

# RULA: a survey method for the investigation of work-related upper limb disorders

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RULA (rapid upper limb assessment) is a survey method developed for use in ergonomics investigations of workplaces 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. It is of particular assistance in fulfilling the assessment requirements of both the European Community Directive (90/270/EEC) on the minimum safety and health requirements for work with display screen equipment and the UK *Guidelines on the prevention of work-related upper limb disorders*.

*Keywords:* Working posture, assessment, upper limb disorders, RSI

## Introduction

This paper describes the development of a posture, force and muscle use assessment tool. Called RULA (rapid upper limb assessment) this tool has undergone initial validation and reliability studies which are also reported upon here.

RULA was developed to investigate the exposure of individual workers to risk factors associated with work-related upper limb disorders. Part of the development took place in the garment-making industry, where assessment was made of operators who performed tasks including cutting while standing at a cutting block, machining using one of a variety of sewing machines, clipping, inspection operations, and packing. RULA was also developed through the evaluation of the postures adopted, forces required and muscle actions of both VDU operators and operators working in a variety of manufacturing tasks where risk factors associated with upper limb disorders may be present.

The method uses diagrams of body postures and three scoring tables to provide evaluation of exposure to risk factors. The risk factors under investigation are those described by McPhee' as *external load factors*. These included:

- numbers of movements;
- static muscle work;
- force;

- work postures determined by the equipments and furniture;
- time worked without a break.

In addition to these factors McPhee cited other important factors which influence the load, but which may vary *between individuals*. These were the work postures adopted, unnecessary use of static muscle work or force, speed and accuracy of movements, the frequency and the duration of pauses taken by the operator. Third, according to McPhee, are factors which altered the *individual's response* to a particular load, individual factors (such as age and experience), workplace environmental factors and psychosocial variables. Many other authors have also reported on risk factors associated with upper limb disorders<sup>2-8</sup>.

In an effort to assess the first four external load factors described above (number of movements, static muscle work, force and postures), RULA was developed to:

- 1 provide a method of screening a working population quickly, for exposure to a likely risk of work-related upper limb disorders;
- 2 identify the muscular effort which is associated with working posture, exerting force and performing static or repetitive work, and which may contribute to muscle fatigue;

3 give results which could be incorporated in a wider ergonomics assessment covering epidemiological, physical, mental, environmental and organizational factors, and particularly to assist in fulfilling the assessment requirements of the *UK Guidelines on the prevention of work-related upper limb disorders*.

RULA was developed without the need for special equipment. This provided the opportunity for a number of investigators to be trained in doing the assessments without additional equipment expenditure. As the investigator only requires a clipboard and pen, RULA assessments can be done in confined workplaces without disruption to the workforce. Those who are trained to use it do not need previous skills in observation techniques although this would be an advantage.

When reviewing the literature, various methods are found to assess the postures, movements and forces exerted while performing a job and their effect on the physical capacity and capability of the person. Survey methods have been developed to gather information about the musculoskeletal complaints reported by the working population'. Kemmlert and Kilbom<sup>10</sup> developed a checklist of questions which links risk factors at work with information about operator's reports of body part discomfort. Methods to evaluate the working posture are also reported upon, either by observation<sup>1,12</sup>, videotape, optical or frame-grabbing systems<sup>11</sup>. The use of task analysis to evaluate the forces exerted, frequency of movements and working postures adopted is reported by Drury<sup>15</sup>.

However, although all these methods are undoubtedly useful, they were developed for different purposes from RULA.

### The development of RULA

The development of RULA occurred in three phases. The first was the development of the method for recording the working posture, the second was the development of the scoring system, and the third was the development of the scale of action levels which provide a guide to the level of risk and need for action to conduct more detailed assessments.

#### STAGE I: The development of the method for recording working postures

To produce a method which was quick to use, the body was divided into segments which formed two groups, A and B. Group A includes the upper and lower arm and wrist while Group B includes the neck, trunk and legs. This ensures that the whole body posture is recorded so that any awkward or constrained postures of the legs, trunk or neck which might influence the postures of the upper limb are included in the assessment. The OWAS system<sup>8</sup>, which uses the concept of numbers to represent postures with an associated coding system, is a clear and concise method which can be used quickly. This was used as a suitable basis for RULA.

The range of movement for each body part is divided into sections according to criteria derived through interpretation of relevant literature. These sections are

numbered so that the number 1 is given to the range of movement or working posture where the risk factors present are minimal. Higher numbers are allocated to parts of the movement range with more extreme postures indicating an increasing presence of risk factors causing load on the structures of the body segment. This system of scoring each body part posture provides a sequence of numbers which is logical and easily remembered.

To allow easy identification of the posture ranges from the diagrams, each body segment is presented in the sagittal plane. If a posture cannot be represented in this way, for example when abduction occurs, the scoring to be adopted is described beside the diagram.

*Group A* Figure 1 shows the diagrams for scoring the posture of the body parts in Group A, which are the upper arm, lower arm and wrist, with a section to record the pronation or supination occurring (called 'wrist twist').

