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# Rapid upper limb assessment (RULA): validity and reliability evidences in identifying workplace ergonomics among bank employee's using computers

# Avaliação rápida de membros superiores (RULA): evidências de validade e confiabilidade na identificação da ergonomia do local de trabalho entre funcionários de bancos que usam computadores

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**RESUMO | INTRODUÇÃO:** Distúrbios musculoesqueléticos (DME) representam uma das principais causas de lesões e incapacidades ocupacionais. Postura corporal inadequada durante a digitação é associada com DME entre os usuários de computador. O RULA (*rapid upper limb assessment*) é um método subjetivo de observação da postura para utilização em investigações ergonômicas de postos de trabalho. **OBJETIVO:** Examinar a validade e confiabilidade do RULA aplicado a usuários de computadores do setor bancário. **MATERIAIS E MÉTODOS:** Amostra aleatória simples de bancários com medidas antropométricas (idade, altura e peso). A validade concorrente do RULA foi estabelecida na comparação com o instrumento validado de Avaliação Rápida do Corpo Inteiro (REBA). A confiabilidade intraexaminador do RULA foi estabelecida pelo investigador principal em dois ensaios no mesmo grupo de participantes, na mesma condição ambiental e nos mesmos tempos, com um intervalo de 2 dias. A confiabilidade interavaliadores foi estabelecida pelo investigador principal e outro pesquisador no mesmo grupo de participantes com as mesmas condições ambientais e com um intervalo de 2 minutos. **RESULTADO:** Total 301 participantes foram recrutados, sendo 170 participantes do sexo masculino e 131 do sexo feminino. O RULA apresentou alta correlação com o REBA (ρ = 0,91; p <0,001). A confiabilidade intra e interobservador do RULA foi excelente com ICC = 0,92 (0,90-0,94) e 0,91 (0,89-0,93), respectivamente. **CONCLUSÃO:** A validade e a confiabilidade do RULA foram estabelecidas entre bancários no uso de computadores, com excelente correlação e concordância interexaminadores.

**PALAVRAS-CHAVE:** Ergonomia. Ergonomia no local de trabalho. Ergonomia musculoesquelética. Risco ergonômico. Musculoesquelético.

**ABSTRACT | BACKGROUND:** Musculoskeletal disorders (MSDs) represent one of the leading causes of occupational injury and disability. Awkward body posture while typing is associated with MSDs among the computer users. RULA (rapid upper limb assessment) is a subjective observation method of posture analysis for use in ergonomics investigations of workplaces where work-related upper limb disorders are reported. To date, no data available on reliability and validity of RULA among the bank employee's using computers. **OBJECTIVE:** To examine the validity and reliability of RULA among the bank employees' using computers. **MATERIALS AND METHODS:** A sample of bank employee were recruited by simple random sampling technique to take part in this validity and reliability study. All anthropometric measurement was taken before the beginning of the study including age, height and weight. The concurrent validity of RULA was established with the criterion referenced, Rapid Entire Body Assessment (REBA). Principal investigator recorded both the scores of RULA and REBA to estimate the concurrent validity. Intra-rater reliability of RULA was established by the principal investigator across two trials on the same group of participants in the same environmental condition and same timings with a gap of 2 days. Inter–rater reliability of RULA was established by the principal investigator and another researcher on the same group of participants with in the same environmental conditions and same with a gap of 2 minutes. **RESULT:** Total 301 Participants were recruited in this study, in which 170 participants were males, and other 131 were females. Concurrent validity of RULA with the criterion measure REBA is found to be good as measured by spearman's rank correlation test, ρ=0.91 (p<0.001). Intra-and inter-rater reliability of RULA is found to excellent with ICC=0.92 (0.90-0.94) and 0.91 (0.89-0.93) respectively. **CONCLUSION:** Validity and reliability of RULA have been established among the bank employees' using computers. There exists good validity and excellent reliability among them.

**KEYWORDS:** Ergonomics. Ergonomics workplace. Ergonomics musculoskeletal. Ergonomic risk. Musculoskeletal.

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## Introduction

The International Labour Organization (ILO) and the World Health Organization (WHO) regard musculoskeletal disorders (MSDs) as a work-related disease, which is also referred to as a "new epidemic" that should be researched and solved[1]. MSDs have a huge impact on work-related absence and a high proportion of days lost is due to MSDs[2]. The work-related MSD is estimated to affect 4% of the total world population with addition of 160 million new cases of work-related disorder per year[3], according to the International Labour Office (ILO). Among them 15% of cases are from work-place factors particular to the biomechanical factors[4]. Overall this leads to reduction in production, absenteeism and early retirement[2]. Computers have become an integral part of offices and work places.

