Literature Reviews

Rapid Entire Body Assessment: A Literature Review

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Abstract: The aim of this review is to provide a summary of one of the observational postural analysis ergonomic assessment tools; Rapid Entire Body Assessment (REBA) in terms of its development, applications, validity and limitations. Research showed REBA's convenience for postural assessment of jobs in numerous professional settings, including industrial and health care jobs, construction, sawmill tasks, supermarket industry, food industry, computer based jobs, packaging, school workshop, odontological services and for firefighters and emergency medical technicians. Face validity is established in two stages. In terms of concurrent validity, several studies used REBA to compare the results with other observational and direct methods so that the level of conformity between the two is determined. The limitations discussed in this review did not hold the method's implementation back, on the contrary, it is currently used and remains a rapid to use tool with computerized checklist and tables available in public domain.

Keywords: Ergonomic Assessment, REBA, Literature Review

Introduction

Ergonomic assessment of Work-Related Musculoskeletal Disorders (WMSDs) involves the evaluation of risk of developing a range of disorders to muscles, nerves and joints, primarily to the upper limb and low back, associated with occupational tasks.

Musculoskeletal disorders are among the most widely spread occupational problems for both developed and developing countries, in industries and services, with increasing expenses of salary compensation and health costs, declining productivity and lower quality of life. These disorders are caused by different risk factors' interactions resulting from several factors, which can be categorized into individual, psychosocial and physical factors.

Physical load of work is usually evaluated by analyzing body posture, movement; recurring and forceful activities and maximum force, or increasing muscle load over time.

Observational and instrument based techniques are proposed in research to provide a quantitative measure for the degree of discomfort and postural strain caused by different body positions. The angular departure of a body segment from the neutral posture in the observational technique is acquired through visual perception, whereas recordings of the body positions done continuously in the instrument-based techniques are taken using a device attached to a person. The observational techniques are broadly used in industry for their noninterference with the work performed, low price and simplicity of use (Kee and Karwowski, 2007; Janowitz *et al.*, 2006).

Based on a review of different observational techniques, it is shown that the purpose of their development is for various uses and therefore they are applied in a multiple workplace circumstances. Each technique has its own posture classification application, which is different from other techniques, so different positional load rates can be assigned for a given posture, based on the technique used. On the other hand, there are lots of studies that evaluate many techniques with regards to their performance and dependability (Kee and Karwowski, 2007).

Observational techniques include Ovako Working Posture Assessment System (OWAS), Posture, Activity, Tools and Handling (PATH), Quick Exposure Check (QEC), Rapid Upper Limb Assessment (RULA), American Conference of Governmental Industrial Hygienists Threshold Limit Value (ACGHI TLV), Strain Index (SI), Occupational Repetitive Actions (OCRA), NIOSH Lifting Equation, Rapid Entire Body Assessment (REBA)… etc.

Programs of risk prevention and reduction are based on measuring the exposure to identifiable risk factors. In

order to achieve the optimal solutions, these programs should be based on ergonomics principles and should include a wide-range assessment of all elements of the work system (David, 2005).

The purpose of this review is to provide an overview of one of the observational postural analysis ergonomic assessment tools; Rapid Entire Body Assessment (REBA) in terms of its development, applications, validity and limitations as indicated in the literature.

Note: The target audiences for this review are those considering using the REBA method but do not have prior knowledge of it. It presents the method technique, its applications, and further discusses its validity as an ergonomics assessment tool.

Background and Development

One of the necessary requirements for evaluating job activities is postural analysis. The risk of musculoskeletal injury associated with the recorded positions can be useful in implementing change in the working practices, in the context of a full ergonomic workplace evaluation. The ergonomics practitioner can greatly benefit from the availability of task-sensitive field techniques (Hignett and McAtamney, 2000).

REBA was proposed by Hignett and McAtamney (2000) in the UK as a requirement observed within the range of postural analysis tools, specifically with sensitivity to the type of changeable working positions found in health care (e.g., animate load handling) and other service industries.

REBA provides a quick and easy measure to assess a variety of working postures for risk of WMSDs. It divides the body into sections to be coded independently, according to movement planes and offers a scoring system for muscle activity throughout the entire body, stagnantly, dynamically, fast changing or in an unsteady way and where manual handling may happen which is referred to as a coupling score as it is significant in the loads handling but may not always be using the hands. REBA also gives an action level with a sign of importance and requires minor equipment: Pen and paper method (Hignett and McAtamney, 2000; Coyle, 2005).