The ranges of movement for the *upper arm* were assessed and scored on the basis of findings from studies carried out by Tichauer<sup>16</sup>, Chaffin<sup>17</sup>, Herberts *et al*<sup>18</sup>, Hagberg<sup>19</sup>, Schuldt *et al*<sup>20</sup>, and Harms-Ringdahl and Schuldt<sup>21</sup>. The scores are:

- 1 for 20° extension to 20° of flexion;
- 2 for extension greater than 20° or 20–45° of flexion;
- 3 for 45–90° of flexion;
- 4 for 90° or more of flexion.

If the shoulder is elevated the posture score derived as above is increased by 1. If the upper arm is abducted the score is increased by 1. If the operator is leaning or the weight of the arm is supported then the posture score is decreased by 1.

The ranges for the *lower arm* are developed from work by Grandjean<sup>22</sup> and Tichauer<sup>23</sup>. The scores are:

- 1 for 60–100° flexion;
- 2 for less than 60° or more than 100° flexion.

If the lower arm is working across the midline of the body or out to the side then the posture score is increased by 1.

The guidelines for the *wrist* issued by the Health and Safety Executive<sup>23</sup> are used to produce the following posture scores:

- 1 if in a neutral position;
- 2 for 0–15° in either flexion or extension;
- 3 for 15° or more in either flexion or extension.

If the wrist is in either radial or ulnar deviation then the posture score is increased by 1.

Pronation and supination of the wrist (*wrist twist*) are defined around the neutral posture based on Tichauer<sup>24</sup>. The scores are:

- 1 if the wrist is in mid-range of twist;
- 2 if the wrist is at or near the end of range of twist.

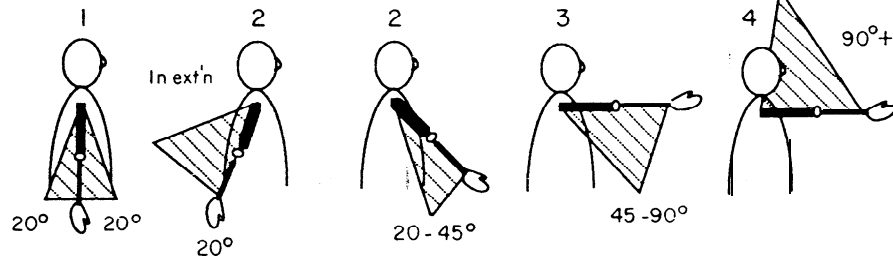
*Group B* The posture ranges for the *neck* are based on studies by Chaffin<sup>17</sup> and Kilbom *et al*<sup>3,25</sup>. The scores and ranges are:

Upper arms

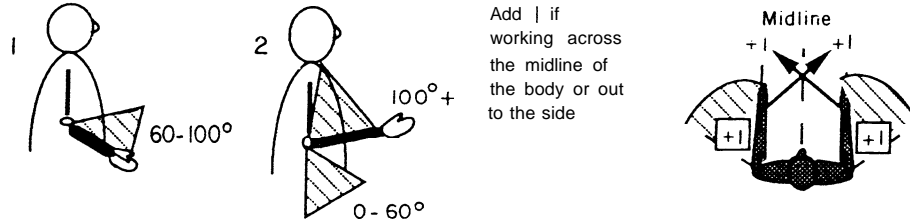
Add 1 if shoulder is raised

Add 1 if upper arm is abducted

Subtract 1 if leaning or supporting the weight of the arm

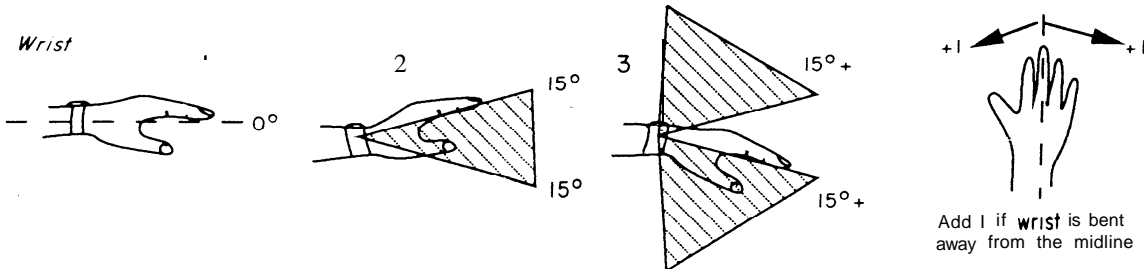


Lower arms



Add 1 if working across the midline of the body or out to the side

Wrist



Add 1 if wrist is bent away from the midline

Wrist twist

1 Mainly in mid-range of twist

2 At or near the end of twisting range

Figure 1 The posture scores for body part group A, the upper arm, lower arm, wrist and wrist twist

- 1 for 0-10° flexion;
- 2 for 10-20° flexion;
- 3 for 20° or more flexion;
- 4 if in extension.

If the neck is twisted these posture scores are increased by 1. If the neck is in side-bending then the score is increased by 1 (Figure 2).