The banking sector in India is witnessing a tremendous change because of globalization, liberalization and other worldwide proceedings. The beginning of electronic banking reforms and widespread use of computers and setting up of ATMs nationally are changing model of bank employees working in India. However, there is also an increasing prevalence of upper quadrant symptoms with computer usage. Neck and shoulder pain have been found to be associated with prolonged working hours and improper sitting postures[5]. Sustained sitting postures and poor workstation designs have been found to be linked with development of musculoskeletal disorders among computer users[5]. Bankers have to work for prolonged durations on computer workstations and may have to work overtime as well.

Awkward body posture while typing is associated with MSDs among the computer users. RULA (rapid upper limb assessment) is a subjective observation method of posture analysis that focuses on the upper body where work-related upper limb disorders are reported. This tool requires no special equipment in providing a quick assessment of the postures of the neck, trunk and upper limbs along with muscle function and the external loads experienced by the body. A coding system is used to generate an action list which indicates the level of intervention required to reduce the risks of injury due to physical loading on the operator[6]. RULA was developed as a screening tool for exposure of adults to risk factors for work-related upper limb disorders, and takes into account the repetitive movements and force that may be required for a task. It was designed to be carried out quickly and with minimal equipment or change to the working environment, and with minimal disruption to those under observation. It requires no previous skills in observation techniques and is easy to learn. RULA has previously been shown to be reliable with adults. Statistical calculations were not published but the authors state that the scores indicated a high consistency among assessors.6 RULA is found to be valid and reliable for the rapid assessment of computer workers but not among the bank employees'[7]. Maintaining ideal body posture is essential for the prevention of MSD among this large population. This study aimed to examine the validity and reliability of RULA among the bank employees' using computers.

## Materials and methods

### Ethical statement

The Study protocol was approved from Institutional Ethical committee of Srinivas university, Mangaluru, Karnataka and the study was performed in correspondence with the guidelines assigned by ICMR 20178 and ground rules framed by Declaration of Helsinki (revised 2013)[9].

### Recruitment of participants

After obtaining the prior permission from the bank authorities, the sample of bank employees took part in this study. Written informed consent was obtained from all the participants before their enrolment in this study. All anthropometric measurement was taken before the beginning of the study including age, height and weight.

### Validity

The concurrent validity of RULA6 was established with the criterion referenced, Rapid Entire Body Assessment (REBA)[10]. REBA was designed for easy use without need for an advanced degree in ergonomics or expensive equipment. Using the REBA worksheet, the evaluator assigned a score for each of the following body regions: wrists, forearms, elbows, shoulders, neck, trunk, back, legs and knees. After the data for each region is collected and scored, tables on the form are then used to compile the risk factor

variables, generating a single score that represents the level of MSD risk

**Reliability**

Intra-rater reliability: Intra-rater reliability of RULA was established by the principal investigator across two trials on the same group of participants in the same environmental condition and same timings i.e. between 10:30 a.m. - 11:00 a.m. in the morning with a gap of 2 days. These measures were taken to minimize bias due to time variation.

**Rater training and testing**

For estimating inter-rater reliability, another equally qualified investigator attended a 45-min training session on the use of RULA. The session included a lecture/demonstration using a PowerPoint presentation to introduce RULA and detailing the allocation of the scores. This was followed by a practical session where raters could observe and evaluate four video clips of bank employee working on computers on a training DVD. Results were compared and discussed until the raters felt comfortable with RULA. Interpretations of the allocation of RULA scores were clarified. Following the training, raters were allocated an individual time for their testing session. Raters were randomly assigned DVD 1 or 2 depending on the order they walked into the room for the training session. A set of simple instructions was given to each participant before they started the testing session and the same procedure and protocol was adhered to for all raters. All testing took place under similar conditions with raters seated at a desk 3 m from a screen onto which the video clips were projected. Raters were asked to assess the right hand side posture of each bank employee. Each rater was allowed to take as much time as she required after each video clip to complete the RULA scoring sheet. A break was offered to participants after every eight video clips to prevent fatigue, as established during the pilot stage of the project. The testing protocol was repeated one week later. Each rater viewed the video clips on a different randomly selected DVD than that viewed during the earlier session. Rater bias was minimised by separating the two sessions by one week, by using a different DVD for each rater in session 1 and session 2 and by the fact that the raters were requested to complete the RULA assessment sheet, but the researchers calculated the scores at a later stage. On completion of testing the Grand Scores and the Action Levels were calculated and cross checked by two different researchers[11].