Simple tasks were analyzed varying in the load, movement distance and height in order to define the initial body segments and to establish body part ranges according to the diagrams of the body part (Group A and B) from RULA (McAtamney and Corlett, 1993), Fig. 1.

Several techniques were used to collect data: NIOSH, Rated Perceived Exertion, OWAS, Body Part Discomfort Survey and RULA.

Fig. 1. REBA assessment worksheet

Three ergonomists independently coded 144 posture grouping and then integrated the sensitising concepts of load, coupling and activity scores to produce the final REBA score (1-15), with associated risk and action levels. REBA was further refined by analyzing more postures from healthcare, manufacturing and electricity industries and allowing for inter-observer reliability analysis of body part coding (Hignett and McAtamney, 2000).

REBA is most likely to be used by ergonomists and other practitioners. Before using this tool, a little practice and training is recommended, nevertheless, no former ergonomic skills are required (David, 2005; Chiasson *et al*., 2012; Shanahan *et al*., 2013; Coyle, 2005).

Several studies have indicated the differences between REBA and RULA. Stanton *et al*. (2004) and Hashim *et al*. (2012) mentioned that REBA assessment is suitable for whole body evaluation and best for both static and dynamic works. There are five levels of actions to indicate the obtained scores. RULA assessment is more towards upper side of the body. It is best for sedentary and seated works and there are four levels of actions to indicate the obtained scores.

REBA was improved in the definition of the neutral postures and leg postures from those of RULA. While RULA defined the neutral position of the wrist, neck and trunk with 0° of corresponding joint motion angle and changeable leg positions are classified into only two balanced and unbalanced classes, REBA defined the neutral posture as postures with some ranges of the angular deviations of the related joints and by classifying leg positions into four classes (Kee and Karwowski, 2007).

REBA adapts better than RULA to highly varied workstations. This can be attributed to the development of RULA within a specific research context that makes it unreliable when applied in a different context (Chiasson *et al*., 2012).

Additional development of weights was given for diverse items of the counting of risk index, combination of items from another checklist and software for palm computer (Janowitz *et al*., 2006).

Description of the Method

While Hignett and McAtamney (2000) first described the REBA method, several other studies also provided a thorough description of the method (Coyle, 2005; Pillastrini *et al*., 2007; Lasota, 2014).

The body posture is analyzed using the REBA method by articular angles measurement, observing the force load and movements' repetitiveness and the postural changes' frequency.

The neck, trunk, upper and lower arms, legs and wrists' postures are assembled into ranges.

Each positional range, corresponding to the anatomical areas assessed, is related to a score corresponding to the values that get increasingly higher as the distance from the segment's neutral position increases.

Score A represents the summation of the posture scores for the trunk, neck and legs and the Load/Force score. Group A has a total of 60 posture combinations for the trunk, neck and legs. This reduces to nine possible scores to which a "Load/Force" score is added.

Score B is the sum of the posture scores for the upper arms, lower arms and wrists and the coupling score for each hand. Group B has a total of 36 posture combinations for the upper arms, lower arms and wrists, reducing to nine possible scores to which a "Coupling" score is added.

The A and B scores are combined in Table C to give a total of 144 possible combinations and finally an activity score is added to give the final REBA score.

The Activity score describes any static postures held for longer than 1 minute and a repetition more than 4 times per minute or large rapid changes in postures, or an unstable base.

A specific process is used considering all these factors and a REBA score is produced, as a number between 1 and 15 (see Fig. 2).

This REBA score represents REBA action level (between 0 and 4) defining whether action is required and its urgency (see Table 1).

The process sometimes can be repeated when changing the task due to interventions or control measures, the new REBA score can be compared with the previous one to monitor the effectiveness of the changes.

Stanton *et al*. (2004) provided an example of using slide sheets by care workers to roll a patient. REBA is useful here in educating the care worker of the right posture as part of the risk assessment process for patient handling.

The incorrect although commonly adopted posture is shown in Fig. 3. Lines of reference have been added to the correct posture in Fig. 4.

In Fig. 3, the trunk angle is between 20 and 60°, yielding a score of 3. The neck position is neutral, giving a score of 1. As for the leg score, it is divided in two: Weight is taken on both feet, giving a score of 1; the knee is bent between 30 and 60°, yielding +1. The load/force is between 5 and 10 kg, yielding a score of 1.