The ranges for the trunk are developed from Drury<sup>15</sup>, Grandjean<sup>16</sup> and Grandjean *et al.*<sup>17</sup>.

- 1 when sitting and well supported with a hip-trunk angle of 90° or more;
- 2 for 0-20° flexion;
- 3 for 20-60° flexion;
- 4 for 60° or more flexion.

If the trunk is twisting the score is increased by 1. If the trunk is in side-bending, the score is increased by 1.

The leg posture scores are defined as:

- 1 if the legs and feet are well supported when seated with weight evenly balanced;
- 1 if standing with the body weight evenly distributed over both feet, with room for changes of position;
- 2 if the legs and feet are not supported or the weight is unevenly balanced.

*Recording the posture score* The assessment commences by observing the operator during several work cycles in order to select the tasks and postures for assessment. Selection may be made of the posture held for the greatest amount of the work cycle or where highest loads occur. As RULA can be conducted quickly, an assessment can be made of each posture in the work cycle. When using RULA, only the right or left side is assessed at a time. After observing the operator it may be obvious that only one arm is under load; however, if undecided, the observer would assess both sides.

Using Figure 1 the observer records the posture scores for the upper arm, lower arm, wrist and wrist twist in the column of boxes marked A on the left side of the score sheet (Figure 3). Similarly, using Figure 2, the posture scores for the neck, trunk and legs are calculated and recorded in the column of boxes marked B on the score sheet.

The level of detail required in RULA was selected to provide enough information upon which initial recommendations can be made, but also to be brief enough to be administered quickly as an initial screening tool. The balance of detail was discussed and developed over some time with the assistance of four ergonomists and an occupational physiotherapist.

