Validity and Reliability of the Modified RULA (mRULA) among Public and Private Office Workers

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Abstract. The Rapid Office Strain Assessment (ROSA) is a valid and reliable simple observational tool specifically for computer workers however it does not include muscle/force loads as compared to the Rapid Upper Limb Assessment (RULA), which is the most commonly used tool regardless of occupations. A modified Rapid Upper Limb Assessment (mRULA) has been developed specifically for computer use among office workers, however, its validity and reliability has weak evidence from only a small pool of currently available studies. This study primarily aims to determine the validity and reliability - namely the external validity, internal consistency, and inter- and intra-rater reliability - of the mRULA in the assessment of ergonomic risk factors among public and private office workers. Secondly, this study aims to compare the ergonomic risk between office workers in public and private companies. This study is a quantitative psychometric study. Data were obtained through video method of participants from the selected public and private companies in their respective office workstations. Two assessors used both ROSA and mRULA tools for two trials. Results determined the external validity thru Pearson Correlation Test based on ROSA, internal consistency thru Cronbach alpha, inter-rater reliability thru Wilcoxon Signed Test, and intra-rater reliability thru the Intra-Class Coefficient of mRULA and compared public and private companies thru Mann Whitney U Test. significant difference, either in the public company ($Z = -6.218, p \text{ value} = .000$) or in the private company ($Z = -2.211, p \text{ value} = .027$), was found between ROSA and mRULA while approaching moderate internal consistency ($\text{Cronbach alpha} = 0.536$) was found.

1. Introduction
Work-Related Musculoskeletal Disorders (WRMDs) is a collective term for disorders of the body affecting muscular, skeletal, and other tissues whose cause has been linked to the work environment such as in cases of prolonged usage of computers among office workers. The neck, shoulder, and upper limbs are the most commonly affected segments [2]. These WRMDs lead to absences from occupational work, loss of income during such absences, individual costs, and costs for the public health system [3]. Development of WRMDs is attributable to factors such as age, sex, and work stress. However, job hazard analysis reveals that risk factors such as prolonged static muscle activity, repetitive movements, and physical conditioning are linked to WRMDs [4]. WRMDs of the upper
Extremities in particular are frequently reported, prevalent among office workers, and linked to other factors such as workstation designs, duration of keyboard and mouse usage, and the posture assumed during computer work [5]. Thus, increased use of computers poses a major health risk in the development of WRMDs and that preventive and corrective measures at the workplace are warranted [6].

Ergonomics is defined as the study of work systems and the work environment [7]. The goal of ergonomics is to optimize the interactions of humans with their work environment and technical equipment to maximize safety and efficiency [8]. By applying its basic principles, the workstation and equipment are designed to fit the size and capability of the worker, both to optimize their well-being and performance and to reduce the risks for WRMDs. Current studies on ergonomics encompass a variety of occupations, and while that is helpful in determining general trends and the prevalence of musculoskeletal conditions, it is not focused enough to establish more reliable and specific information about the ergonomic risk associated with certain tasks [9]. There is a deficit in the knowledge necessary to identify the level of ergonomic risk involved for specific types of tasks in both the private and public sector [10].

Different methods and tools have been developed to assess exposure to risk factors for WRMDs. These can be divided into three groups according to measurement technique: self-report, direct measurements, and observational methods. Self-report methods include worker diaries, rating scales, questionnaires, checklist, and interviews. These can be used to collect data on workplace exposure to both physical and psychosocial factors, however, these are not always reliable [11]. Direct method pertains to collection of data from sensors attached to the body. These sensors may cause discomfort and may influence the postural behavior of a subject making the method difficult to implement in real work situations. Lastly, observational method consists of two categories—simple and advanced observational methods. Observational method involves direct observation of a subject and his/her task.

Rapid Upper Limb Assessment (RULA) is the most commonly used simple observational ergonomic tool, which analyzes joint angle deviations of the wrist, elbow, shoulder, neck, and trunk regions from their neutral positions in different working positions [12]. It has been established as valid (moderate concurrent validity) and reliable (both inter- and intra-rater reliability of 0.41 to 0.80 respectively) and has shown a strong correlation between the scores obtained and the level of risk for musculoskeletal injuries [12,13]. It has the ability to briefly observe workers and acquire a quick impression of the workplace. Moreover, it is a pencil – paper observation that is easily performed without special training. However, it has no specification for certain jobs. In literature, this tool has been used not only among office workers but also used widely in other ergonomic settings [14]. RULA was originally developed for use among industrial workers, but a modified version for computer use among office workers has been developed. The modified Rapid Upper Limb Assessment (mRULA) has been designed to focus more on office work risk factors that include the wrist keyboard slope and number of hours working on the computer, unlike the RULA. As compared to ROSA, mRULA includes muscle activation/force load [14]. These tools focus on the upper limb, neck and shoulder, which are the most relevant body segments in WRMDs, and can be used as foundation for ergonomic programs. Further, these are easy to use and are readily available [13]. However, mRULA remains to be questionable in terms of its validity and reliability due to lack of sufficient study and evidence [15].