Using table A for group A (Trunk, neck and legs), the three positions scores are entered to yield a score of 4. This is added to the load/force score of 1 to yield a score A equal to 5.
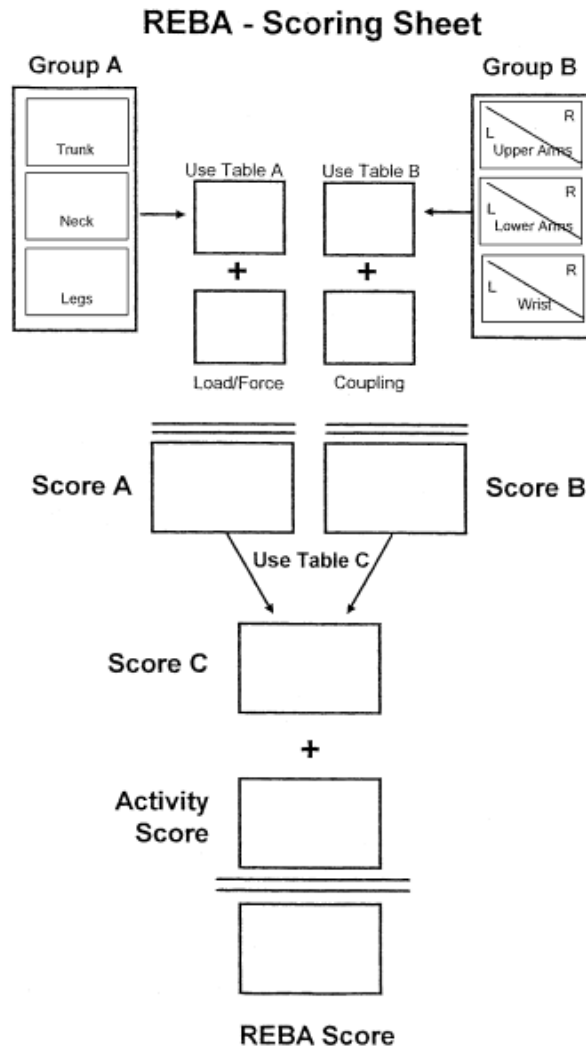
Fig. 2. REBA score sheet

Table 1. REBA action levels

REBA action levels

Action level	REBA score	Risk level	Action (including further assessment)
0	1	Negligible	None necessary
1	2-3	Low	May be necessary
2	4-7	Medium	Necessary
3	8-10	High	Necessary soon
4	11-15	Very high	Necessary NOW

Since the right arm is only visible in Fig. 3, this limb is scored. It is expected that the left arm was in a similar position. The upper arm is in a posture between 45 and 90°, yielding a score of 3, while the lower arm is between 0 and 60°, yielding a score of 2. The wrist is not obvious in the photograph, but the position was recorded when the photograph was taken. The wrist was extended with the fingers gripping the sheet, giving a score of 2. The coupling is fair, giving a score of 1.

Using table B to get the single posture score from the upper and lower arms and wrist posture scores, the score is 5, which is added to the coupling to score 1 to yield a score B of 6.

Score A and score B are entered into Table C to generate score C. The activity score 0 (no repeated, static, or sudden large range changes in posture) is added to score C. The final REBA score is 7. The action level is confirmed as a medium risk level indicating a necessary action.
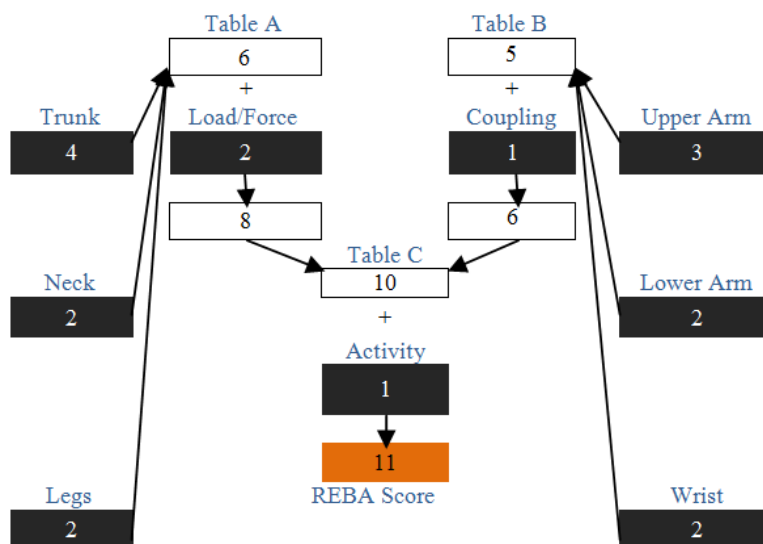
Fig. 3. The incorrect posture