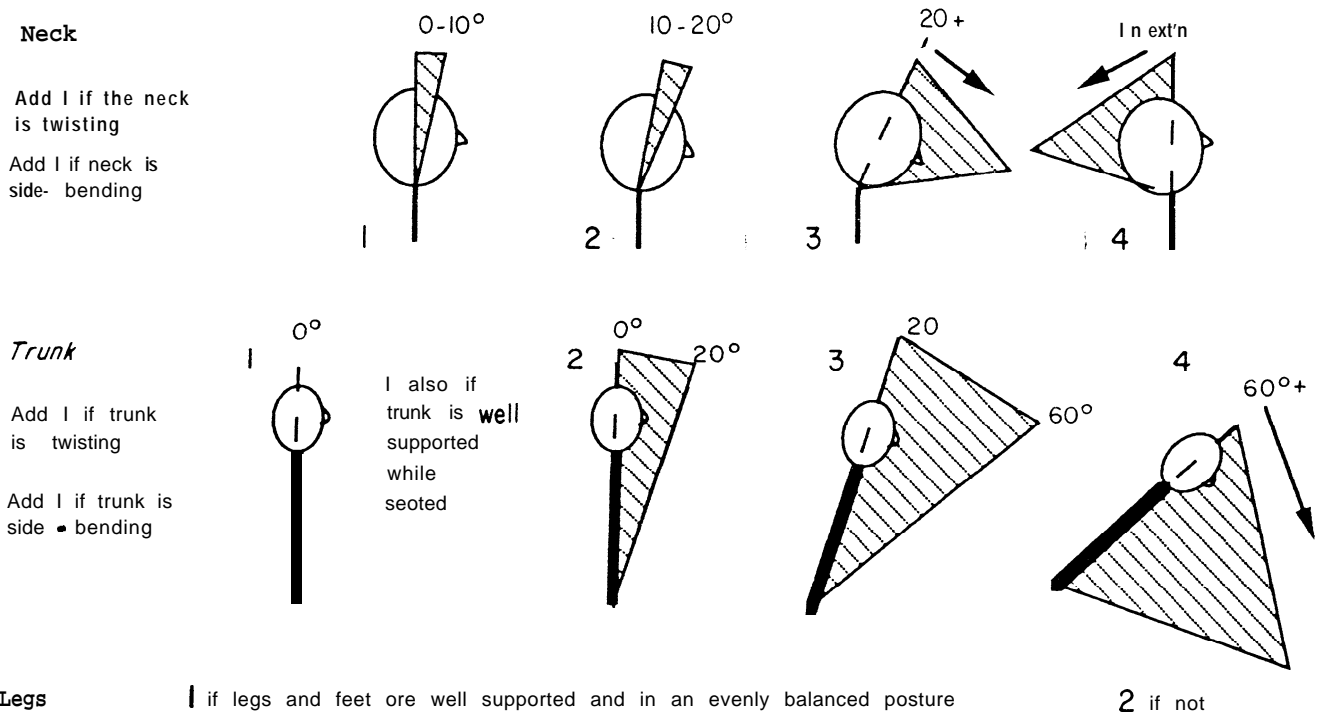


Figure 2 The posture scores for body part group B, the neck, trunk and legs

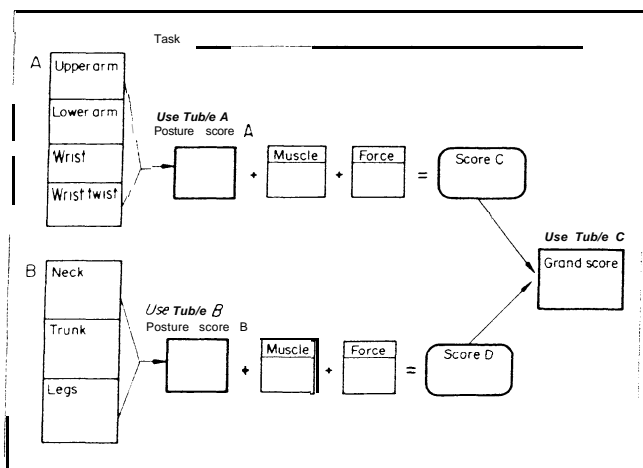


Figure 3 The RULA scoring sheet

To provide a quickly administered screening tool, some detail is excluded from the RULA method and can be considered in further developments. Most noticeably, the postural assessment of the fingers and thumb may be required in some investigations where exposure to risk factors is high for these digits. RULA does not include such detail, although any force exerted by the fingers or thumb is recorded as part of the assessment procedure.

**STAGE 2: Development of the system for grouping the body part posture scores**

A single score is required from the Groups A and B which will represent the level of postural loading of the musculoskeletal system due to the combined body part

postures. The first step in establishing such a system was to rank each posture combination from the least to the greatest loading based on biomechanical and muscle function criteria<sup>27</sup>. This process was conducted over some time by two ergonomists and an occupational physiotherapist. Each ranked the postures on a scale from 1 to 9. A score of 1 was defined as the posture where the least musculoskeletal loading occurred. Where differences in the scores occurred the loads on the musculoskeletal system were discussed and a score agreed. This produced a table of consolidated body segment posture scores called posture score A and B respectively.

The next step was to observe video recordings of ten subjects who performed one of five tasks. The tasks were data processing operations, sewing machine operations, production line packing, brick sorting and a wire-twisting task. The posture scores A and B were calculated and ordered from the lowest to the highest. Then the videotaped postures were reviewed in order of their scoring so that the level of musculoskeletal loading was compared for each posture score to reveal any inconsistent scoring. The inconsistencies found were discussed and several adjustments to the scores were subsequently made. From this process tables were developed for groups A and B which were titled Table A (see Table 1) and Table B (see Table 2) and are presented below. When the posture scores for each body part are recorded in the columns of boxes A and B (Figure 3), they are used in Tables 1 and 2 to find the combined scores called score A and score B. This is usually done after the survey is completed.

**Muscle use and force scores** A scoring system was developed to include the additional load on the

**Table 1 Table A into which the individual posture scores for the upper limbs are entered to find posture score A**

Upper arm	Lower arm	Wrist posture score							
		1		2		3		4	
		W. twist	W. twist	W. twist	W. twist	W. twist	W. twist	W. twist	W. twist
		1	2	1	2	1	2	1	2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	<b>4</b>	<b>4</b>	<b>4</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>6</b>	<b>6</b>
5	1	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>6</b>	<b>6</b>	<b>7</b>
	2	<b>5</b>	<b>6</b>	<b>6</b>	<b>6</b>	<b>6</b>	<b>7</b>	<b>7</b>	<b>7</b>
	3	<b>6</b>	<b>6</b>	<b>6</b>	<b>7</b>	<b>7</b>	<b>7</b>	<b>7</b>	<b>8</b>
6	1	<b>7</b>	<b>7</b>	<b>7</b>	<b>7</b>	<b>7</b>	<b>8</b>	<b>8</b>	<b>9</b>
	2	<b>8</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>9</b>	<b>9</b>	<b>9</b>
	3	<b>9</b>	<b>9</b>	<b>9</b>	<b>9</b>	<b>9</b>	<b>9</b>	<b>9</b>	<b>9</b>

musculoskeletal system caused by excessive static muscle work, repetitive motions and the requirement to exert force or maintain an external load while working. These scores are calculated for each of the groups A and B and recorded in the appropriate boxes on the score sheet. After the scores A and B have been calculated from Tables 1 and 2, the muscle use and force scores and added to them as shown below (see Figures 4 and 5):

Score A + muscle use and force scores for group A = Score C

Score B + muscle use and force scores for group B = Score D

Assessment of the amount of static loading or forces exerted which will cause fatigue and subsequent tissue damage is dependent upon the time that the operators are exposed to the external risk factors. RULA provides a simplified and conservative rating system to be used as a guide to indicate whether these risk factors are present. It would be the function of a subsequent more detailed assessment to establish their extent and effect on the operator's wellbeing and work.