This study, therefore, aims to examine the internal consistency, external validity, and inter-rater and intra-rater reliability of the mRULA, in order to be applied to the office workers in the local setting. This study also aims to compare the ergonomic risk levels between public and private offices.

2. Materials and Methods

2.1. Research Design
A quantitative psychometric study design was utilized to quantify risk associated with computer work and to determine psychometric properties of the mRULA tool such as external validity, internal
consistency, and inter- and intra-rater reliability. As an ergonomic risk assessment tool, objective determination of these properties are imperative to ensure its effectiveness, and as the mRULA itself uses numerical values to score subjects, a quantitative study was used to establish objective connections between findings.

2.2. Participants
Convenience sampling was the method used to obtain participants of the study, as nine public and private companies were approached and invited to participate in the study, however, only the two companies included in the study responded affirmatively. The public and private companies are located at San Jose Del Monte and Meycauayan, Bulacan, respectively. A participant information sheet and a questionnaire was used. Population rather than sample size was assessed for eligibility in each company since agreement was done such that risk profiling will be for the company as a single entity.

2.3. Outcomes
The Modified RULA (mRULA) considers biomechanical and postural load requirements of job tasks on the neck, upper extremity and trunk. It evaluates body posture, force and repetition. Scores are entered for each body region and compiled on a given table to generate a single score that represents the level of ergonomic risk. It was established to increase its relevance for evaluating computer workers, and therefore scoring was modified as to wrist posture, slope of keyboard and time sitting in front of the computer during the day. An additional point was given in the upper arm component to work with raised shoulders or speak on the phone on average at least 10 minutes per hour, and sometimes "scrunching" of the neck when speaking on the phone (maximum of 1 point for any of these conditions). An additional point was also given in the wrist component if keyboard is unstable, keyboard wobbles, or keyboard is on an uneven platform as shown in Figure 1.

![Figure 1. Sample of An Assessment Using A Component of The Modified RULA32 Used Among Office Workers in Public and Private Companies](image)

2.4. Data Gathering
Data gathering initiated by the distribution and completion of information sheets and informed consent forms. Video method was used for accuracy and ability to review and replay observational data. Three researchers of the study filmed the participants in their respective workstations with their respective equipment during their office hours using Samsung NX1000 20.3 Megapixels, Nikon D3200 24.2 Megapixels, Nikon Coolpix S9300 16.0 Megapixels and Canon IVIS HF M51 cameras at sagittal view on the right side for approximately 30 minutes when the participant was sufficiently engrossed with their task during office hours. Each camera and tripod were at approximately 5 meters away from and perpendicular to the workstation and adjusted to the participant’s height to avoid distortion of the body
joint angles. To eliminate bias, the three assigned researchers of the video data gathering did not inform other student researchers, who implemented the assessment tools, of any impressions regarding the participants and the workstations. The session included lecture using a PowerPoint presentation to introduce ROSA and mRULA and detailing the allocation of the scores. This was followed by a practical session where raters could observe and evaluate four video clips of workers. On a non-working day the researchers conducted an ocular inspection and a trial set-up. Two researchers were filmed as test subjects at the workplace. All student researchers evaluated the test subjects from the trial set-up using ROSA and mRULA and based on their results, two were chosen to be assessors for the study.

2.5. Statistical Method

Data were encoded using Microsoft Excel 2013 and SPSS Version 22 was used. Shapiro-Wilk Test was used to examine the normality of data in order to determine whether or not parametric or nonparametric tests should be used to analyze data. As the data were not normally distributed, nonparametric tests were used with 5% alpha error used. Average values were also reported.

3. Result and Discussion

Figure 2 reveals that a great number of the participants in the study are females as opposed to males. Among the 44 office workers, 87% and 90% of the public and private office workers were female, respectively. The mean age of all the workers was 32 years old (SD: 10.96, median 28.5, ranging from 19-55), with the mean age of the workers in the public company at 40 years old (SD: 9.55, median 42.5, ranging from 23-55) and the mean age of the workers in the private company at 24 years old (SD: 5.24, median 22, ranging from 19-36). 67% of the population spends > 6 hours on the computer per day (71% public company, 66% private company) and 37% of the population spends > 1 hour continuously or > 4 hours per day on the computer without getting up (43% from the public company) as compared to 33% of the population spending < 30 minutes continuously or < 1 hour (40% private company). 45% of the population spends > 1 hour continuously or > 4 hours per day on the keyboard; 64% of those in the public company and 45% in the private company with < 30 minutes continuously or < 1 hour per day. 40% of the population spends 30 minutes to 1 hour continuously or 1 to 4 hours per day with the mouse (43% public company); 70% spends < 30 minutes continuously or < 1 hour per day in the private company. 74% of the population < 30 minutes continuously or < 1 hour per day on the telephone/phone (70% public company and 80% of the private company). 70% of the population is aware of the ergonomic risks in the workplace (70% public of the company and 50% of the private company).