REBA Assessment Worksheet
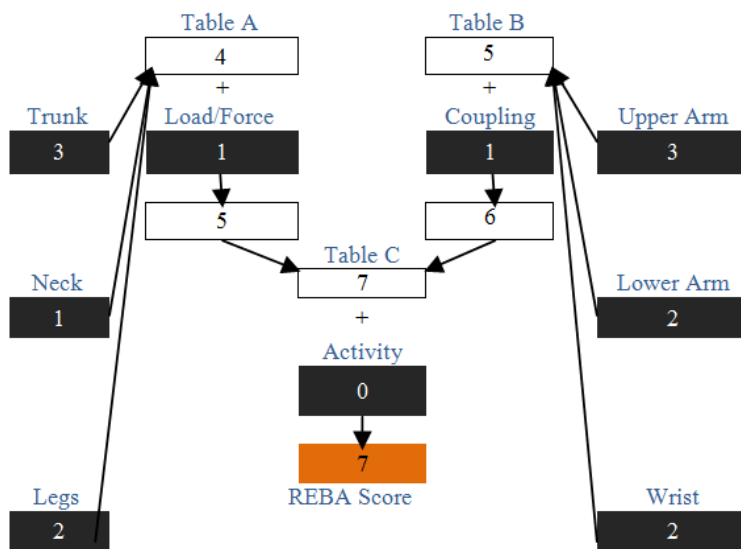
Fig. 4. The correct posture

The same process for scoring is used in Fig. 4 and the final REBA score is 11. This is categorized as a very high risk level, with immediate action needed to control the risks. One immediate control measure is to raise the bed height and an electric bed could facilitate this action.

The risk assessment contains other factors such as the worker's collaboration, his size, the surrounding environment, other manual handling operations' frequency, the available resources and equipment and the worker's ability to identify when a task is beyond his ability and ask for help.

Uses and Applications

Research showed REBA's convenience for postural assessment of jobs in several occupational settings, including industrial and health care jobs (Kee and Karwowski, 2007; Chiasson et al., 2012; Janowitz et al., 2006), construction (Shanahan et al., 2013), sawmill tasks (Jones and Kumar, 2007; 2010), supermarket industry (Coyle, 2005), food industry (Joseph et al., 2011), computer based jobs (Pillastrini et al., 2007), packaging (Lasota, 2014), school workshop (Hashim et al., 2012), odontological services (De Sa et al., 2006) and for firefighters and emergency medical technicians (Gentzler and Stader, 2010).

Comparisons between REBA and other observational methods were also achieved (David, 2005; Takala et al., 2010).

Kee and Karwowski (2007) compared OWAS, RULA and REBA based on the evaluation results of 301 working positions sampled from industrialized jobs (the iron and steel, electronics, automotive and chemical industries) and a general hospital. Postures covered various work types, such as lifting and seated tasks and balanced and unbalanced leg positions using images recorded by camcorder and classified as stressful to the human musculoskeletal system. The comparison required that REBA regroup into four action groups or action levels and the postures were classified by industry, work type and leg positions.

REBA intra-rater reliability was the highest among the three (re-assessment to the postures was done after three weeks by the ergonomist).

OWAS and REBA were less sensitive to postural stress than RULA and they underestimated postural load for the considered postures.

Joseph et al. (2011) mentioned that the difficulty faced by practitioners is the lack of a guideline to direct the choice of the suitable method that is being tested in the actual field according to the need of the ergonomist.

Their paper tried to cover the practitioner's need to identify if the different methods result in comparable findings for a given exposure at a workstation, since the literature and previous studies compare the results of different methods qualitatively (David, 2005; Jones and Kumar, 2007; Coyle, 2005).

Assessments made to review and compare between the observational methods that address exposure to multiple body segments are between OWAS, RULA and REBA (Kee and Karwowski, 2007) and RULA, REBA, ACGHI TLV, SI and OCRA (Jones and Kumar, 2007; 2010).