In recent years studies have shown that very **low** levels of static loading are associated with muscle fatigue. Björkstén and Jonsson<sup>28</sup> have shown that static muscle work maintained for over 1 h should not exceed 5-6% of maximal voluntary contraction (MVC). Jonsson<sup>29</sup> further suggested that static loading is acceptable only if it is lower than 2% of MVC when maintained for the entire working day. Grandjean<sup>22</sup> quantifies static loading in three categories relating to the forces required. If a high force is exerted static muscle actions should be for less than 10 s; for a moderate force, less than 1 min, and for a low force, less than 4 min.

This was generalized in the RULA method so that the posture score (A or B) is increased by 1 if the posture is mainly static, that is, held for longer than 1 min.

The muscle use is defined as repetitive if the action is repeated more than four times a minute. This is acknowledged as a conservative general definition from which a risk may be present; however, further assessment would be required. Drury<sup>15</sup> provides a detailed assessment of repetition rate which is calculated with respect to the postures adopted.

The contributions of forceful actions or holding loads, such as a hand tool, are dependent upon the weight of the object, length of holding and recovery time as well as the adopted working posture. If the load or force is 2 kg or less and held intermittently then the score is 0. However, if the intermittent load is 2-10 kg a score of 1 is given. If the load of 2-10 kg is static or

**Table 2 Table B into which the individual posture scores for the neck, trunk and legs are entered to find posture score B**

Neck posture score	Trunk posture score											
	1		2		3		4		5		6	
	Legs	Legs	Legs	Legs	Legs	Legs	Legs	Legs	Legs	Legs	Legs	
	1	2	1	2	1	2	1	2	1	2	1	2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

<p>Give a score of 1 if the posture is</p> <ul style="list-style-type: none"> <li>mainly static, eg held for longer than 1 min</li> <li>repeated more than 4 times /min</li> </ul>
--

Figure 3 The muscle use scores which are added to posture score A and B

0	1	2	3
<ul style="list-style-type: none"> <li>No resistance or less than 2 kg intermittent load or force</li> </ul>	<ul style="list-style-type: none"> <li>2-10 kg intermittent load or force</li> </ul>	<ul style="list-style-type: none"> <li>2-10kg static load</li> <li>2-10kg repeated load or force</li> </ul>	<ul style="list-style-type: none"> <li>10kg or more static load</li> <li>10kg or more repeated loads or forces</li> <li>Shock or forces with a rapid build-up</li> </ul>

Figure 5 The force or load score which is added to posture score A and B

repeated the score is 2. The score is also 2 if the load is intermittent but more than 10 kg. Lastly, if the load or a force of more than 10 kg is experienced statically or repeatedly, the score is 3. If a load or force of any magnitude is experienced with rapid build-up or a jolting action the score is also 3. These ranges were developed from Putz-Anderson<sup>30</sup> and Stevenson and Baidva<sup>31</sup>.

The muscle use and force scores are assessed for the body part groups A and B and recorded in the boxes provided on the score sheet of Figure 3. These are then added to the posture scores which are derived from Tables 1 and 2 respectively to give two scores called score C and score D.

*STAGE 3: Development of the grand score and action list*

The third stage of RULA, and thus of its development, is to incorporate both score C and score D into a single grand score whose magnitude provides a guide to the priority for subsequent investigations. Each possible combination of score C and score D was given a rating, called a grand score, of 1-7 based upon the estimated risk of injury due to musculoskeletal loading (Figure 6). For a grand score of 1 or 2, the working posture would have scored 2 or less for both body segments groups A and B, and the scores for muscle use and force would be 0. Working postures and actions which have a grand score of 1 or 2 are considered acceptable if not maintained or repeated for long periods. A grand score of 3 or 4 will be given to working postures which are outside suitable ranges of motion as defined in the literature and also working postures which are within suitable ranges of motion but where repetitive actions, static loading or the exertion of force are required. Further investigation is needed for these operations and changes may be required. A grand score of 5 or 6 indicates those working postures which are not within suitable ranges of motion: the operator is required to perform repetitive movements and/or static muscle work, and there may be a need to exert force. It is suggested that these operations are investigated soon and changes made in the short term while long-term measures to reduce the levels of exposure to risk factors are planned. A grand score of 7 would be given to any working postures at or near the end of range of

movement where repetitive or static actions are required. Any postures where the forces or loads may be excessive are also included in this group. Investigation and modification of these operations is required immediately to reduce excessive loading of the musculo-skeletal system and the risk of injury to the operator.

The requirements for action into which the grand scores are divided is summarized into *Action levels* as follows:

*Action level 1*

A score of 1 or 2 indicates that posture is acceptable if it is not maintained or repeated for long periods.

*Action level 2*

A score of 3 or 4 indicates that further investigation is needed and changes may be required.

*Action level 3*

A score of 5 or 6 indicates that investigation and changes are required soon.

*Action level 4*

A score of 7 indicates that investigation and changes are required immediately.

The higher action levels will not, however, lead to unequivocal actions to eliminate any risks to the operator. It must be strongly emphasized that, since the human body is a complex and adaptive system, simple methods cannot deal in simple ways with postural and loading effects on the body. What the RULA system provides is a guide, and it was developed to draw boundaries around the more extreme situations. However, the combination of factors which influence the load but vary between operators, and factors which alter the individual's response to a particular load, may contribute to increasing the load from being within acceptable boundaries to being a serious problem for some people.

