A NARRATIVE REVIEW OF THE RAPID UPPER LIMB ASSESSMENT (RULA) TOOL: APPLICATIONS, VALIDITY, AND EVOLVING DEBATES

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ABSTRACT

Abstract: The Rapid Upper Limb Assessment (RULA) is a popular observational ergonomic assessment scale that is used to assess the risk of work-related musculoskeletal disorders (WMSDs) related to upper limb position, muscular activity, and external forces. Since its invention in the early 1990s, RULA has been an integral part of ergonomic practice because it is simple, fast and does not require much in the way of resources. This literature review is a synthesis of the available literature that aims to define the basic methodology used by RULA, its vast use in various spheres (industry to modern office and school), and its psychometric characteristics, such as reliability and validity. Moreover, the review is a critical analysis of the debates that surround its sensitivity, granularity of the postural classification, and that it can be applied in dynamic or complex tasks. This review should allow practitioners and researchers to have a balanced perspective of the role of RULA in modern ergonomic risk management, and also to provide avenues through which future methodological improvements can be made. The data indicate that RULA still is a useful screening instrument, but its limitations have to be interpreted carefully and, where feasible, should be complemented with more objective outcomes.
Keywords: *Rapid Upper Limb Assessment, RULA, ergonomic risk assessment, musculoskeletal disorders, observation, validity, reliability, musculoskeletal disorders at work.*

Introduction:

Work-related musculoskeletal disorders (WMSDs) are a serious problem in the world in terms of individual health, industrial output, and the economy. They can be cumulative disorders which occur as a result of prolonged exposure to ergonomic risk factors that include; awkward positioning, repetitive actions, stationary muscle loading and insufficient rest time (Punnett and Wegman, 2004). WMSDs have prompted the ergonomics discipline to devise practical, effective, and convenient methods of risk detection and priority in the real-world context. The Rapid Upper Limb Assessment (RULA) procedure established by McAtamney and Corlett in the University of Nottingham in 1993 evolved into a classic and celebrated tool. RULA was specifically designed to offer rapid, systematic and visual assessment of the postural loads on the neck, trunk, and upper extremities, mainly in work that is typified by sedentary work or other light industrial requirements (McAtamney and Corlett, 1993). Its origin was based on the empirical need to have a tool that could be used by both ergonomists, occupational health and safety practitioners and even non-experts with a background training to effectively screen potential hazards without using a sophisticated or invasive tool. The fact that the tool has remained popular globally in the last 30 years is due to its classy design that is user friendly. It is an efficient way of converting complicated biomechanical findings into one, practical score. RULA then uses standardized posture diagrams and scoring tables in the 2 body segment groups (Group A: arm, forearm, wrist, Group B: neck, trunk, legs) and adopts the elements of adjustment factors to the use of muscle and force/load, resulting in a final score between 1 and 7. The score is directly converted into an Action Level (between 1 and 4), which determines the urgency of ergonomic intervention, between Acceptable and Investigation and Changes Required Immediately. The use of RULA has greatly challenged its initial industrial application. It is now commonly used in office ergonomics to test computer workstations (Choobineh et al., 2004), in healthcare settings to test the postures of surgeons, dentists, and nurses when handling patients (Kee and Seo, 2007), in service industry, and, based on a growing literature, in the educational setting to test the postural health of school-going children at their desks, computers and carrying schoolbags (e.g., Ismail et al., 2009; Patel et al., 201 Nevertheless, it is precisely its ubiquity that has stimulated the development of strong academic discussion. The same questions have consistently been raised as to its intra- and inter-rater reliability, its being able to measure risk in highly dynamic, variable, or complex tasks, the extent to which its action-level thresholds are universally applicable to diverse populations and work cultures. Thus, the main purpose of this narrative review is to review and assess the available literature on the RULA tool critically. In particular, it attempts to: (1) clarify its fundamental methodological framework and scoring mechanisms; (2) trace its versatile and growing areas of use; (3) assess the amount of empirical evidence about its reliability and different varieties of its validity; and (4) comment on some of the most significant criticism, limitations, and future prospects of its implementation, adaptation, and integration with the emerging technologies. This broad survey will serve to demystify the proven usefulness of the tool and its practical utility and openly discuss its methodological limitations, thus supporting the evidence-based and situationally-informed ergonomics practice.

