HSE

Health and Safety Executive

Further development of a tool for the assessment of repetitive tasks (ART)

(March 2008 - March 2010)

Prepared by the **Health and Safety Laboratory**
for the Health and Safety Executive 2010

RR808
Research Report

HSE

Health and Safety Executive

Further development of a tool for the assessment of repetitive tasks (ART)

(March 2008 - March 2010)

Jeremy Ferreira
Mike Gray
Matthew Birtles

Health and Safety Laboratory
Harpur Hill
Buxton
Derbyshire
SK17 9JN

The Assessment of Repetitive Tasks (ART) tool was developed to help Inspectors assess repetitive tasks of the upper limbs and some of the common risk factors in repetitive work that contribute to the development of upper limb disorders. In addition to retaining ART as an inspection tool, the aim of the project was to develop ART further to target a broader group of users with responsibility for the design, assessment, and management of repetitive work. This would include occupational health and ergonomics specialists; health and safety professionals with responsibility for ULD risk management, and others involved in the design and organisation of repetitive work.

The purpose of this report is to document further development of ART from March 2008 to its publication in March 2010. The work focussed on making improvements to the ART booklet, increasing the scope of the tool to take account of multiple repetitive tasks, and moving the training material to a more accessible web-based format.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

HSE Books

First published 2010

ACKNOWLEDGEMENTS

The authors are extremely grateful to the organisations and individuals who assisted the collection of case studies and filming of repetitive tasks.

The authors also acknowledge the support and contribution of colleagues in policy, operational and communications directorates who assisted in the publication of ART.

CONTENTS

EXECUTIVE SUMMARY

The Assessment of Repetitive Tasks (ART) tool was developed to help Inspectors assess repetitive tasks of the upper limbs. It assists in assessing some of the common risk factors in repetitive work that contribute to the development of upper limb disorders (ULD). In addition to retaining ART as an inspection tool, the aim of the project was to develop ART further to target a broader group of users with responsibility for the design, assessment, and management of repetitive work. This group would include: occupational health and ergonomics specialists; health and safety professionals with responsibility for ULD risk management; and others involved in the design and organisation of repetitive work. The purpose of this report is to document further development of ART from March 2008 to its publication in March 2010.

Main Findings

The project focussed on making improvements to the ART booklet, increasing the scope of the tool to take account of multiple repetitive tasks, and moving the training material to an accessible web-based format.

The ART booklet was developed further in preparation for publication (INDG438; HSE, 2010a). This drew upon feedback from training courses, piloting, and technical workshops, ongoing technical review and use, as well as input from design, editorial and publishing specialists. The work focussed on making improvements to the overall format and the assessment guide so that people who obtained a copy of the ART booklet, yet had no prior knowledge of the tool, would be able to understand its purpose, how to use it, and access additional information and training.

An approach was developed to improve the scope and usability of ART when confronted with jobs that involve several repetitive tasks. A qualitative approach is used first and foremost to check that other tasks within the rotation do not expose workers to similar risk factors. Supporting the qualitative approach, the numerical scoring system can help users to take account of a worker's exposure to each repetitive task within the rotation. An electronic workbook was developed to calculate a worker's job exposure score for rotation that occurs frequently (at least every hour) or infrequently (after more than one hour). This job exposure score represents a worker's cumulative exposure to repetitive work.

A website was developed to support the publication of ART. This provides more detailed instruction on how to make an assessment with ART, analyse the findings and take action to reduce the scores. It contains videos of repetitive tasks that visitors to the site can use to practice making assessments before applying ART in their workplace. The ART booklet, worksheets and other relevant resources can also be obtained through this website.

1 INTRODUCTION

1.1 BACKGROUND

The Assessment of Repetitive Tasks (ART) tool was developed to help Inspectors assess repetitive tasks of the upper limbs. It assists in assessing some of the common risk factors in repetitive work that contribute to the development of upper limb disorders (ULD). In February 2008, a cohort of about 100 Inspectors from the Health and Safety Executive (HSE) and Local Authorities (LA) received training in the use of ART and then piloted the tool at over 200 organisations. An evaluation of the pilot (Carter and Corbett, 2008) reported that ART was a practical tool that offered a structured approach to help the inspection process. It was a good filter (or screening tool) that showed evidence of a risk. It was also a useful training aid that facilitated understanding and confidence when assessing repetitive tasks.