For these reasons the action list leads, in most cases, to proposals for a more detailed investigation. To draw

		Score D (neck, trunk, leg)						
		1	2	3	4	5	6	7+
Score C (upper limb)	1	1	2	3	3	4	5	5
	2	2	2	3	4	4	5	5
	3	3	3	3	4	4	5	6
	4	3	3	3	4	5	6	6
	5	4	4	4	5	6	7	7
	6	4	4	5	6	6	7	7
	7	5	5	6	6	7	7	7
	8	5	5	6	7	7	7	7

Figure 6 Table C into which score C (posture score A plus the muscle use score and the force or load score) and score D (posture score B plus the muscle use score and the force or load score) are entered to find the grand score

the limits too tightly would lead to an undue expense in changing jobs without any guarantee that those still within the boundary would be safe. Hence the use of RULA will give a priority order for jobs which should be investigated, while the magnitude of the individual posture scores and the muscle use or exerted force scores indicate which aspects of the postures are likely to be those where trouble will be expected.

It should be noted that while RULA provides a guide to the risks associated with work-related musculoskeletal injuries there is no substitute for some understanding of occupational ergonomics if sound decisions are to be made on the basis of the information, when redesigning operations.

### Assessment of the validity and reliability of RULA

To assess the validity of RULA an experiment was conducted in an ergonomics laboratory using a VDU-based data-entry operation. Under laboratory conditions the exposure of operators to postural loading could be controlled. The aim of the experiment was to establish whether RULA assessments provided a good indication of musculoskeletal loading which might be reported as pain, ache or discomfort in the relevant body region.

Sixteen experienced operators (1 male and 15 female, mean age 32.4 years) performed a VDU-based data-entry task of 40 min in one of two working postures. Each operator completed eight tasks (four in each posture condition) during four sessions which were conducted at the same time of day during four consecutive weeks. The order of postures was randomized.

A height-adjustable chair and monitor stand were used with a VDU table and footstool. The equipment was adjusted so that each subject was in a posture which gave a RULA score of 1 for the first experimental condition. For the second condition, the screen was placed on the table so that it caused 20° or more neck flexion; the keyboard was placed so that the forearms were flexed more than 90°, the right wrist was extended and in ulnar deviation. In addition, the foot support was removed.

The task required data entry only, using the right-side number pad. The data for keying were presented on the screen to control for neck posture changes. Before starting and at the completion of each task the subjects marked any areas of pain, ache or discomfort they were experiencing on a body map based on the Corlett and Bishop body part discomfort (BPD) method<sup>1</sup>. Recording of RULA was conducted 15 min after starting the task when the operator had settled into a working rhythm and posture. The right side of the body was evaluated, as that was the arm experiencing higher musculoskeletal loading.

#### Individual body parts

For each of the body parts, (neck, trunk, upper arm, lower arm and wrist) the RULA scores were divided into two groups. The operators with a posture score of 1, which is defined as an acceptable working posture.

were put in the first group. The second group included all other operators regardless of how high their posture score was. While postural discomfort is frequently used as a guide to evaluating working postures and workplace fit, there is a wide variation in the length of time before operators perceive discomfort and in the level of discomfort which they report. To have conducted these trials over a longer period would have provided higher scores; however, it is known that operators adjust their working posture to relieve loading on areas which are uncomfortable. A large number of subjects would have been required if this study was to test the relationship of the magnitude of a RULA score to the magnitude of pain, ache or discomfort. The aim of this study was to establish if the RULA scoring could reflect whether or not a working posture was in the acceptable range as defined earlier.

The  $\chi^2$  statistical test was used to determine the association between the subject's score defined by this grouping and any reported pain, ache or discomfort from that body part region. The results are given in Table 3.

The relationship of the individual RULA body part scores to the development of pain or discomfort is statistically significant for the neck and lower arm scores ( $P < 0.01$ ) and not significant for the trunk, upper arm or wrist scores.

The statistical significance of the neck and lower arm body part scores reflects the high loading of these body parts while performing a VDU-based task. Functionally, the neck-shoulder region experiences static muscle fatigue contributed to by the load of the arms and their position". The lower arm region includes the muscles and associated soft tissue structures responsible for the posture and action of the wrist, hand and fingers. The task required constant keying so that the structures in the neck and shoulder region were performing a static posture function while the structures of the forearm performed high repetition rate and low force finger movements with no recovery period over the 40 min trial. With these experienced data-entry subjects the loading of these structures was sufficient to cause reporting of discomfort or pain of a significant level. Further studies of other tasks commencing with cash till operators are planned to evaluate the different associations of individual body part discomfort with the musculoskeletal loading from the working postures adopted.

#### Functional units

Assessing the effect of loading in all the structures when grouped as functional units would be achieved by relating posture scores A and B to the reporting of pain, ache or discomfort in the whole region. A  $\chi^2$  statistical test was again used and the operators' results were grouped according to whether there was a posture score of 1 or a score greater than 1 for both A and B scores. There was a highly significant association ( $P < 0.01$ ) between both posture scores A and B and reported pain or discomfort in the relevant functional unit regions (see Table 4).

