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Original article

Comparisons of the results from between Rapid Entire Body Assessment and Quick Exposure Check as ergonomic evaluation tools

Khongrit Pinyowiwat*, Soontorn Supapong, Thanapoom Rattananupong

Department of Preventive and Social Medicine, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand

Background: Ergonomic tools are used to conduct risk assessments in the workplace. The Rapid Entire Body Assessment (REBA) is a favourite tool of ergonomists and practitioners, whereas the Quick Exposure Check (QEC) is more widely used. However, comparative studies of these two ergonomic tools are limited.
Objectives: To compare the results of two ergonomic evaluation tools, the Rapid Entire Body Assessment (REBA) and the Quick Exposure Check (QEC), and determine the prevalence of musculoskeletal disorders using Nordic questionnaire in a steel factory.
Methods: This cross-sectional study recruited 296 workers in a steel factory. The data were collected using self-administered questionnaires and data collection forms administered by the researchers. Proportionally stratified random sampling was used. The weighted kappa coefficient was used to compare the results of the two tools.
Results: The comparisons of the REBA and QEC results showed slight to fair strength of agreement. The 12- month prevalence of musculoskeletal disorders in the workers was 69.0%, and in 55.0% of those workers, their symptoms affected their work. The highest prevalence of symptoms was in the low back, followed by the shoulder and neck.
Conclusion: The comparisons of the REBA and QEC results showed slight to fair strength of agreement. However, this research was conducted in only one steel factory; therefore, further studies are required.

Keywords: Ergonomic evaluation tools, work-related musculoskeletal disorders, risk assessment, Rapid Entire Body Assessment, Quick Exposure Check, standardised Nordic questionnaires.

Work-related musculoskeletal disorders are among the most common occupational diseases. Work-related musculoskeletal disorders are injuries or disorders of the muscles, tendons, joints, cartilage and spinal discs that occur when the work environment and performance of the work contribute significantly to the condition and/or the condition is worsened or persists longer due to work conditions.[1] The characteristics of work-related musculoskeletal disorders are unique that they develop gradually, resulted from overuse. There are multiple causes of these disorders, and they are effectively preventable with adequate preventive measures.[2]

***Correspondence to: Khongrit Pinyowiwat**, Department of Preventive and Social Medicine, Faculty of Medicine, Chulalongkorn University, Bangkok 10330, Thailand.
E-mail: Khongritp@yahoo.com
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Work-related musculoskeletal disorders are major problems in many countries, including the United States, according to the report from the Center for Disease Control and Prevention. Work-related musculoskeletal disorders are associated with work absenteeism, disablement and high healthcare costs, and even though they are not life-threatening conditions, they can impair the quality and mobility of a large number of working people. The Institute of Medicine estimates that the economic burden of work-related musculoskeletal disorders, including compensation fees, loss of revenue and loss of productivity, are up to 45 to 54 billion USD each year.[1] According to the Work-related Musculoskeletal Disorders (WRMSDs) Statistics in Great Britain 2017, the number of affected employees in both new and old cases was up to 507,000. The most frequently affected body parts were the upper limbs or neck, lower limbs and back, and most of the affected

workers were in the construction sector. The calculated days lost was 8.9 million.[3] Furthermore, the Safe Work Australia Annual Report of 2016 reported that although the number of claims for compensation decreased, the median lost working time and compensations fee increased between 2000 - 2001 and 2012 - 2013.[4]

In Thailand, according to the 2016 report of the Bureau of Environmental and Occupational Diseases, Department of Disease Control, Ministry of Public Health, the number of cases with diagnosis code M00-M99 (diseases of the musculoskeletal system and connective tissue) and G56.0 (carpal tunnel syndrome) with Y96 (work-related condition) as an external cause in the ICD-10™ coding system was 81,266, equivalent to 135.26 per 100,000 persons; this was higher than the 123.93 reported in 2015, and the highest proportion of affected workers were in agriculture.[5]

Conducting ergonomic risk assessment is important because it helps employers identify significant risks in their workplace and can result in adequate preventive measures. Simple observation is a commonly used ergonomic evaluation technique. It is practical, user-friendly and gathers information from both employees and practitioners.

Rapid Entire Body Assessment (REBA), developed by Hignett S, *et al*. [6], is a favourite tool of ergonomists and practitioners, and there are many studies worldwide related to this tool. The Quick Exposure Check (QEC) by David G, *et al*. developed later [7], is a widely used ergonomic tool because it can identify the origin of hazards and allows systematic data collection from both practitioners and employees.