Inter-rater reliability: Inter–rater reliability of RULA was established by the principal investigator and one other researcher (physiotherapist with five years of clinical experience) on the same group of participants with in the same environmental conditions and same timings i.e. between 10:30 a.m. - 11:00 a.m. in the morning with a gap of 2 minutes. Two experienced raters analyzed independently three hundred and one video-tasks in a randomized order. Both the raters received training together. After training the raters received 301 video-tasks to analysis (test) and reanalysis (retest) in separate. Playback of the videos could be done as often as needed and they could use a stopwatch and calculator[12].

**Data analysis**

The normality of collected data was established by Kolmogorov-Smirnov test (n>50). As the data does not follow normal distribution the descriptive statistics of demographic characteristics were expressed in mean with 95% CI, median and range. Reliability was established by using intra-class correlation coefficient ICC (3, k) for inter-rater reliability and ICC (2, 1) for intra-rater reliability with 95% confidence interval (CI). According to Shrout and Fleiss (1979) ICC interpretation <0.5 denotes poor reliability, 0.5-0.75 to be moderate reliability, 0.75-0.90 shows good reliability and >0.90 as excellent reliability[13]. The concurrent validity of RULA was established with the criterion measure, REBA test by spearman's rank correlation coefficient test. As recommended by Donner et al.[14] and Walter et al.[15], the sample size for reliability study should be minimum of 50 (n = 50). The sample size for the correlation study is estimated using the formulae for the correlation study[16], $n = [(Z\alpha+Z\beta) / C]2 + 3$, where $C = 0.5 \times \ln [(1+r) / (1-r)]$; $Z\alpha = 0.01$ (type 1 error is 1% or level of significance at 0.01); $Z\beta = 0.04$ (power of the study is 96%); $r = 0.25$ (fair degree of correlation, Portney and Watkins criteria)[17]. Thus, the minimum sample size required is found to be, n = 290. Hence, we have recruited the sample of bank employees greater than the required sample size (n > 290). For all data analysis level of significance (LOS) was set as $p<0.01$. Statistical analysis of collected data was performed using the statistical package of social sciences (SPSS, version 20.0 Inc, Chicago, IL).

## Results

Total 301 Participants who fulfilled the inclusion criteria were recruited in this study, among them 170 participants were males. There were one missed to follow up documented. One participant from male was absent in the second day intra- rater reliability session. Normality of collected data was corroborated by using Kolmogorov-Smirnov test. Detailed demographic data of participants including mean with 95% CI, median and range was showed in Table 1. Table 2 displayed the gender specific demographic characteristics expressed in mean with 95% CI, which shows there were a significant difference (Mann Whitney U test) of height and weight between both the genders. But, no significance difference was identified in BMI. Concurrent validity of RULA with the criterion measure REBA by spearman's rank correlation test were describe in Table 3 and Figure 1 by a scatter plot graph, in which it was found that there is significant association between RULA and REBA (P<0.001). Intra-class correlation coefficient (ICC) of intra- rater and inter- rater reliability of RULA in assessing computer workers was elaborated in Table 4; Whereas Figure 2 displayed the reliability between two sessions by the same rater in measuring RULA with ICC and 95%CI, and reliability between two sessions by two different raters in measuring RULA with ICC and 95% CI was framed up in Figure 3. Figure 4 and 5 portrayed the intrarater reliability and interrater reliability by Bland Altman graph, in both the graph level of agreement lies with in 2SD.