The high statistical significance of the relation

**Table 3**  $\chi^2$  statistical analysis of the RULA body part scores (1 or > 1) and the reported pain, ache or discomfort in that region

Body part		Posture score		$\chi^2$	P
		"1"	> 1		
Neck	No pain	11.9	37.8	7.3 (1 df)	< 0.01
	Pain	12.5	83.2		
Trunk	No pain	13.8	17.5	0.5 (1 df)	0.48
	Pain	26.3	42.5		
Upper arm	No pain	26.9	44.4	3.1 (1 df)	< 0.07
	Pain	26.9	44.4		
Lower arm	No pain	16.9	14.4	9.9 (1 df)	< 0.01
	Pain	19.4	49.4		
Wrist	No pain	35.2	7.2	0.5 (1 df)	0.48
	Pain	30.4	7.2		

**Table 4**  $\chi^2$  statistical analysis of the RULA body part scores (1 or > 1) and the reported pain, ache or discomfort in that region

	Score A		Score B	
	1	> 1	1	> 1
No pain	20.8	3.3	31.1	34.2
Pain	41	34.9	6.8	12.2
$\chi^2$	17.1 (1 df)		12.1 (1 df)	
P	< 0.01		< 0.01	

between posture scores A and B with the regional pain, ache and discomfort indicates that the RULA scoring is sensitive to the changes from an acceptable to an unacceptable working posture based on the criteria which have been set out in the development of RULA. It also reinforces the importance of assessing the whole region as well as the individual body parts because the impact of musculoskeletal loading has important consequences for the function of the unit as a whole.

For a test of its reliability, RULA was presented as a methodology during the training of over 120 physiotherapists, industrial engineers, safety and production engineers. Videotaped examples of operators performing screen-based keyboard operations, packing, sewing and brick sorting were shown and each subject completed a RULA assessment. Comparison of their results indicated a high consistency of scoring amongst subjects. Discrepancies only occurred when a body segment posture was at a border between two ranges, usually when assessing the lower arm posture. As a consequence, the lower arm ranges were subsequently adjusted from the original version (a score of 1 being 0-90° and a score of 2 being 90° or more range of movement) to the present system reported here.

## Application of RULA

During the period in which RULA underwent validation tests it was used in both industrial and office settings by ergonomists from the Institute for Occupational Ergonomics and by physiotherapists who attended introductory courses in ergonomics. Specific operations where RULA was reported as a useful assessment tool include a variety of hand and machine packing operations, VDU-based tasks, garment-making operations, supermarket checkout operations, microscopy tasks and operations in the car manufacturing industry.

Once the users were familiar with RULA they reported that it was quick and easy to use. RULA was frequently reported as being useful when presenting the concept of musculoskeletal loading due to work, in meetings with management. Managers were quick to recognize and remember the grand scores and their associated action levels. This was reported as being helpful in the communication of problems, deciding upon the priority for investigations and the changes to be conducted in the workplace. In addition, RULA was found particularly valuable in reassessing any changes in musculoskeletal loading after modifications had been introduced to the work and workstation.

As noted earlier, if a comprehensive assessment of the workplace is to be made, RULA should be used as part of a larger ergonomics study covering epidemiological, physical, mental, environmental and organizational factors. A more complete methodology to identify and investigate work-related upper limb disorders, which includes RULA, has been produced by the Institute for Occupational Ergonomics<sup>14</sup>.

## Conclusions

RULA was developed to provide a rapid assessment of the loads on the musculoskeletal system of operators due to posture, muscle function and the forces they exert. It is designed to assess operators who may be exposed to musculoskeletal loading which is known to contribute to upper limb disorders. RULA fulfils the role of providing 'a method for screening a large number of operators quickly, but the scoring system developed also provides an indication of the level of loading experienced by the individual body parts. RULA is used without the need for any equipment and, after training in its use, has proved a reliable tool for use by those whose job it is to undertake workplace assessments. It can be used as a screening tool or incorporated into a wider ergonomics assessment of epidemiological, physical, mental, environmental and organizational factors.

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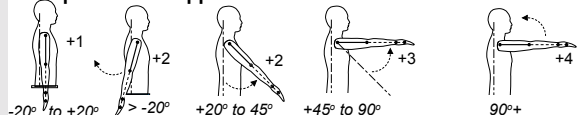
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# RULA Employee Assessment Worksheet

Complete this worksheet following the step-by-step procedure below. Keep a copy in the employee's personnel folder for future reference.