Narrative Review Methodology: The review used a narrative synthesis methodology, which is aimed at offering a general, interpretative overview of the literature on a specific topic (Greenhalgh et al., 2018). Systematic search strategy was used to cover as much as possible. The queries were made in electronic databases such as PubMed, Scopus, Web of Science, and Google Scholar, containing a combination of key words and Boolean operators: (Rapid Upper Limb Assessment OR RULA) AND (validity or reliability or application or musculoskeletal disorders or ergonomic risk). The publication date was not a limit to the search to trace the entire historical development and changing discourse of the tool. Hand-searching of the reference lists of major articles was also done to find more relevant studies. Peer-reviewed journal articles, seminal book chapters, and empirical studies of the psychometric properties (reliability, validity) of RULA were of interest as inclusion criteria based on the following: the development and theoretical foundation of RULA; studies using RULA in a particular occupational or non-occupational environment; and empirical studies of RULA psychometric properties. The exclusion criteria were non-

English articles, articles in which RULA was mentioned in passing without any significant analysis of the issue, and purely anecdotal reports. Articles were screened by title and abstract identification and full text of potentially relevant papers was acquired. The information that is related to the study design, the population, the context of RULA application, the main results on reliability/validity, and conclusions made by the authors were identified and systematized into a specific theme. The synthesis was organized in such a way as to develop a coherent narrative that follows the path of RULA, as it developed and became commonly used, points of consensus, as well as areas of current discussion in the field.The Development and Theoretical Underpinning of the RULA Tool: Framework and Scoring System: RULA was created as a direct result of a gap in the arsenal of tools available to the ergonomist: a rapid and initial level of assessment that would allow to tell whether job or task needed further examination. The tool was based on the well-known ergonomic principles that associate this or that risk factor with WMSDs, specifically in the upper body (McAtamney and Corlett, 1993). These are the main principles: Awkward Postures: The movement of body parts out of its neutral posture will add stress on muscles, tendons and joints. Statical Muscle Loading: The processes of sustained postures cause muscle fatigue, decreased blood circulation and accumulated metabolites. Repetition: Intense repetitions are likely to cause strain and inflammation of tissues. Force/External Load: The intensity of load on the joints and muscles is directly related to the intensity of the force used or dealt with. RULA translates these concepts into a straightforward paper-based workbook, which enables even complicated biomechanical information to be displayed as visual aids and decision trees.

Procedure of Step-by-Step Assessment: RULA assessment is systematic at step-by-step: Data Collection: The assessor observes the worker, usually during a task cycle recording the worst or most representative position of the job through direct observation, shooting or recording video. Body Segment scoring: The posture is scored in two categories: Group A (Upper Limb) The position of upper arm, lower arm and wrist are assessed separately with reference diagrams providing a score depending on the flexion/extension, abduction, and rotation angle. Group B (Body and Neck): The level of neck, trunk, and legs positions are also rated. Muscle Function and Load Adjustment Each group is then assigned its initial posture score which is then adjusted according to: Muscle Use Score: Did the posture include any movement or was stationary (held more than 1 minute) or did the posture involve repeated/rapid movements. Force/Load Score: This is the level of force used or weight manipulated (it is divided into <2kg, 2-10kg, or >10kg). Final Score Calculation: An adjusted Group A and Group B score would be determined by the use of a final scoring table to create a Grand Score of 1 to 7. Action Level Determination: The Grand Score is applied to one of four Action Levels: Action Level 1 (Score 1-2): Good as long as not continued or sustained with a long period of time, the posture is acceptable. Action Level 2 (Score 3-4). This should be further examined and adaptation might be necessary. Action Level 3 (Score 5-6): There is a need to investigate and make changes in the nearest future. Action Level 4 (Score 7): The changes and investigation are needed as soon as possible. Action Level Interpretation: Action Level system is the key output of the tool that can be used in making decisions. It is purposely meant to be conservative so that it focuses on sensitivity (finding potential risk) rather than specificity. Level 3 or 4 score and above serves as an obvious "red flag," which requires an ergonomic intervention. At level 1 and 2, though less risky, does not always mean that the task is safe, particularly when it is of long duration, which underlines the importance of using the tool as a screener, but not a final risk classifier.