According to Joseph et al. (2011), a gap is present especially for comparison of observational methods other than RULA. Their study's aim was to conclude the degree of reliability in exposure information across three methods (OCRA, QEC and 4D Watbak) in the context of continuous improvement. The study took place at a food processing plant specialized in the transformation of frozen fish products for USA and Canada. Four distinct work tasks were assessed for WMSDs risk exposure.

This study suggests that further comparisons for these three methods should be done for wider range of tasks with larger sample size.

David (2005) provided an overview of the range of methods that have been developed, considering their advantages and scope of use, with emphasis on the needs of occupational safety and health practitioners as they are responsible for risk prevention and reduction programs. In his paper, he compared REBA with other 14 methods in terms of main features and functions and exposure factors assessed as part of in-depth review aimed to compare the methods' advantages and disadvantages and to allow an informed choice to be made about which technique to use in which situations.

The paper concludes that REBA is freely available from developers and associated sources, enables physical factors to be assessed and allows the assessment of the whole body including lower limbs. It is the best method matched to the needs of occupational safety and health practitioners- and related professions-who have limited time and resources (David, 2005; Joseph et al., 2011).

Chiasson et al. (2012) compared between eight different methods for determining risk factors for WMSDs primarily to the upper limbs to assess 224 workstations with cycle times ranging from 0.03 min to 18.75 h involving 567 tasks located in 18 plants from various industrial sectors over a 4 year period.

Results were compared using three risk classes: Low, moderate and high. Data were gathered using video and measurements taken at the workstations and a survey was used by the workers.

The diverse methods differed in their analyses of the same workstation.

Correlation was highest between RULA and REBA.

These two methods did not identify any workstations as low risk.

The REBA method appeared to be the only method capable of capturing the very uncomfortable postures that were frequently observed only in the tree nursery sector (squatting, sitting on the ground, lumbar flexion greater than 90° and torso twisting).

The results provided a better understanding of the differences between many risk assessment methods and a useful information for practitioners when choosing a method prior to an ergonomic intervention in industry.

The paper's strength is that it had a large sample size and long period of study and a variety of workplaces. It encourages more studies to be undertaken in order to develop new or modified WMSDs risk assessment methods.

Shanahan et al. (2013) evaluated the efficacy of RULA, REBA and Strain Index (SI) in the assessment of non-fixed work (non-structured, non-routinised and multi task work) through comparison to four occupationally relevant Borg 10 psychophysical scales: Lifting Effort, Grasping Effort, Wrist Discomfort and Low Back Discomfort.

Fourteen male rodworkers participated in this study who had at least six months experience and had no musculoskeletal injuries in the six months preceding their participation.

Rodworkers are construction trade workers involved in the moving, placing and tying of steel rods for concrete reinforcing. They perform a broad range of tasks in a variety of conditions and are exposed to many upper limb WMSDs risk factors including repetitive and forceful use of hand tools in a range of postures.

The differences in the levels of risk predicted by REBA and SI scores in Shanahan et al. (2013) study are consistent with findings of disagreement between the tools in studies of fixed work and mono-task jobs. Jones and Kumar (2007) found 'meaningful variations' in the mean risk levels assigned by RULA, REBA and SI when assessing a single manual task by a sawmill operator.

SI is the most effective tool for assessing upper limb WMSD risk in rodwork because it differentiated between tasks and correlated positively with worker perceptions of Grasping Effort and Wrist Discomfort. REBA used here was not appropriate for assessing non-fixed work as it was insensitive to WMSDs risk factors other than those associated with loads handled.

However, Shanahan et al. (2013) study was limited in the sample size and the assessment of a single non-fixed occupation and therefore the nature of the posture data used.

REBA was used to assess activities related to the fulfillment of an order for three workstations; order picking, carton sealing and sorting parcels, in a company that sells books in a chain of stores and via the internet (Lasota, 2014). Results revealed that packers working in the positions studied faced a high level of exposure to the risk of WMSDs, mainly because of postures related to keeping the back bent and twisted, maintaining a significant deviation of the arms from the body, working in a standing position and the weight of the packaged carton.

So corrective actions and ergonomic intervention recommended are reorganization of workstations and redesigning of working methods and to do re-evaluation with REBA method to verify the effectiveness of the changes.

Jones and Kumar (2010) included REBA among the five ergonomic risk assessment tools (RULA, ACGIH TLV, SI and OCRA) used to examine their agreement and ability to classify 4 at risk jobs calculated on the basis of quantitative exposure measures.