The steel factory is a kind of heavy industry with complex working procedures in which workers may be affected by multiple ergonomic risk factors. There are benefits of conducting ergonomic risk assessment in a factory that may contribute to a shift in practices. However, comparative studies of these two ergonomic tools are limited.

This research aimed to determine the agreement between REBA and QEC results in a steel factory. The secondary purpose was to determine the prevalence of musculoskeletal disorders based on self-reported symptoms using standardised Nordic questionnaires.

Materials and methods

This study was a cross-sectional study. The subjects were required be able to understand and communicate in Thai and older than 18 years of age; they were excluded if they were disabled or handicapped, which may limit the evaluation of work postures.

The study was approved by the Institutional Review Board (IRB) of the Faculty of Medicine, Chulalongkorn University (IRB no. 304/61). All subjects were clearly informed of the study objectives and methods and provided informed consent to participate in the study.

The sampling method was proportionally stratified random sampling. In each department, the workstations were chosen almost proportionally to include those the workers complained about and those that safety officers and managers considered risky. As for this study, assessment was performed at workstations. As for workstations with short work cycles, at least ten work cycles were observed. For workstations with very long work cycles, the most critical tasks of the cycles were evaluated.

Questionnaires were administered to gather data from the employees. The questions were divided into 3 parts: general information, questions from the Quick Exposure Check tool (only those that required evaluation of the participants) and questions from standardised Nordic questionnaires.

A researcher assessed work posture, frequency of working, and amount of weight lifted and collected all the information required for the QEC and REBA tools on a data collection form. The researchers received permission from the owners as the tools for the research. The process used to translate the tools into Thai was back translation. Both the questionnaires and the data collection form were scrutinised by two occupational medicine physicians and an orthopaedic surgeon.

Statistical analysis

STATA version 15.0 (StataCorp 2017, Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC) was used for data analysis. Descriptive statistics showed the general characteristics of the subjects, risk categories and evaluation tool results and are described in Tables 1, 2 and 3, respectively.

Risk levels were classified as low, moderate and high, according to Chiasson M, *et al*.'s study. For the REBA, scores of 1, 2 - 7 and 8 - 15 were classified as low, moderate and high risk, respectively. For the QEC, the 4 risk categories described in the original QEC

paper were reclassified into 3 groups: very high risk and high risk were merged into a high risk group. The scoring system for the total QEC scores was divided into 3 groups: low risk (less than 40.0% of the entire score), moderate risk (40.0% to less than 70.0% of the entire score) and high risk (70.0% or more of the entire score).The results of the QEC and REBA were compared and are presented as the percent agreement between the tools and weighted kappa coefficients (Table 4). The prevalence of musculoskeletal disorders is presented as the number of affected workers and percentage (Table 5).

Results

The number of subjects in the research was 296; they had a mean age of 40.49 ± 10.52 years. Most of them were male (91.9%), had a high school or vocational certificate educational background (29.6%) and had worked at this steel factory for less than 5 years (35.8%). Baseline characteristics of subjects are shown in Table 1.

The risk level distribution determined using the REBA and QEC tools is illustrated in Table 3. The classification was based on Chiasson M, *et al*.'s study (see more in Table 2).[8] A majority of the employees emerged as moderate or high risk (Table 3). With the REBA, most of the subjects (199 workers, equivalent to 67.2%) were classified into the high-risk group. For QEC, results were varied depending upon component assessed, as provided in Table 3.

Comparisons of the REBA and QEC results, according to the Landis JR, *et al*.[9] interpretation of weighted kappa coefficients, revealed slight to fair strength of agreement. Comparisons of the REBA and QEC results for assessment of the back during seated or standing stationary tasks and when remaining in a static position most of the time showed slight agreement (K_w = 0.11). Comparisons of the REBA and QEC results for back assessment during lifting, pushing/pulling and carrying tasks also presented slight agreement (K_w = 0.14). Comparison of the REBA and QEC results for shoulder/arm assessment showed fair agreement (K_w = 0.27). Comparison of the REBA and QEC results for wrist/hand evaluation also showed fair agreement (K_w = 0.27). Comparisons of the REBA and total QEC scores for seated or standing stationary tasks and back remaining in a static position most of the time (static tasks) showed slight agreement (K_w = 0.02). A comparison of the REBA and total QEC scores for lifting, pushing/pulling and carrying tasks (moving tasks) also showed slight agreement (K_w = 0.07). More details are displayed in Table 4.