RULA Applications has found to use across a very broad range of industries, suggesting that RULA is a useful tool in the generic postural evaluation industry Manufacturing and Industry: This is where RULA has always been the norm. It is widely applied to the measurement of the workers of assembly lines, machine operators, and packaging personnel, and the work of which is often associated with repetitive movement of upper limbs and fixed postures. Research has used RULA to determine high-risk workstations in both automotive production (Graveling et al., 2003) and electronic production (which frequently results in redesign of workstations to lessen postural load).

Office and Computer Work: RULA has been assumed to be a common tool in office ergonomics assessment with the spread of computer-based work. It is employed to analyze the posture of users in the video display terminal (VDT), the risks that have been created by non-adjustable chairs, monitor height, and keyboard/mouse positioning (Choobineh et al., 2004). The simplicity of it enables mass screening of office employees to put priority on those who need to be trained or supplied with ergonomic equipment.

Healthcare: WM is very susceptible to healthcare professionals. RULA has been implemented to evaluate:

Surgical Teams: The analysis of stationary and awkward positions that are maintained during protracted operations (Kee and Seo, 2007). Dentists, Assessment of the flexion of the neck and back in the treatment of the patient. Nurses:Although it cannot be properly used in patient lifting (a high-force, dynamic activity), it has been applied to measuring postures during medication preparation, computer documentation, and other non-mobility activities.

Education: An up-and-coming field of implementation is musculoskeletal discomfort that is associated with classroom settings and assessed in children. RULA was applied to the sitting posture of the students on standard chairs, on computers or tablets (Patel et al., 2014), and even to estimate the risk of schoolbags being carried by overweight students. This extension emphasizes the versatility of the tool on the conventional occupational health.

Emerging and Non-Traditional Sectors: It has been shown to be used in the agricultural, retail (cashier work), logistics (order picking), and food service industries, showing that it is a universal first-pass assessment tool of postural risk in any environment where people must work in sustained postures.

Psychometric Properties: Reliability and Validity: Consistency and accuracy determine the usefulness of any assessment tool. RULA psychometric properties have been studied in a wide range of studies.

Reliability: Reliability defines how similar is the measure in case of different raters or the same rater in different periods of time. Inter-Rater Reliability: The research usually gives moderate to good inter-rater reliability with intraclass correlation coefficients (ICCs) in the range of 0.6 to 0.8 (Dieën et al., 2001). But reliability is much affected by the training and experience of the rater Untrained users are very unreliable, whereas trained ergonomists are much more reliable. The most frequent disagreement is encountered in the classification of intermediate postures in between the diagrammatic illustrations. Intra-Rater Reliability: Intra-rater reliability (ICC to over 0.75) is good when the assessor is the same trained assessor when assessing the same postures at different times, which suggests an internal consistency.

Validity: validity determines whether the tool measures what it is designed to measure. Face and Content Validity: RULA has been universally accepted to be of high face validity intuitively it appears to be measuring postural risk. Its content validity, which is based on the fact that it is based on the biomechanical principles and is designed by professionals, is also deemed to be strong. Criterion Validity: This is the most controversial one. Criterion validity is the relationship between RULA scores and a gold standard of musculoskeletal load or disorder in comparison to electromyography (EMG), correlations tend to be moderate. Usually RULA is practical in differentiating distinctly good and distinctly bad poses but less precise in distinguishing among moderate-risk poses where differences in muscle activity are less obvious (David, 2005). It correlates more with subjective scale of discomfort or pain indicating that it is an effective predictor of perceived strain, a clinically relevant outcome (Dockrell et al., 2010). Predictive Validity: Longitudinal studies of high RULA scores predicting the future development of WMSD symptoms offer the greatest support in the use of it. Although they are small in size, some studies have established that employment with Action Levels 3 or 4 is correlated with far more reports of neck and shoulder pain (e.g., Janowitz et al., 2006).