**Table 1.** Demographic dimension of the participants recruited (n=301)

| Demographic dimensions | Mean (95% CI) | Median | Range |
|---|---|---|---|
| Age (years) | 38.1 (32.0-39.2) | 38 | 24-55 |
| Height (cm) | 172.2 (171.2-173.2) | 173 | 152-188 |
| Weight (Kg) | 80.7 (79.6-81.8) | 81 | 58-97 |
| BMI (Kg/m$^2$) | 27.1 (26.9 -27.3) | 27.4 | 20.3-28.7 |

**Abbreviations:** CI – confidence interval; cm – centimetres; kg – kilogram; BMI – Body Mass Index

**Table 2.** Demographic dimension of the male and female bank employee's recruited

| Demographic dimensions | Male (n=170) | Female (n-131) | p-value |
|---|---|---|---|
| Age (years) | 36.1 (34.7-37.4) | 40.8 (39.1-42.6) | 0.06 |
| Height (cm) | 178.2 (177.3-178.9) | 164.5 (163.3-165.6) | <0.001 |
| Weight (Kg) | 86.9 (86.0-87.8) | 72.7 (71.3-74.0) | <0.001 |
| BMI (Kg/m$^2$) | 27.4 (27.2-27.6) | 26.8 (26.5-27.2) | 0.48 |

**Abbreviations:** cm – centimetres; kg – kilogram; BMI – Body Mass Index

**Table 3.** Concurrent validity of Rapid Upper Limb Assessment (RULA) against criterion measure Rapid Entire Body Assessment (REBA) among the bank employee's

| Concurrent validity | RULA# | REBA# | Spearman's rank correlation ($\rho$) | p-value |
|---|---|---|---|---|
| **RULA Vs REBA** | 4.96 (3-7) | 5.98 (4-9) | 0.91 | <0.001 |

**Abbreviations:** # - Expressed in mean (range); REBA - Rapid Entire Body Assessment; RULA - Rapid Upper Limb Assessment

**Table 4.** Cronbach's alpha and intra class correlation coefficient for Intra- rater reliability and Inter –rater reliability of Rapid Upper Limb Assessment (RULA) among the bank employee's

| Reliability | Cronbach's alpha | ICC | 95% CI (ICC) |
|---|---|---|---|
| **Intra- rater** | 0.96 | 0.92 | 0.90-0.94 |
| **Inter- rater** | 0.95 | 0.91 | 0.89-0.93 |

**Abbreviations:** ICC – Intra class correlation coefficient; CI – confidence interval

**Figure 1.** Scatter plot describing the association between Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA)

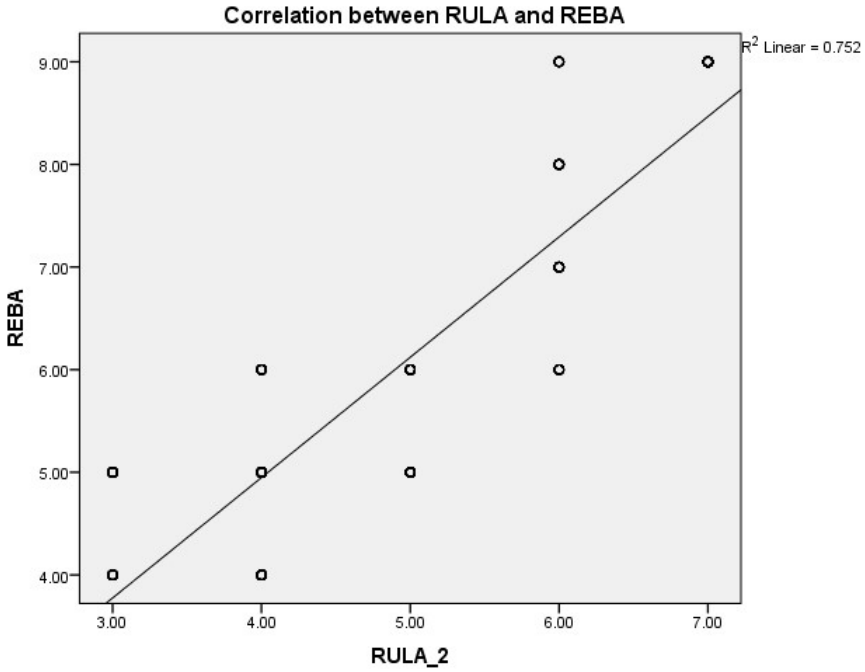



**Figure 2.** Scatter plot portraying the intrarater reliability of Rapid Upper Limb Assessment (RULA) among bank employees