The evaluation also suggested that ART would be more useful if it was made available to users beyond the small group of Inspectors who participated in the pilot. During the pilot, many duty holders were interested in ART and wanted to make use of the tool; particularly those already familiar with the Manual handling Assessment Charts (MAC) tool. However, there were a number of aspects that required attention prior to its publication. For example, experience suggested that an element of training and regular use was required in order to use ART accurately and reliably. Whereas this was originally delivered through one-day training courses, more accessible training material was required to support the wider publication of ART. An approach to deal with task rotation was also required to help users consider whether task rotation was sufficient to manage the health risks.

1.2 AIM

The aim of the project was to continue developing ART, as well as its training and support material, to the point that it was sufficiently credible and user-friendly to release to external users. In this case, ‘external users’ referred to people with responsibility for the design, assessment, and management of repetitive work. This would include: occupational health and ergonomics specialists; health and safety professionals with responsibility for ULD risk management; and others involved in the design and organisation of repetitive work.

The purpose of this report is to document further development of the Assessment of Repetitive Tasks (ART) tool from March 2008 to its publication in March 2010. The work focussed on three main objectives:

1. To continue developing the ART booklet in preparation for publication;

2. To develop an approach for dealing with task rotation; and

3. To develop web-based training material, providing further instruction on how to use ART as well as examples of repetitive tasks for users to practice making assessments.

2 FURTHER DEVELOPMENT

2.1 ART BOOKLET

This section summarises changes made to the ART booklet, as it progressed from its pilot in March 2008 to its publication in March 2010. Information obtained during several activities was used to refine the format and content of the ART booklet over this time. This included:

1. Feedback and discussion during ART training courses, which were delivered to a first cohort of HSE and LA Inspectors in the January 2008 and a second cohort of HSE Inspectors in November/December 2009;

2. Feedback from Inspectors involved in a pilot of ART during the 2007 Better Backs inspection campaign;

3. Findings from a benchmarking exercise of ART (Ferreira *et al*., 2009);

4. Technical feedback received during consultation with the UK Motor Industry Ergonomics Group (MIEG) and at the 2008 Annual Conference of the Ergonomics Society;

5. Ongoing technical review and use by HSE and HSL ergonomics specialists;

6. Design, editorial and publishing input from HSE's Creative Services Team.

The work focussed on making improvements to the general design and structure of the assessment guide so that people who obtained a copy of the ART booklet, yet had no prior knowledge of the tool, would be able to understand its purpose, how to use it, and access additional information or training. Since the pilot of ART in 2008, the main changes have occurred to the format and style of the tool. These changes have included:

- Relocating the fold-out task description form and score sheet to the back of the booklet;
- Increasing the font size;
- Increasing the number of pages to accommodate a larger font size and further instruction;
- Revising the line drawings illustrating awkward postures; and
- Revising the style and format of the tables.

The main changes to the technical content of the tool included:

- Providing further instruction on how to complete the score sheet, deal with task rotation, and use the assessment to assist with risk reduction;
- Removing the 1kg and 4kg hand force criteria from the force graph;
- Revising the layout of the score sheet;

- Including a prompt within the 'other factors' risk factor about whether tools or work pieces cause discomfort or cramping of the hand or fingers; and

- Reducing the medium/high exposure level boundary from a score of 24 to a score of 22.

Table 1 (appended) shows the full list of changes that were made to the ART booklet as well as the drivers and reasoning behind the changes.

2.2 APPROACH TO TASK ROTATION

Where workers rotate to other repetitive tasks in their job, the assessment guide directs users to assess all of the tasks involving repetitive movements of the upper limbs and consider the overall exposure. There are two elements of the ART scoring system:

- The qualitative colour coded scoring system, which allows users to identify the more significant risks in the tasks (i.e. those that score red); and

- The numerical scoring system, which allows users to prioritise repetitive tasks for improvement, and also help consider a worker's exposure to the repetitive task.

An approach was developed whereby both scoring systems could be used to assess jobs that involve several repetitive tasks.