![Population Pyramid](image)

**Figure 2.** Population Pyramid Among Office Workers in Public and Private Companies in Nov 2017-Jan 2018 (n=44)

External validity based on ROSA showed a significant difference (< 0.05), regardless of company sector. Table 1 shows difference between ROSA and mRULA both in the public company (Z = -6.218,
A difference in the median ROSA score between the public and private companies was observed, with the median ROSA score for public companies at 5.00 and for private companies at 7.00 (Z = -6.218, p value = .000) and in the private company (Z = -2.211, p value = .027). The analysis for internal consistency yielded a Cronbach alpha of 0.536, signifying that the items are not homogeneous.

### Table 1. Difference between ROSA and mRULA Among Office Workers in Public and Private Companies

| Variable | Public | Z [P value] | Private | Z [p value] |
|----------|--------|-------------|---------|-------------|
| ROSA     | Median | 5.00        | -6.218  | 7.00        |
| mRULA    | 7.00   | [.000]*     | 7.00    | .027]*     |

The summary of inter- and intra-rater reliability analysis of the mRULA are as follow. No significant differences were found for mRULA total scores between the two assessors. However, results showed differences between the two assessors for upper arm score (Z = -2.709, p value = .007), lower arm score (Z = -4.107, p value = .000), wrist score (Z = -3.329, p value = .001), neck score (Z = -3.584, p value = .000), and trunk score (Z = -5.155, p value = .000) for Trial 1 but no significant differences were noted across all components during Trial 2. Table 4 shows that between public and private companies, total mRULA scores revealed no significant difference between the two assessors; however, differences were noted in wrist score (Z = -2.441, p value = .015), neck score (Z = -2.408, p value = .016) and muscle use score (Z = -3.036, p value = .002). Moreover, Table 2 shows significant differences were noted between the two assessors in specific components within each company.

### Table 2. Comparison of mRULA between Assessors A and B Among Office Workers in Public and Private Companies

| Variable | Assessor | Public | Z [P value] | Private | Z [p value] |
|----------|----------|--------|-------------|---------|-------------|
| Upper Arm | A        | 3.00   | -1.692      | 3.00    | -2.196      |
|          | B        | 3.00   | [.091]*     | 3.50    | [.028]*     |
| Lower Arm | A        | 2.00   | -2.918      | 2.00    | -2.946      |
|          | B        | 2.00   | [.004]      | 2.00    | [.003]*     |
| Wrist    | A        | 3.00   | -4.53       | 4.00    | -4.381      |
|          | B        | 3.00   | [.651]      | 4.00    | [.000]*     |
| Neck     | A        | 2.00   | -2.455      | 2.00    | -3.318      |
|          | B        | 3.00   | [.014]*     | 2.00    | [.001]*     |
| Trunk    | A        | 1.00   | -3.958      | 1.00    | -3.369      |
|          | B        | 2.00   | [.000]*     | 2.00    | [.001]*     |
| Leg      | A        | 2.00   | -1.201      | 2.00    | -4.79       |
|          | B        | 2.00   | [.230]      | 2.00    | [.632]      |
The median grand ROSA score is 5, specifically 5 in the public company and 7 in the private company, which correspond to “high risk” and that workstations should be assessed further. According to ROSA, 90% of the population is at “high risk” and that workstations should be assessed further. Of that 90%, 59% came from the public company. Meanwhile, the median mRULA total score is 7, regardless of company sector, which indicates Action Level 4 wherein investigation and changes are required immediately. According to mRULA, 69% of the population belongs to Action Level 4, which indicates investigation and changes are required immediately. Of that 69%, 66% came from the public company. Table 3 shows no significant differences were found between public and private companies using mRULA; However, significant difference was noted using ROSA. Descriptive statistics also revealed that 70% of the population reports being aware of the ergonomic risks with 50% of the private company while 70% of the public company being aware of such risks.

Table 3. Difference of each tool among Office Workers in Public and Private Companies in Nov 2017- Jan 2018

| Variable | Difference between Public and Private (Z) | Significance (p value) |
|----------|------------------------------------------|------------------------|
| ROSA     | -6.531                                   | 0.000*                 |
| mRULA    | -0.641                                   | 0.521                  |

*Significant at p<0.005

4. Conclusion
For external validity, mRULA is independent of ROSA and screens individuals rather than assesses and quantifies risks in the work environment as ROSA, though both can suggest the level of action needed. The mRULA has moderate internal consistency and its reliability is dependent on the experience level of assessors, therefore additional investigation by an ergonomics and health and safety expert can be conducted. The researchers recommend the use of mRULA for screening postures and muscle force loads of individuals in the workplace, ROSA in assessing and quantifying risks involving the interaction between the individual and the workplace, and both tools to provide a comprehensive ergonomic risk assessment as to working postures and the working environment. Based from the results both companies may benefit from an ergonomic program to prevent the development of WRMDs.

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