Table 1. Baseline characteristics of and general information for subjects (n = 296).

Information	Number of people	Percentage
Sex (n = 296)		
Male	272	91.9
Female	24	8.1
Age (n = 293)		
21 - 30 years	66	22.5
31 - 40 years	78	26.6
41 - 50 years	92	31.4
< 50 years	57	19.5
Education (n = 294)		
Elementary education	50	17.0
Junior high school education	68	23.1
High school education or vocational certificate	87	29.6
Diploma	56	19.1
Bachelor's degree or higher	33	11.2
Work experience (n = 291)		
5 years or less	104	35.7
6 - 10 years	55	18.9
11 - 15 years	32	11.0
16 - 20 years	29	10.0
< 20 years	71	24.4

Table 2. Risk categories used to compare output results.

Methods	Risk categories		
	Low	Moderate	High
REBA			
Total REBA score	1	2 - 7	8 - 15
QEC			
Back (static)	8 - 15	16 - 22	23 - 40
Back (moving)	10 - 20	21 - 30	31 - 56
Shoulder/arm	10 - 20	21 - 30	31 - 56
Wrist/hand	10 - 20	21 - 30	31 - 46
Neck	4 - 6	8 - 10	12 - 18
Driving	1	4	9
Vibration	1	4	9
Work pace	1	4	9
Stress	1	4	9-16
Total QEC score (static) (%)	< 40.0	≥ 40.0, < 70.0	≥ 70.0
Total QEC score (moving) (%)	< 40.0	≥ 40.0, < 70.0	≥ 70.0

Table 3. Results of evaluations using REBA and QEC.

Methods	Risk categories					
	Low		Moderate		High	
	Number	Percentage	Number	Percentage	Number	Percentage
REBA						
Total REBA score (n = 296)	14	4.7	83	28.0	199	67.2
QEC						
Back (static) (n = 61)	8	13.1	17	27.9	36	59.0
Back (moving) (n = 232)	7	3.0	84	36.2	141	60.8
Shoulder/arm (n = 293)	22	7.5	103	35.2	168	57.3
Wrist/hand (n = 292)	34	11.6	105	36.0	153	52.4
Neck (n = 290)	12	4.1	32	11.0	246	84.8
Driving (n = 281)	215	76.5	28	10.0	38	13.5
Vibration (n = 282)	203	82.0	43	15.3	36	12.8
Work pace (n = 293)	95	32.4	185	63.1	13	4.4
Stress (n = 295)	62	21.0	147	49.8	86	29.2
Total QEC score (static) (n = 55)	11	20.0	41	74.6	3	5.5
Total QEC score (moving) (n = 214)	18	8.4	154	72.0	42	19.6

Table 4. Percent agreement and weighted kappa coefficient for the comparison between REBA and QEC.

QEC	Compare to REBA	
	Percent agreement	Weighted kappa
Back (static) (n = 61)	60.7	0.11
Back (moving) (n = 232)	80.4	0.14
Shoulder/arm (n = 293)	78.3	0.27
Wrist/hand (n = 292)	76.5	0.27
Neck (n = 290)	78.8	0.07
Total QEC score (static) (n = 55)	79.1	0.02
Total QEC score (moving) (n = 214)	63.3	0.07

Table 5. 12-month prevalence of musculoskeletal disorders and their effect on work.

Body part	Prevented from doing regular work (at home or away from home)				
	Number of affected subjects	12-month prevalence	Number	Number of affected subjects	Percentage
At least one site	196	69.01	196	99	50.5
Neck	84	28.67	80	26	32.5
Shoulder	97	33.33	91	31	34.1
Elbow	24	8.25	23	5	21.7
Wrist/hand	69	23.71	68	30	44.1
Upper back	82	28.18	81	39	48.2
Low back	129	44.48	125	52	41.6
Hip/thigh	64	21.99	60	28	46.7
Knee	77	26.46	68	31	45.6
Ankle/foot	64	22.07	61	34	55.7

The previous 12-month prevalence of musculoskeletal disorders was defined as trouble (ache, pain or discomfort) with a body part (neck, shoulder, elbow, wrist/hand, upper back, low back, hip/thigh, knee and/or ankle/foot). The analysis of the completed questionnaires (n = 284) showed that 69.0% of the subjects were affected by trouble with at least one site, and in 50.5% of those who had symptoms, the symptom affected their work. The highest prevalence of the symptoms occurred in the low back, followed by the shoulder and neck, and the lowest prevalence was in the elbow, as presented in Table 5.