2.2.1 Qualitative approach

First and foremost, with the qualitative approach, users are instructed to compare the risk factor colours across the different tasks (Figure 1). If it is found that workers rotate to tasks with similar red scores or amber scores, then this suggests that the task rotation may not provide enough variation or recovery in the work. In this case, users are directed to examine the task rotation further; for example, by speaking to workers about whether the rotation provides enough recovery or improves their job in other ways.

This approach is thought most useful when the purpose of using ART is to screen repetitive tasks for more significant risks and to check that the other tasks within the rotation do not expose workers to similar risks. This approach is useful because it is simple, allowing users to make a quick visual check for similar red and amber colours across the different tasks (Figure 1). It can also be undertaken within the work areas and does not require other equipment apart from multiple score sheets. However, this approach does not consider the worker's exposure to each task within the rotation.

Figure 1 An example of how the colour-coded scoring system can be used to make a quick visual check for similar risks across several repetitive tasks

2.2.2 Quantitative approach

The numerical scoring system for ART support the qualitative approach, allowing users to consider the worker's exposure to a repetitive task. When ART was developed, the procedure to calculate the exposure score was only applicable where a worker performed a single repetitive task during the day or shift. More recently, procedures for multitask analysis of the Occupational Repetitive Actions method (OCRA; Occhipinti *et al*., 2008) and revised NIOSH lifting equation (Waters *et al*., 2007) have been developed to consider an individual's exposure to multiple tasks. It was considered appropriate to apply this approach to ART, as much of the assessment process and scoring system for ART was based upon the OCRA checklist. This would allow users, using the numerical scoring system, to take account of a worker's exposure to each repetitive task within the rotation, as well as their cumulative exposure to repetitive work.

In their approach to multitask analysis, Occhipinti *et al*. (2008) describe two separate procedures: one for quite frequent task rotation (e.g. once an hour or even more frequently) and one for less frequent rotation (e.g. once every 1.5 hours or more). These procedures were adopted to calculate a job exposure score. The job exposure score was introduced with the purpose of improving the scope and usability of ART when confronted with jobs involving more than one repetitive task. In particular, the job exposure score can be used to help prioritise jobs involving more than one repetitive task, and help take account of task rotation as a means of managing the risks posed by repetitive work. It may also assist those who wish to consider workers' cumulative exposure to repetitive work. This may arise when workers carry out more complex jobs as a result of measures such as job enlargement or formalised systems of task rotation.

The sections below describe how the procedures are applied to calculate the job exposure score for frequent and infrequent rotation. Some terminology has been altered to make it consistent to that already used in ART.

Frequent Task Rotation

The method for frequent task rotation is intended to apply when task rotation occurs at least every hour or even more frequently. The method calculates a time-weighted average exposure score for all of the tasks involved in the job. This method assumes that tasks with higher exposure levels are, to some extent, compensated for by tasks with lower exposure levels that occur close together. This is represented in the following formula:

$$JES(F) = (TES_{(a\ max)} \times FT_a) + (TES_{(b\ max)} \times FT_b) + \ldots + (TES_{(n\ max)} \times FT_n)$$

where:

- JES(F) is the job exposure score when there is frequent task rotation
- $TES_{(a\ max,\ b\ max,\ldots n\ max)}$ are the task exposure scores for each task within the rotation, if they were (hypothetically) performed for the total repetitive work time (i.e. if there was no task rotation)
- FT_a, FT_b,… FT_n are the fractions of time each task is performed compared to the total repetitive work time

Section 4.2 (appended) provides a worked example of how the job exposure score is calculated for frequent rotation.

Infrequent Task Rotation

This method is intended to apply when task rotation is infrequent, which for simplicity has been defined as rotation that occurs after more than one hour. For these situations, a separate method is provided because the time-weighted average is believed to underestimate the actual level of exposure (Occhipinti *et al*., 2008). The time-weighted average does not take sufficient account of the higher task exposures, as it flattens out any significant peaks in exposure. Therefore, the approach adopted for infrequent task rotation is instead based on the concept of the 'most demanding task as minimum'. This approach will estimate a job exposure score that is at least equivalent to the exposure score of the most demanding task and, at most, equivalent to the exposure score of the most demanding task if it were (hypothetically) performed for the whole period of repetitive work. This is represented in the following formula:

$$JES(IF) = TES_{(1)} + [(TES_{(1\ max)} - TES_{(1)}) \times K]$$

where:

- JES(IF) is the job exposure score when there is infrequent task rotation
- $TES_{(1)}$ is the task exposure score of the most demanding task within the rotation
- $TES_{(2,\ 3,\ \ldots\ n)}$ is the task exposure score of the 2nd, 3rd, … nth most demanding tasks within the rotation (i.e. ranked according to highest task exposure score values)
- $TES_{(1\ \ max)}$ is the task exposure score of the most demanding task if it was (hypothetically) performed for the total repetitive work time (i.e. if there was no task rotation)
- $TES_{(2\ max,\ 3\ max,\ \ldots\ n\ max)}$ is the task exposure score of the 2nd, 3rd, … nth most demanding tasks if they were (hypothetically) performed for the total repetitive work time (i.e. if there was no task rotation)

- FT_1, FT_2,… FT_n are the fractions of time that the 1st, 2nd, … nth most demanding tasks are performed compared to the total repetitive work time
- $$K = \frac{(TES_{(1\ max)} \times FT_1) + (TES_{(2\ max)} \times FT_2) + \ldots + (TES_{(n\ max)} \times FT_n)}{TES_{(1\ max)}}$$

Section 4.2 (appended) provides a worked example of how the job exposure score is calculated for infrequent rotation. An electronic workbook was developed to assist the calculation of job exposure scores for frequent and infrequent task rotation.

Key Points

This quantitative approach is provided to improve the scope and usability of ART when assessing jobs made up of several repetitive tasks. However, users should be aware of a number of limitations when interpreting a job exposure score or using ART to inform the design of task rotation schedules:

- The quantitative approach has not been validated as a method to predict incidences of upper limb disorders;
- The quantitative approach does not take account of the order in which tasks are assigned to workers; and
- Neither the quantitative nor qualitative approach consider many other factors that are important to planning task rotation schedules; for example, the skills, abilities, preferences and availability of workers. They also do not consider the influence of task rotation on psychosocial factors.

For these reasons, users must be aware of the limitations of this method, so that they can make informed decisions about how to interpret the job exposure score, and ensure they take account of other factors important to planning task rotation.

2.3 WEBSITE

2.3.1 Background

During early development, testing and consultation, it was recognised that an element of training and regular use would be required in order to use ART accurately and reliably (Ferreira *et al.*, 2009). One-day training courses had proved to be sufficient to equip small groups of regulators with the knowledge and skills to apply ART in a variety of workplaces (Carter and Corbett, 2008). The practical elements of this training were regularly perceived to be most useful, during which users viewed repetitive tasks on video, practiced making assessments with the tool, and received feedback on their judgements and assessment findings. However, to support the publication of ART, other means would be required to deliver the training material more widely. Hosting this training material on the HSE website was preferable, as this was most accessible and could be regularly updated and linked to other HSE resources and information on upper limb disorders and ergonomics in the workplace.

2.3.2 Approach to the Work

The on-line training material was developed over a number of phases:

Filming of repetitive tasks

Several organisations were approached with a view to obtaining videos of repetitive tasks that could be shown as part of the web-based training. The following process was used to collect videos:

1. Several organisations were contacted by email or telephone to explore whether repetitive tasks made up a part of their production processes and whether they would be willing to facilitate some filming of these tasks during a visit to their premises.

2. Organisations that expressed a willingness to take part were sent a letter, which confirmed the requirements of the site visit and filming and each organisation's right to withdraw from participating at any time.

3. Arrangements were made for HSL specialists in ergonomics and visual presentation to visit the site to collect film of appropriate repetitive tasks and make an assessment of the tasks using ART. During each site visit and prior to any filming, the workers who were performing the repetitive task were given an information sheet, which explained the purpose of the filming and that the videos would be shown to the public in presentations, training courses, and on the HSE website. If individuals agreed to be filmed for these purposes, they signed a consent form authorising filming to start.

4. The raw video footage was edited into short repeatable clips showing the movement and positioning of the workers' upper limbs that would allow viewers to obtain as much information as possible to make an assessment with ART.

5. The organisations were sent a CD of the raw video footage collected at their premise. They were also sent copies of any edited video clips, along with a consent form seeking final permission to show these to the public in presentations and on the HSE website. Organisations confirmed permission through either email or by returning the signed consent form.