Criticisms, Limitations, and Contemporary Debates: RULA, even with its popularity, does not go without limitations and a critical analysis of them is the key to the successful application. Absence of Postural Granularity: The posture diagrams have general categories (e.g. "arm raised between 20 and 45 degrees). This may result in information loss and two postures with different risks in clinical terms may be assigned the same score. It might not be sensitive enough to locate any minor but significant progress after an intervention.

Dynamic vs. Static Task Assessment: RULA was developed to provide a snapshot examination of a static or quasi-static pose. It finds it difficult to cope with very dynamic actions whose postures are in a fast transition. The choice of the single worst posture position is subjective and it may not reflect the cumulative of peak load. It fails to sufficiently consider movement velocity or frequency of changing the posture.

The Subjectivity and the Dilemma of the Worst Posture: The direction to mark the worst posture is subjective in nature and may differ among assessors. This will directly influence the ultimate mark and action point which is a drawback to standardized evaluation between various evaluators or location.

Streamlined Management of Force and Duration: Force/load adjustment is crude (three types). It does not make a distinction between gripping, pushing and pulling forces. More importantly, RULA fails to give specific marks on the length of time and recovery time of work, which are fundamental determinants of cumulative risk. A 30-second high-risk pose could be less alarming than a 4-hour moderate-to-high-risk pose, but RULA would not treat them differently. Another major development of today is the task of integrating RULA into DHM software (e.g., Siemens Jack, RAMSIS, AnyBody). Such systems enable ergonomists to simulate an imaginary human being in an electronic working area and automatically determine the RULA scores of the postures proposed. This is effective to proactive design but its scoring can be different, than interpretation by a human rater and it has all the inherent flaws of the original RULA methodology.

Future Directions and Conclusion: The intelligent augmentation is the way forward of RULA. Investigations are underway: Computer Vision and AI: Automatically detecting posture in video using machine learning algorithms and putting the RULA scores on-the-fly, allowing the continuous monitoring of a person. Wearable Sensors: combining the information of inertial measurement units (IMUs) to get objective and continuous posture monitoring that could be used to inform or even automatically perform RULA-like examinations at a higher level of precision.

Population-Specific and Task-Specific Modifications: Studies should be conducted on proven modifications to the scoring thresholds or posture classifications of RULA in particular population groups (e.g., children, older workers) or highly intensive tasks (e.g., microsurgery, maintenance of aircraft), where the anthropometric or task requirements of the tool are very different than those of the normative base used to develop it.

Hybrid and Tiered Assessment Strategies: Tiered approach is increasingly being recommended as the best practice. RULA is an ideal Level 1 screening tool. High Action Level jobs or tasks to be assessed should then be assessed at Level 2 with more specific measures (e.g. Strain Index of hand/forearm tasks, OCRA of repetitive upper limb tasks, or direct instrumental measurements such as surface EMG). It combines the advantages of RULA with the speed of the latter and mitigates the drawbacks with further, more stringent analysis.

Conclusion: The Rapid Upper Limb Assessment (RULA) has become one of the main pillars of the cannon of ergonomics. Over 30 years, its power has been its abstract simplicity: to reduce complex biomechanical threat to a highly accessible and visual and act-able model. It is an ideal tool of quick screening, creating awareness, prioritizing resources and launching the process of the ergonomic intervention in a wide and truly impressive variety of environments: factory floors to school classrooms. Nevertheless, its simplicity is as this review highlights, a two-sided sword. Practitioners need to use RULA with a clear sense of its limitations: its roughness in classifying the posture, its difficulty working with dynamic tasks, its reliance on the skills of the rater, and its incompleteness in addressing the variables of time and force. It is, and is never designed, to be a replacement of finer biomechanical analysis. Finally, the long-term merit of RULA is that it is not a risk judge but a highly good conversation starter and risk flagging system. The further development of it, especially integrating with digital technologies and its intelligent application as a part of the tiered assessment approach, will make it a useful and efficient tool in the constant struggle to create healthier work environments and avoid work-related musculoskeletal discomfort.

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