Discussion

Analysis of the measurement of agreement between the results of the REBA and QEC indicated a percentage of agreement between 60.66 and 80.39, which was lower than that reported in the study of Chiasson M, *et al*.[8] However, that research was performed in multiple workplaces with a variety of job tasks, whereas in this paper, the researcher collected data only in a steel factory. Analysis of agreement using weighted kappa coefficients showed slight to fair agreement. Among studies performed in similar industries, Nadri H, *et al*. studied 82 workers at an anodising factory in Iran, and a comparison of the REBA and QEC showed slight agreement (K_w = 0.12)[10], while Mohit M. studied 66 metal workers industry and found fair agreement (K_w = 0.26). [11] Additionally, some papers using different statistical methodologies, such as correlations, have provided different outcomes.[12]

However, when interpreting the results of ergonomic evaluation tools, assessors consider action levels more often than scores. Consequently, comparisons using kappa or weighted kappa coefficients are more appropriate.

The reasons for the different outputs from the QEC and REBA are listed below. First, the REBA mainly focuses on working posture and evaluates the weight lifted, repetition of tasks and contact stress. The QEC also assesses vibration; nonetheless, there is no question related to cold temperatures in either questionnaire. Second, in terms of components of ergonomics, the REBA covers only physical ergonomics, whereas there are some questions in the QEC regarding cognitive and organisational ergonomics. Although in regular practice, great importance is attached to physical ergonomics, both cognitive and organisational ergonomics are also essential. Third, in terms of the source of input, the REBA collects data only from practitioners, while the QEC includes opinions from employees as a part of the evaluation. It is worth noting that some factors could not be determined from observation, including psychosocial aspects and frequency of working multiple-task jobs. Finally, in terms of the questionnaires, the QEC is more comprehensive; it assesses exposure, and there are evaluations of the frequency of work and the overall work times. Additionally, the outcomes of the QEC tool provide assessments of each body part, which contributes to extended applications.

The highest prevalence of musculoskeletal disorders over the previous 12 months occurred in the low back, followed by the shoulder and neck, and the lowest prevalence occurred in the elbow. Aghilinejad M, *et al*. collected data from 1,439 workers in 4 steel factories and found that the highest 12-month prevalence of symptoms occurred in the low back (64.1%), knee (47.8%) and neck (44.9%).[13] Meanwhile, Habibi E, *et al*. performed research in 1,030 subjects in a steel factory in Iran and found that the 12-month prevalence of musculoskeletal disorders was highest for the low back (40.7%), neck (24.5%) and shoulder (22.4%). [14] Similarly, a study by Lei L, *et al*. of foundry workers in China showed the highest 12-month prevalence in the low back (29.2%), shoulder (10.5%) and wrist/hand (6.5%). [15] Those 3 studies and the present research have some results in common. However, musculoskeletal disorders are associated with work procedures; therefore, different job tasks in each workplace are among factors that explain the differences in results, including prevalence and the affected body parts. In this study, some of the subjects were office workers, which could be a reason the prevalence was lower than that of other studies.

As this is a cross-sectional study; therefore, it is limited in the ability to determine a causal relationship between the results of the ergonomics evaluation tools and musculoskeletal disorders. The research was conducted at one steel factory; thus, the results may not be representative of the entire steel industry. Stratified sampling was used to represent the exact proportion of workers, and subjects were selected from each department by convenience. The survey of musculoskeletal disorders using questionnaires may have resulted in recall bias because current workers at the factory are healthy and unhealthy people may remove themselves to more appropriate occupations. This phenomenon is technically called the "healthy worker effect". In addition, steel work is considered a heavy industry, so there are few static job tasks.

Conclusion

This study is a pioneering research on the use of the QEC tool in Thailand. The researchers received permission from the executives of steel factories to collect data from every department. There are future opportunities for further studies regarding the characteristics of musculoskeletal disorders in the steel industry and analyses of the relationships between the results of ergonomic evaluation tools and reported musculoskeletal disorders.

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Conflict of interest

The authors, hereby, declare no conflict of interest.

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