Selection and scoring of case studies

In total, 21 videos of repetitive tasks were collected from seven visits to premises within the printing, food and manufacturing sectors. Using the videos and task information collected during the site visits, a team of three ergonomists experienced in the use of the tool assessed each task, discussing the assessment until consensus scores were agreed.

From these, six videos were selected to be included on the website. The videos were selected to ensure that the repetitive tasks were diverse and presented a broad range of risk factors and scores.

Development of an interactive presentation

An interactive presentation was developed, which incorporated: the content delivered during one-day training courses for regulators; case studies showing the selected videos and consensus scoring; and links allowing users to navigate freely through the material. This presentation provided a working draft of the material on which to base the sitemap and web content.

2.3.3 Development

The material in the interactive presentation was used to create a website that was consistent in design and format to the HSE website. The site was made up of four key topics:

1. What is the ART tool – to provide an overview of ART; for example, its purpose, scope, key features and benefits.

2. Learning to use the ART tool – to provide information that users will need to know when using the tool. This repeats information contained within the assessment guide of the booklet, as well as additional tips that were previously delivered during training courses. It also walks users through an example of how the tool assesses a repetitive task, and provides several opportunities for visitors to try ART out prior to using it in the workplace, or as a refresher exercise.

3. Analysis and actions – to provide information that helps users interpret the scores, deal with task rotation, and consider different measures available to address factors that score red or amber.

4. Downloading the ART tool – to provide quick and easy access to electronic copies of the booklet, additional score sheets, and the task rotation workbook.

2.3.4 Summary

A website has been developed for the ART tool, allowing users to learn about the tool, download the tool, practice making assessments of repetitive tasks, and obtain information and other resources on risk reduction (HSE, 2010b). An evaluation of the website's usability and the extent to which reviewing the site might improve the accuracy and reliability of users' assessments was beyond the scope of this project.

3 CONCLUSIONS

From March 2008 to March 2010, work was undertaken to advance the Assessment of Repetitive Tasks (ART) tool from its pilot version into a published document (INDG 438; HSE, 2010a). In addition to retaining ART as an inspection tool, it was developed further to target a broader group of users with responsibility for the design, assessment, and management of repetitive work. This group would include occupational health and ergonomics specialists; health and safety professionals with responsibility for MSD risk assessment and management; and others involved in the design and organisation of repetitive work. Several packages of work were required to make ART appropriate for this new group of users and ensure that they could access the same information and support material given to the small group of regulators who were currently using the tool.

The ART booklet was developed further in preparation for publication. This drew upon feedback from training courses, piloting, and technical workshops, ongoing technical review and use, as well as input from design, editorial and publishing specialists. The work focussed on making improvements to the overall format and the assessment guide so that people who obtained a copy of the ART booklet, yet had no prior knowledge of the tool, would be able to understand its purpose, how to use it, and access additional information and training.

An approach was developed that allows ART to be used to assess jobs that involve several repetitive tasks. First and foremost, a qualitative approach is used to check that other tasks within the rotation do not expose workers to similar risks. Supporting the qualitative approach, the numerical scoring system allows users to calculate a job exposure score. This represents a worker's cumulative exposure to repetitive work and helps to take account of a worker's exposure to each repetitive task within the rotation. An electronic workbook was developed to calculate the job exposure score for rotation that occurs frequently (at least every hour) or infrequently (after more than one hour).

A website was developed to provide training and support for external users of ART. This provides more detailed instruction on how to make an assessment with ART, analyse the findings and take action to reduce the scores. It also contains videos of repetitive tasks that visitors can use to practice making assessments before applying ART in their workplace.

