mentioned above used the NMQ [23] to collect MS discomfort data. Subjective data is further used to compare discomfort level after ergonomic interventions [21, 32]. While some authors use published and validated tools such as the NMQ [12, 22, 23, 26], others develop or custom-tailor the tools for their particular study [21]. In both ways, subjective tools are effectively used for collecting symptom data.

The attempts to collect symptom data along with the QEC indicated that adding a symptom data collection part to the method could contribute to its effectiveness. To that end, MS symptom data collection items for body parts addressed in the observer's assessment could be added to the method as a separate, optional section. The question could be worded as; "Do you experience ache, pain, tingling in your..." for each body part requiring responses on symptom frequency or severity scales. Addition of this section could meet the need to use another tool for combined assessment of risk factors and MS symptoms. Moreover, body part identifications could differ in other tools [12, 22, 23] and an important benefit of adding the symptom data part to the QEC is that the data can be collected for the exact body parts assessed in the method. Also, addition of the symptom data can enable researchers to assess intervention outcomes in terms of changes in prevalence of MS symptoms as well as the changes in risk levels.



Future applications of the QEC

Literature review indicates that the QEC is weightily applied for the assessment of physical risk factors. The literature emphasizes that psychosocial risk factors can contribute to the occurrence of the MS problems [12-14] and thus, the QEC can serve to explore the interaction between physical risk factors, psychosocial risk factors, thereby providing valuable insight into the mechanism of MS problems. Addition of MS symptom data collection part can significantly enhance analytic capabilities of the QEC and enable researchers to correlate MS symptoms not only with physical risk factors, but also with psychosocial risk factors.

Computerization of the assessment methods like the QEC introduces multiple improvements to the assessment process [24]. The QEC can be applied in pen-paper form [17 – 19] and when computerized, video analysis feature can help involve workers assess their own postures and observe the risks themselves. In addition, computation of the risk scores and reporting can be significantly more efficient using computer interfaces. Therefore, computerization of the QEC including the symptom data part has important merit for future studies. The digital capabilities that can expand the use of the QEC include developing mobile applications for the QEC so practitioners can use it more easily and efficiently in natural work environment.

Conclusions

The studies reviewed in this study provided evidence to the applicability and effectiveness of the QEC in most of the industrial tasks. Association between the QEC assessment results and the occurrence of MS symptoms was also explored in some of the reviewed studies and contradictory findings implied that further research is necessary to draw more concrete conclusions. Addition of self-report questions to collect MS symptom data to the QEC could enhance the effectiveness of the assessment. Furthermore, developing and using computerized versions of the QEC, including mobile applications, could enhance efficiency in the assessment process. Future applications of the QEC in different industrial tasks and work environments would provide more feedback regarding the applicability and effectiveness of the tool and would point to further improvements.

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