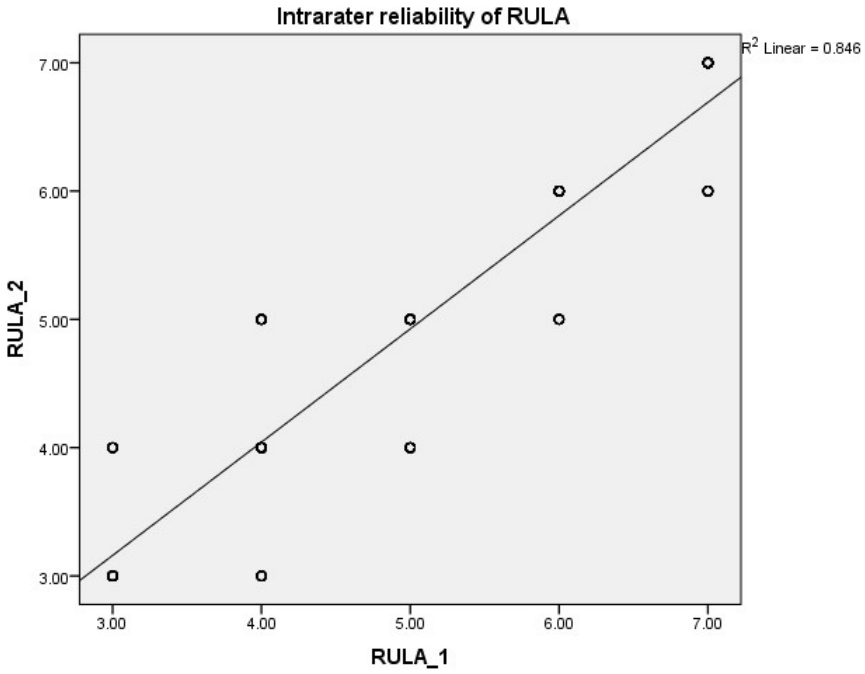


**Figure 3.** Scatter plot portraying the interrater reliability of Rapid Upper Limb Assessment (RULA) among bank employees

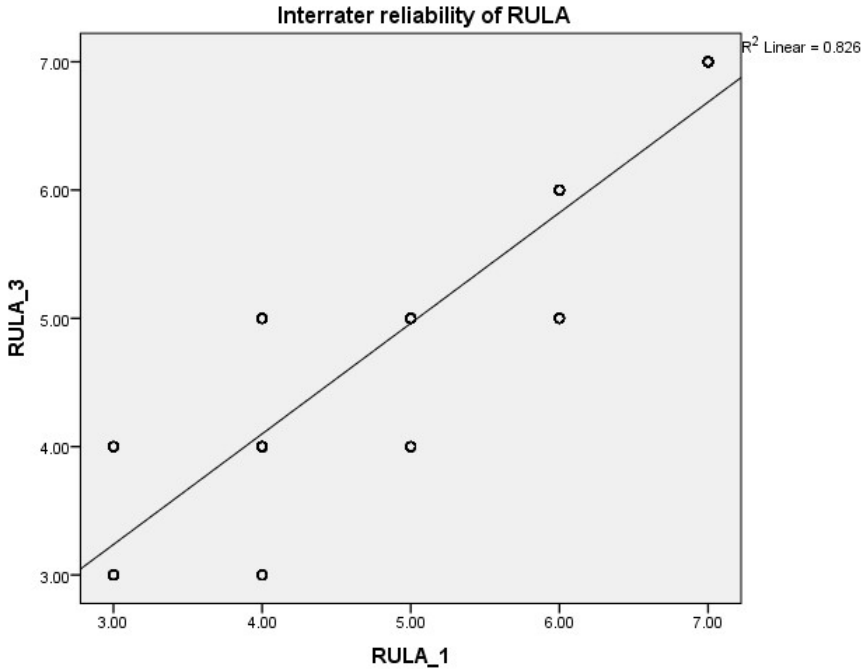



**Figure 4.** The Bland Altman graph shows level of agreement (LOA) in intrarater reliability of Rapid Upper Limb Assessment (RULA)