## A. Arm & Wrist Analysis

### Step 1: Locate Upper Arm Position

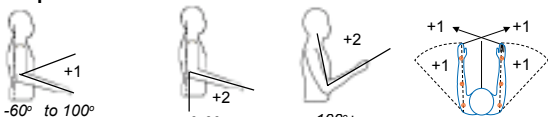


#### Step 1a: Adjust...

If shoulder is raised: +1;  
If upper arm is abducted: +1;  
If arm is supported or person is leaning: -1

Final Upper Arm Score =

### Step 2: Locate Lower Arm Position

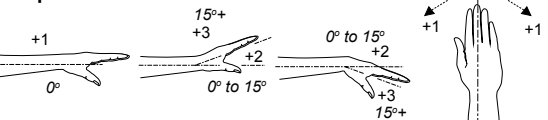


#### Step 2a: Adjust...

If arm is working across midline of the body: +1;  
If arm out to side of body: +1

Final Lower Arm Score =

### Step 3: Locate Wrist Position



#### Step 3a: Adjust...

If wrist is bent from the midline: +1

Final Wrist Score =

### Step 4: Wrist Twist

If wrist is twisted mainly in mid-range = 1;  
If twist at or near end of twisting range = 2

Wrist Twist Score =

### Step 5: Look-up Posture Score in Table A

Use values from steps 1,2,3 & 4 to locate Posture Score in table A

Posture Score A =

### Step 6: Add Muscle Use Score

If posture mainly static (i.e. held for longer than 1 minute) or;  
If action repeatedly occurs 4 times per minute or more: +1

Muscle Use Score =

### Step 7: Add Force/load Score

If load less than 2 kg (intermittent): +0;  
If 2 kg to 10 kg (intermittent): +1;  
If 2 kg to 10 kg (static or repeated): +2;  
If more than 10 kg load or repeated or shocks: +3

Force/load Score =

### Step 8: Find Row in Table C

The completed score from the Arm/wrist analysis is used to find the row on Table C

Final Wrist & Arm Score =

## SCORES

Table A

Upper Arm	Lower Arm	Wrist							
		1		2		3		4	
		Wrist Twist	Wrist Twist	Wrist Twist	Wrist Twist	Wrist Twist	Wrist Twist	Wrist Twist	Wrist Twist
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	4	4	4	4
	3	3	4	4	4	4	5	5	5
3	1	3	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	4	5	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	4	5	5	5	5
5	1	5	5	5	5	5	6	6	6
	2	5	6	6	6	6	7	7	7
	3	6	6	6	6	7	7	7	7
6	1	7	7	7	7	7	8	8	8
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

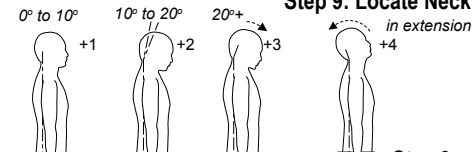
Table C

	1	2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

Final Score =

## B. Neck, Trunk & Leg Analysis

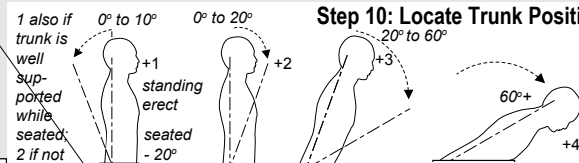
### Step 9: Locate Neck Position



#### Step 9a: Adjust...

=Final Neck Score  
If neck is twisted: +1; If neck is side-bending: +1

### Step 10: Locate Trunk Position



#### Step 10a: Adjust...

If trunk is twisted: +1; If trunk is side-bending: +1

### Step 11: Legs

If legs & feet supported and balanced: +1;  
If not: +2

Trunk Posture Score

	1		2		3		4		5		6		
Neck	1	2	1	2	1	2	1	2	1	2	1	2	
1	1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7	
3	3	3	3	3	4	4	5	5	6	6	7	7	
4	4	5	5	5	6	6	7	7	7	7	8	8	
5	5	7	7	7	7	7	8	8	8	8	8	8	
6	6	8	8	8	8	8	8	8	9	9	9	9	

Table B

### Step 12: Look-up Posture Score in Table B

Use values from steps 8,9,& 10 to locate Posture Score in Table B

= Posture B Score

### Step 13: Add Muscle Use Score

If posture mainly static or;  
If action 4/minute or more: +1

= Muscle Use Score

### Step 14: Add Force/load Score

If load less than 2 kg (intermittent): +0;  
If 2 kg to 10 kg (intermittent): +1;  
If 2 kg to 10 kg (static or repeated): +2;  
If more than 10 kg load or repeated or shocks: +3

= Force/load Score

### Step 15: Find Column in Table C

The completed score from the Neck/Trunk & Leg analysis is used to find the column on Chart C

= Final Neck, Trunk & Leg Score

Subject: \_\_\_\_\_

Date: \_\_\_\_ / \_\_\_\_ / \_\_\_\_

Company: \_\_\_\_\_

Department: \_\_\_\_\_

Scorer: \_\_\_\_\_

**FINAL SCORE: 1 or 2 = Acceptable; 3 or 4 investigate further; 5 or 6 investigate further and change soon; 7 investigate and change immediately**

Source: McAtamney, L. & Corlett, E.N. (1993) RULA: a survey method for the investigation of work-related upper limb disorders, *Applied Ergonomics*, 24(2) 91-99.

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