The physical exposures of 87 sawmill workers performing 4 recurring jobs were recorded using surface electromyography and electro goniometry.

Dichotomization of risk to no risk and at risk produced high conformity between the methods. Percentage of perfect conformity between the methods when 3 levels of risk were considered was moderate and varied by job.

Of the methods examined, the RULA and SI were best (correct classification rates of 99 and 97% respectively), REBA rate was 64% and the quantitative ACGIH TLV for mono-task hand work and Borg scale were worst (misclassification rates of 86 and 28% respectively).

Limitations of this study include the small sample size and the inclusion of at risk jobs only.

Another study conducted with the same purpose of the previously described. Quantified physical exposure information obtained from 15 saw-filers in four sawmill facilities was used to calculate the RULA, REBA, ACGIH TLV, SI and OCRA procedures based on several posture and exertion changeable definitions. It evaluated the ability of risk assessment component scores to differentiate between facilities with great different levels of exposure and evaluated the association between risk output and recorded incidence rates of workers.

All risk assessment methodologies evaluated (except for ACGIH TLV) settled on a level of risk that was associated with performance of the saw-filer job and posture and exertion changeable definitions were observed to significantly affect the component scores and/or risk output of all methods.

REBA scores described were calculated with dynamic force applied and peak forearm/wrist postures across subjects.

Both REBA risk index and REBA risk level scores were sensitive to inter facility differences. REBA risk

levels were not observed to increase with reported incidence of upper extremity musculoskeletal injuries events however.

As quantified demands data was only available for the wrist and forearm in this study, the importance of the ability of the REBA method to identify significant differences in neck, trunk and upper arm postures between facilities and the true effect of posture variable definition on risk assessments in view of a larger number of body regions could not be assessed in this study (Jones and Kumar, 2007).

Hashim *et al*. (2012) compared between ergonomic risk assessment methods (RULA and REBA) and self report questionnaire in order to identify risk level of 13 to 15 years old students working posture in school workshop where the students use it for one hour and 45 minutes per week.

About 336 students were randomly selected to answer the questionnaire. Images were taken every 30 sec and 104 images of most happened working postures during tasks performance were picked.

The results showed that 13 years old students were faced with higher posture problems and risk exposure while using the workstation and intervention was suggested to overcome these problems.

The study also defined the relationship of postural stress by RULA and REBA- as students needed to do the tasks while sitting and standing-where it showed that both are reliable and gave the same results.

Ergonomic tools (REBA, NIOSH lifting equation, RULA) and anthropometric measurements of equipment and persons and on-site observations were used to analyze three tasks (lifting the fire hoses, rolling the drained hoses and in-transit patient care) to determine the risks for physical injury mainly due to awkward and extreme postures (Gentzler and Stader, 2010). Five participants were involved.

REBA was used to analyze lifting the fire hoses and rolling the drained hoses. Analysis of posture strain after the hose has been lifted to drain it of excess water where the firefighter was holding the hose above the shoulders. The REBA assessment values were calculated automatically using a software package from NexGen Ergonomics, Inc.

REBA indicated a high risk for injury and its incorporation contributed to the solutions suggested in the paper in order to reduce the risk of injury, such as devising two simple yet potentially labor saving roller devices to help drain the 12.70 cm hose (squash and pinch rollers) and could be useful in rolling up the hoses and further automating them.

REBA was compared with RULA using odontological assistance service (De Sa *et al*., 2006), developed by the students of the Odontology course, at Federal University of Paraiba. The participants' activities

were photographed every 30 sec and 39 positions of most happened postures (from a total of 118) had been analyzed and the data from REBA and RULA analysis was treated by a descriptive statistics using Microsoft Excel. REBA score presented a medium risk with indication of needed changes.

A standard categorization was made for RULA and REBA scores and the results of the study obtained revealed a high coincidence between the methods, in 77% of the postures.

RULA method presented a better sensibility to detect fast and urgent action levels since it analyzes the superior extremity of the body.

The dentist job being done in a sitting position limited the evaluation and analysis of this posture by both methods.

Coyle (2005) used REBA as an assessment tool to assess the manual handling of practices in the supermarket industry in a major supermarket chain in New Zealand and compared it with New Zealand Manual Handling Hazard Control Record which is part of the New Zealand Department of Labor's Code of Practice for Manual Handling, using video footage of the staff performing 6 tasks.

The process generated considerable discussion regarding the benefits and drawbacks of each tool.