4 APPENDICES

4.1 EXPLANATION OF CHANGES TO THE ART BOOKLET FROM 2008 TO 2010

Table 1 List of changes that were made to the ART booklet as well as the driver and reasoning behind the change

Section	*Details of change*	*Driver*	*Explanation*
Booklet	Font size increased.	Design and publishing input	To improve usability and meet publication guidelines.
Booklet	The length of the booklet increased from 8 pages to 20 pages.	Design and publishing input	This was required to accommodate the larger font size and additional text contained in the booklet.
Booklet	The size of the booklet increased from field notebook size to A5.	Design and publishing input	This was required to accommodate the larger font size and meet publication guidelines.
Booklet	Double fold out worksheet at the front of the booklet replaced with single foldout worksheet at the back of the booklet.	Design and publishing input	This was possible with the addition of more pages to the booklet. It allows users to open the booklet to introductory text, without having to fold out the worksheet.
Booklet	Table format and style revised.	Design and publishing input	
Worksheet	The flowchart was moved from the double fold out worksheet to within the booklet.	Design and publishing input	This allowed the double fold out to be replaced with a single fold out with the task description form on one side and the score sheet on the other side. Additional worksheets also containing the flowchart are to be made available on the ART website.
Worksheet	Order of columns on the score sheet revised.	Technical feedback and review	This allowed assessments of the left hand and right hand to remain separate on the score sheet. This was intended to reduce errors when filling in the score sheet and calculating the task scores. However, where an assessment of both arms is made, a limitation of the new score sheet is that some factors that are not specific to a particular side of the body have to be entered into the score sheet twice (e.g. neck posture, workpace). This is explained in instructions on completing the score sheet.

Section	*Details of change*	*Driver*	*Explanation*
Introduction	Target user group broadened from health and safety Inspectors to people with responsibility for the design, assessment, management and inspection of repetitive work.	Policy review	While ART was originally designed, tested and piloted with Inspectors, the reasons for using the tool would also extend to other types of users, particularly health and safety practitioners, consultants, ergonomists and larger organisations.
Assessment guide	Text added to clarify which repetitive tasks are suitable for assessment with ART.	Technical review	This information was originally covered during training, yet its importance to using the tool correctly justified inclusion within the booklet.
Assessment guide	Text added to clarify that the assessment is split into four stages.	Technical review	This information was originally covered during training, yet its importance to understanding how the tool is used justified clarification at the start of the booklet.
Assessment guide	Text added on taking action, which included how to use the ART scoring system to reduce the risks and key points on how to introduce control measures.	Technical review	This information was originally covered during training, yet its importance to understanding what to do after using the tool justified inclusion within the booklet.
Assessment guide	Text added to stress that the use of ART will not prevent all ULDs and that suitable systems for early reporting of symptoms, proper treatment, rehabilitation and return to work are essential components for managing any episodes of ULDs.	Technical review	This information was originally covered during training, yet its importance to understanding how the tool fits in with HSE's framework for managing ULD risks justified inclusion within the booklet.
Assessment guide	Further text added to explain how to complete the score sheet and interpret the scores. This was moved towards the back of the booklet, following the instructions on how to assess each factor.	Technical review	This information was originally explained more fully during training, yet its importance to using the tool correctly justified including more detail within the booklet. It was possible to consolidate this text with the addition of more pages to the booklet. These instructions were placed at the back of the booklet to follow the assessment process.
Assessment guide	Further instruction included on how to deal with task rotation.	Pilot feedback	This information was originally provided during training, yet its importance to using the tool correctly justified including more detail within the booklet.
Assessment guide	The boundary between the medium and high exposure levels was reduced from a score of 24 to 22.	Technical review	Benchmarking exercises suggested that reducing this boundary slightly would more closely align ART assessment findings with the OCRA checklist (Ferreira *et al.*, 2009).