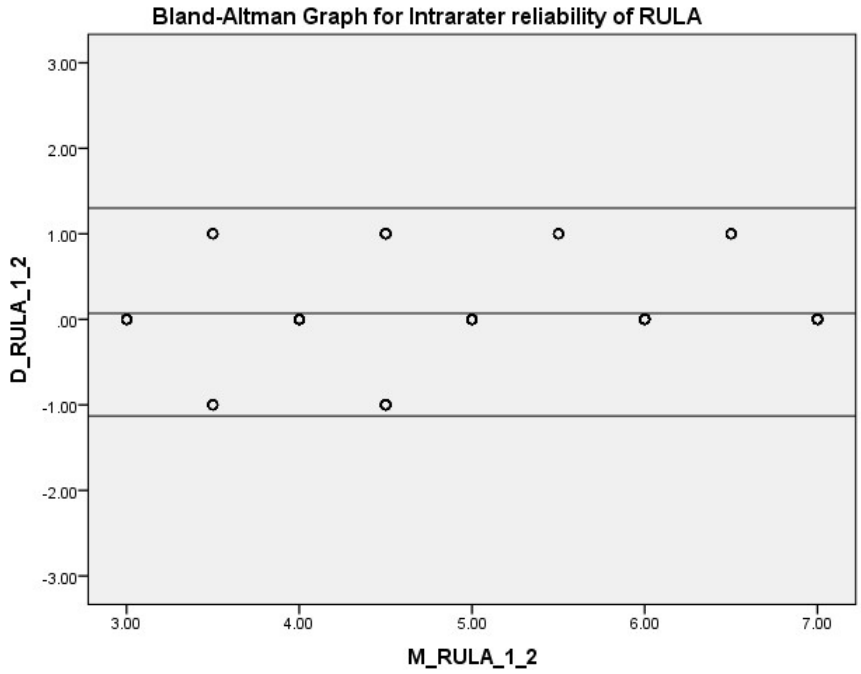
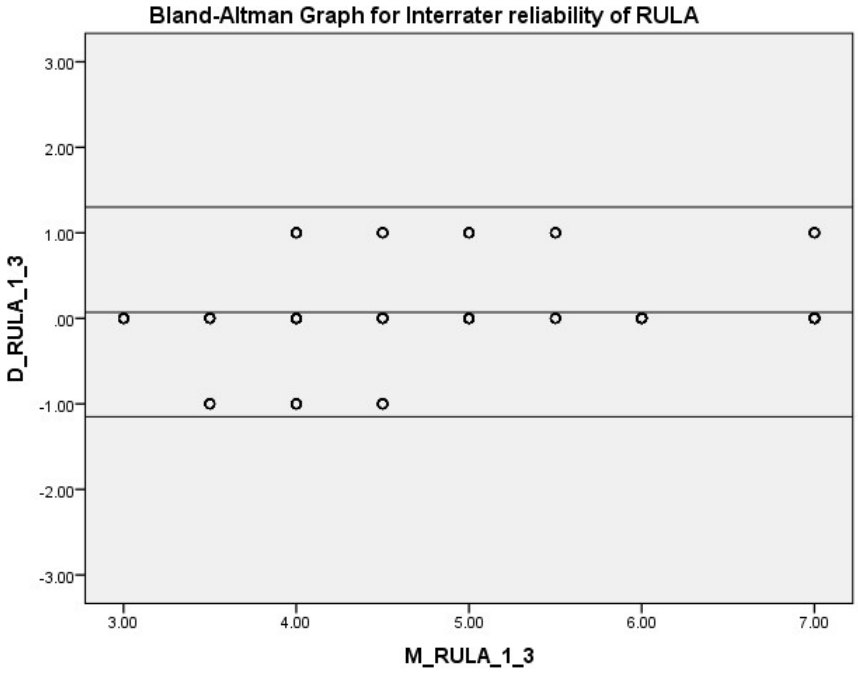


**Figure 5.** The Bland Altman graph shows level of agreement (LOA) in interrater reliability of Rapid Upper Limb Assessment (RULA)




## Discussion

In this study the validity and reliability of RULA is established. The result of the study demonstrated that RULA is found to be valid and reliable among bank authorities. According to Portney and Watkins criteria of judging the strength it shows good to excellent degree[17] of direct relationship between RULA and REBA and according to Shrout and Fleiss ICC interpretation it shows excellent intra-rater reliability as well as inter- rater reliability[13]. Thus, RULA has good concurrent validity with REBA and excellent intrarater and interrater reliability between sessions and ratters from. In Bland-Altman graph the level of agreement between two measurement fall with 2 SD and this confirms the statistical methods for assessing agreement between two methods of clinical measurement, RULA among the computer operators[18].