In order to get the most benefit from REBA, implementing specific ergonomic or biomechanical changes are required to decrease risk of work-related injury (mainly if an objective numeric score is needed for re-assessment after modifications, to verify their effectiveness).

The New Zealand Code of Practice for Manual Handling 'Hazard Control Record' Risk Score analysis process is not fully specific and objective; however, it helps the user implement controls, which are comprehensive, multi-factorial and useful to control hazards relating to several other areas, including task, load, environment, people and management factors.

Pillastrini *et al*. (2007) conducted a study on workers who use Video Display Terminals (VDT) using REBA in conjunction with Pain Drawing to evaluate the effectiveness of a preventive personalized ergonomic intervention, offered by physical therapists, on spinal and upper extremity work-related posture and symptom complaints of these workers.

The participants were 200 workers who spent at least 20 h per week at a VDT and were randomly separated into 2 groups and worked in 2 separate buildings with the same environmental conditions. The study lasted for 6 months. Both groups were assessed at the beginning of the study and at a follow-up 5 months later. The measurements of the spinal and upper-extremity work-related posture were obtained through REBA in the computer workstations as static postures and

photographs were used to calculate the values of the articular angles with a goniometer placed over them.

The first group received the ergonomic intervention and a brochure which is informative based on the relevant Italian legislation and on scientific evidence dealing with the main musculoskeletal complaints that resulted from using VDT, the criteria for an ergonomic workplace and the advantage of micro breaks and the second group received only the brochure.

The first group had a lower REBA score and reduced lower back, neck and shoulder symptoms compared with the second group.

In a study conducted on hospital workers by Janowitz et al. (2006), REBA was used but modified to address sedentary tasks, such as activities in the laboratories and computer workstations.

The paper aim was to document the development and validation of an integrated approach to ergonomics assessment of occupational exposures across various job categories of hospital workers who are at mainly high risk for WRMDs resulting from both patient-care and non-patient care tasks (such as housekeeping, maintenance and food service workers). It analyzed the physical demands of hospital tasks in order to develop instruments for this purpose, yet it offered a wider scope of analysis to include a full range of occupations especially those not dealing with direct patient care as part of an ongoing long-term case-control investigation, Gradients of Occupational Health in Hospital Workers (GROW) study. The participants are workers from widely different economic groups performing a varied range of jobs with varying psychological and physical features, a total of 497 participants from a base of 664 of GROW study and around 6000 hospital employees in two institutional sites for a period of nearly 24 months.

Evidence was supported as to considering and evaluating potential strengths and limitations of different options for measuring physical workload in the hospital environment. The study elaborately explained the options of survey administration, observation and instrumentation and finally justified the observational approach.

Since the hospital management rejected the video graphic observation and instrumentation, the only option left was an observational approach. So the researchers chose to apply the REBA tool modified by combining the neck items with the shoulder and upper extremity and adding peak load assessment and used it in a ''work sampling mode''. In addition, REBA was supplemented with extra validated checklist focusing on computer use with the application of a new weighting algorithm to postures. Self assessment measure for lifting and bending was used at the beginning of the observation period; Dortmunder questionnaire, amended to include

pushing and pulling exertions. A computerized program to record observational data on hand held personal digital assistant was developed.

One of the co-investigators offered training to the study field observer. The field observer used the study instruments on-site for at least 15 one-hour sessions before being permitted to conduct independent observations. Two methods of inter-rater reliability were used to compare the results obtained by the field observer to those of the study ergonomist.

It was shown that both UBA-UC and LBA-UC (Upper and Lower Body Assessment (respectively)- University of California) correlate significantly with REBA. The high strain observations correlate somewhat less strongly.

The modified Dortmunder Index has a modest correlation with LBA-UC, but it is not correlated with UBA-UC, supporting the validity of the upper and lower segregation of scores.

The percent time for the tasks related to the computer did not correlate with either UBA-UC or LBA-UC, agreeing with the study's assessment that this exposure operates independently from either position-load measure and surely correlates negatively with extreme position loads.

There was statistically significant variation by occupational group for all of the measures analyzed.

Validity and Reliability

Evidence of validation of REBA tool was provided by Hignett and McAtamney (2000) where inter-observer reliability between the 14 participants for coding was found to be between 62 and 85%. Janowitz et al. (2006) found that inter-observer reliability is moderate except for neck and upper limbs.