Section	*Details of change*	*Driver*	*Explanation*
Assessment guide	Scoring boxes within each stage of the assessment guide removed.	Design and publishing input and technical review	These were not thought to be a critical design feature of the booklet (i.e. users could simply circle the appropriate scores, rather than record the scores at the bottom of each page of the assessment guide). Furthermore, with a larger font size, the assessment guide instructions for stage C and stage D carried over onto multiple pages, and there was concern that leaving these boxes in the document could increase the potential for scoring errors.
Assessment guide	List of further reading and references to the ART website included in the booklet.	Design and publishing input	This information was originally provided during training, yet its importance to using understanding the topic justified including this within the booklet.
Stage A1	'Shoulder/upper arm movements' replaced with 'arm movements'.	Technical feedback and review	To improve text clarity. The term 'shoulder/upper arm movements' caused some confusion about what part of the arm to observe when assessing this factor. Users typically reported just focusing on the arm movements when assessing this factor.
Stage A2	Users instructed to observe the movement of the 'arm and hand' rather than the 'forearm and wrist/hand'.	Technical feedback and review	To improve text clarity. The term 'forearm and wrist/hand' caused some confusion about what part of the arm to observe when assessing repetition. Users typically reported just focusing on the movement of the hand when looking for similar motion patterns.
Stage B	1kg and 4kg boundaries removed from the force assessment.	Technical feedback and review	These boundaries apply to average hand force requirements and depend on the type of hand grip. There was concern that users who did not appreciate the context in which the boundaries were defined would be prone to making errors when judging the level of force involved in the task (e.g. these boundaries could be applied inappropriately to pushing and pulling actions of the upper limb). Removing these force level boundaries would encourage users to involve workers in force assessment.
Stage B	References to making an assessment of the level of force with 'one hand' removed.	Technical review	The need to make an assessment of force for each hand is shown in the flowchart and score sheet. The emphasis on using the force grid to assess the level of force exerted with one hand was confusing with removal of the 1kg and 4kg boundaries from the force grid.
Stage B	References to the force 'graph' replaced with force 'grid'.	Technical feedback	To improved text clarity, as it was incorrect to refer to the image as a graph.
Stage C	Illustrations showing awkward postures revised.	Design and publishing input	

Section	*Details of change*	*Driver*	*Explanation*
Stage D2	Users instructed to speak to workers about aspects affecting work pace, if they report that it is sometimes difficult to keep up with the work.	Pilot feedback	It is important to know why it is sometimes difficult to keep up with the work, as this could help to make improvements to the task. This factor does not typically score red (possibly because workers do not like to report that it is often difficult to keep up with the work), so more opportunities are required to explore issues that might affect perceived workpace.
Stage D	Duration moved to position D4 and psychosocial factors moved to position D5 in the assessment process.	Technical review	This follows the order that the risk factors are presented on the score sheet, which users often refer to when they need to know which factor to assess next.
Stage D3	Additional text included prompting users to consider whether the tools or work pieces cause discomfort or cramping of the hand or fingers.	Technical review	This was included to help address the tool's limited consideration of static hand gripping.
Stage D3	Prompt for using a tool to strike 'two times per minute or more' changed to 'two or more times per minute'	Design and publishing input	To improve text clarity.
Stage D3	Prompt for using the hand as a tool and struck '10 times per hour or more' changed to '10 or more times per hour'	Design and publishing input	To improve text clarity.
Stage D3	The criterion of 2 – 3 mm was removed from the assessment of fine precise movements of the hand or fingers.	Technical review	This criterion was restrictive and difficult to assess so accurately; a more subjective assessment was deemed appropriate.
Stage D4	Table to estimate the exposure score removed.	Pilot feedback	Users perceived the table to be unnecessary.

4.2 EXAMPLES OF JOB EXPOSURE SCORE CALCULATIONS

This section presents a worked example of how the job exposure score is calculated for frequent rotation (at least every hour) and infrequent rotation (after more than one hour). While the example is based on the procedure for multitask analysis using the OCRA method (Occhipinti *et al*., 2008); slightly different job exposure scores are obtained when using ART due to the fewer categories of duration multiplier available.

In this example, a worker undertakes three repetitive tasks in their day: task A, task B, and task C. Table 2 shows the task scores for each repetitive task, as well as the total amount of time that they spend performing the task in the shift. The worker undertakes repetitive work for a total of 420 minutes (7 hours) each shift.

Table 2 Task information used in the worked examples of how to calculate the job exposure score

Task name	*Task score*	*Total Duration (minutes)*
A	10	210
B	20	120
C	30	90

4.2.1 Calculation for frequent task rotation

If the worker rotates to another task within the rotation at least every hour (e.g. every 30 minutes), the rotation is considered to be frequent and the following calculation applies:

$JES(F) = (TES_{(a\ max)} \times FT_a) + (TES_{(b\ max)} \times FT_b) + (TES_{(c\ max)} \times FT_c)$

$TES_{(a\ max)}$, $TES_{(b\ max)}$ and $TES_{(c\ max)}$ are the exposure scores for each task if there was no task rotation and they were hypothetically performed for the total repetitive work time (i.e. 420 minutes or 7 hours). In this case, they are calculated by multiplying each task score by the duration multiplier of 1.