To best of our knowledge, this article is the first report of validity and reliability among bank employees by RULA. The reason for executing this study among the bank employees, is that the employee spent almost maximum part of working hours in-front of computers or laptops. The position of the computer while being used is an important predictor for developing musculoskeletal pain as this relates to the concept of ergonomic behaviour[19]. Working long hours without rest on a laptop or computer puts considerable strain on position of trunk and neck flexion with hyperextension of the upper cervical spine[20].

Habitual postures might get affected directly by the computer use. Even using computer for very low durations could have devastating effect on posture which might cause the permanent changes in the habitual posture through transient postural changes[20]. Other factors such as poor social functioning might lead to both greater amounts of computer use and changes in posture which may influence the computer use while we considering the habitual posture As the computer use does have a causal effect on habitual posture, the long-term effects on the musculoskeletal system is of potential our concern. Many of the changes in postural angles associated with computer use were consistent across different sitting conditions. For example, greater computer use was related to greater lumbar extension in females when looking ahead, looking down, and slumped sitting[20]. This trend probably relates to a high level of correlation between spinal angles across these three different sitting positions in both males and females. However, these associations tended to persist when standing[20]. The association between head flexion and computer use in males that was observed in the sitting position was similar to that observed during standing. Similarly, the association between lumbar angle and computer use in females observed in the sitting position was similar to that observed during

standing. These consistent associations indicate that computer use may exert an influence on habitual spinal postures[21].

Computer use could also affect habitual postures indirectly, like physical activity or pain. High levels of computer use may lead to reduced physical activity, with a subsequent reduction in muscle endurance that could affect habitual posture[22]. High levels of computer use may increase neck pain[20].

There are five variables which might affect the reliability of this study. They were, the work, the worker, the method, the rater and the time. The variable that may have affected directly reliability were time (test-retest) and the experience of the raters, even though it that confirmed that experience rater level contribute to significant differences in the RULA scores. In contrast, the raters were good agreement for the majority of the steps in inter-rater sassessment using RULA.

Levanon et al (2014) reported that mRULA was found to have moderate to good degree of (r=0.6-0.7) concurrent validity for the assessment of computer workers[7]. This is less valid when compared to our results of good degree of concurrent validity (ρ=0.91) of RULA against REBA. Similarly moderate to good degree of construct validity (r=0.69) against revised Upper Extremity Work Demand (UEWD-R) Scale[23] and strain index (ρ=0.61)[12]. The intra-raters' reliability for the Brazilian version RULA ranged from poor to almost perfect (k: 0.00-0.93) while the inter-raters' reliability was very poor for RULA (k: -0.12 to 0.13)[12]. Good test-retest reliability of ICC = 0.79 were reported by Cavalini et al.[23].

RULA demonstrated the ceiling effect only a little above the threshold of 10%. This finding indicates that the method has certain difficulty in distinguishing the level of risk exposure between the high-risk tasks, and may interfere in the classification for decision-making regarding the immediate or delayed intervention. The study had few limitations. First, unavoidable human error during the measurement of RULA and REBA. Second, the reliability and validity data should be extrapolated with cautious as the data was collected from single city. Nevertheless this is first study to demonstrate the validity and the reliability of RULA among the bank employees. Further the RULA can extend over among specially-abled population and also the test can also be performed among the patients with musculoskeletal and neurological disorders after the modifications.

## Conclusion

The results of this study suggested that RULA has excellent concurrent validity against the criterion referenced REBA. Another findings of this study is that RULA has excellent intra rater reliability and inter rater reliability among bank employee using computers.

### Author's contributions

Kumar A and Kamath S conceived and designed the study, conducted research, provided research materials, collected and organized data and wrote initial draft of article. Kamath S provided the logistic support. All the two authors approved the final draft.

### Competing interests

No financial, legal or political competing interests with third parties (government, commercial, private foundation, etc.) were disclosed for any aspect of the submitted work (including but not limited to grants, data monitoring board, study design, manuscript preparation, statistical analysis, etc.).

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