Face validity was accomplished in two phases; the first involved coding 144 posture combinations by three ergonomists and incorporating the sensitising concepts of load, coupling and activity scores to generate the final REBA score (1-15), with associated risk and action levels and the second phase involved 14 professionals for the collection and individual coding of more than 600 examples of postures from health care, electricity and manufacturing industries (Hignett and McAtamney, 2000; Stanton et al., 2004).

Predictive validity, that is how well the risk-estimation of the method has been shown to be related to or predicting musculoskeletal disorders, was indicated by Jones and Kumar (2010) that modest levels of agreement between methods investigated confirm risk level output will depend on the method used and there is a meaningful risk of disagreement between methods. The results of their study confirm the limited agreement between published ergonomic risk assessment methods

and the need for studies able to examine the predictive validity of the methods in the same worker population to specify the current best model. The implication of this disagreement is the incorrect assessment of risk and/or identification of problem exposures.

In terms of concurrent validity; how well the method correspond with more valid methods, several studies used REBA to compare the results with other observational and direct methods to specify the degree of agreement between the two.

Many studies (Joseph *et al*., 2011; Jones and Kumar, 2010, Kee and Karwowski, 2007; Jones and Kumar, 2070; Coyle, 2005) present results comparing two to five methods for assessing WMSDs risk.

With the exception of Kee and Karwowski (2007) study, where OWAS, REBA and RULA methods are compared using data from a sample of 301 postures obtained from diverse industrial sectors, comparisons are generally made using sample sizes that are small and/or from a single workplace (e.g., Jones and Kumar, 2010).

Kee and Karwowski (2007) paper, REBA showed the highest intra-rater reliability among OWAS and RULA.

The comparison results for RULA and REBA show more agreement than that obtained by Kee and Karwowski (2007). These authors reported 48% consistency, as compared to 73.7% in Chiasson *et al*. (2012) study. The differences between the action levels and risk categories used can be the reason for the variation.

Using the same risk categories as Chiasson *et al*. (2012) study, Jones and Kumar (2010) produced 66% conformity between RULA and REBA, although with a very small sample (four workstations in the same industrial sector).

A high coincidence between the two methods was indicated by De Sa *et al*. (2006).

REBA observations have corresponded moderately to those of the OWAS method according to Takala *et al*. (2010), although REBA classified more postures to have a higher level of risk. No reports on associations with musculoskeletal disorders were found. For leg and trunk postures, inter-observer repeatability was moderate to good but low for upper limbs.

Limitations

Being an observational assessment tool, REBA is a subjective method; it lacks detail and precision and covers three important risk factors: Force, repetition and posture.

Coyle (2005) and Janowitz *et al*. (2006) indicated that some factors (e.g., twisting, lateral bending, abduction) are weighted equally by REBA regardless to what degree they exist (e.g., 5° twisting or 20° of twisting).

According to Coyle (2005), REBA is time consuming; the "worst posture" differs depending on the body part being evaluated.

The data for the right and left hand cannot be combined so they need to be evaluated separately; the user has to decide what to observe (e.g., postures requiring the most muscular activity, most frequently repeated postures, or postures known to cause the most discomfort).

Duration and frequency of items are not considered; the lack of a time-based measures in REBA leads to 'the most common' postures and the high duty cycle postures being ranked the same (David, 2005; Chiasson *et al*., 2012; Shanahan *et al*., 2013; Jones and Kumar, 2010; Takala *et al*., 2010). Studies reviewed agree that no technique has been found appropriate for all applications. A complete evaluation of WMSDs risk in workplace needs to be done using more than one method. A workstation can have risk factors that some methods do not consider; the range of percent agreement between jobs suggests that the methods differ in their suitability to the exposure profiles of different jobs.

Conclusion

REBA is one of the most popular and widely used observational ergonomic assessment tools in various industries and services. Several studies were reviewed in order to provide an overview of this method's development, applications, validation and limitations so far.

Future work is needed to support the predictive and concurrent validity and reliability of the method.

The limitations discussed in this review did not hold the method's implementation back, on the contrary, it is currently used and remains a rapid to use tool with computerized checklist and tables available in public domain.

Research is encouraged with larger sample size and more complex environments in order to assess work-related musculoskeletal disorders risk factors using REBA.

Author's Contributions

Dima Al Madani: Have reviewed, wrote all the paper and contributed to the writing of the manuscript.

Awwad Dababneh: Have guided and designed the research paper and revised the manuscript.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

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