$TES_{(a\ max)} = 10 \times 1 = 10$

$TES_{(b\ max)} = 20 \times 1 = 20$

$TES_{(c\ max)} = 30 \times 1 = 30$

To determine the fraction of time that each task is actually performed (FT), the duration of each task is divided by the total repetitive work time (420 minutes).

$FT_a = 210/420 = 0.50$

$FT_b = 120/420 = 0.29$

$FT_c = 90/420 = 0.21$

Therefore,

JES(F) = (10 x 0.50) + (20 x 0.29) + (30 x 0.21)

= 5.0 + 5.8 + 6.3

= 17.1

4.2.2 Calculation for infrequent task rotation

If the worker rotates to another task within the rotation after more than one hour, the rotation is considered to be infrequent and the following calculation applies:

$JES(IF) = TES_{(1)} + [(TES_{(1\ max)} - TES_{(1)}) \times K]$

This requires the tasks to be ranked according to task score (see Table 2):

- Task 1 (with the greatest task score or 'the most demanding task') is task C with a task score of 30;
- Task 2 (with the second greatest task score) is task B with a task score of 20; and
- Task 3 (with the third greatest task score) is task A with a task score of 10.

$TES_{(1)}$ is the task exposure score of the most demanding task within the rotation (i.e. task C), which is performed for a total duration of 90 minutes during the shift. To calculate $TES_{(1)}$, task score C is multiplied by the appropriate duration multiplier of 0.5.

$TES_{(1)} = 30 \times 0.5 = 15$

$TES_{(1\ max)}$ is the task exposure score of the most demanding task within the rotation (i.e. task C), if there was no task rotation and it was (hypothetically) performed for the total duration of repetitive work (i.e. 420 minutes or 7 hours). To calculate $TES_{(1\ max)}$, task score C is multiplied by the duration multiplier of 1.

$TES_{(1\ max)} = 30 \times 1 = 30$

Similarly, $TES_{(2\ max)}$ and $TES_{(3\ max)}$ represent the second and third most demanding tasks (i.e. task B and A respectively) if there was no task rotation and they were (hypothetically) performed for the total duration of repetitive work (i.e. 420 minutes or 7 hours).

$TES_{(2\ max)} = 20 \times 1 = 20$

$TES_{(3\ max)} = 10 \times 1 = 10$

To determine the fraction of time that each task is performed (FT), the actual duration of each task is divided by the total repetitive work time (420 minutes).

FT_1 = 90/420 = 0.21

FT_2 = 120/420 = 0.29

FT_3 = 210/420 = 0.50

Thus:

$$K = \frac{(TES_{(1\ max)} \times FT_1) + (TES_{(2\ max)} \times FT_2) + (TES_{(3\ max)} \times FT_3)}{TES_{(1\ max)}}$$

$$= \frac{(30 \times 0.21) + (20 \times 0.29) + (10 \times 0.5)}{30}$$

$$= \frac{17.1}{30}$$

$$= 0.57$$

Therefore:

$$JES(IF) = TES_{(1)} + [(TES_{(1\ max)} - TES_{(1)}) \times K]$$

$$= 15 + [(30 - 15) \times 0.57]$$

$$= 15 + (15 \times 0.57)$$

$$= 15 + 8.55$$

$$= 23.55$$

5 REFERENCES

Carter, L. and Corbett, E. (2008)
Perceptions of FIT3 MSD programme work. HSL Report WPS/08/14, Health and Safety Laboratory, Buxton, Derbyshire.

Ferreira, J. Gray, M., Hunter, L. Birtles, M. and Riley, D. (2009)
Development of an assessment tool for repetitive tasks of the upper limbs (ART). HSE Research Report: RR707, Sudbury, Suffolk, HSE Books, available for download from:
http://www.hse.gov.uk/research/rrpdf/rr707.pdf

Health and Safety Executive (2010a)
Assessment of repetitive tasks of the upper limbs (ART): *guidance for health and safety practitioners, consultants, ergonomists and large organisations.* INDG 438, Sudbury, Suffolk, HSE Books.

Health and Safety Executive (2010b)
HSE – ART tool, http://www.hse.gov.uk/msd/uld/art, accessed on 19th March 2010.

Occhipinti, E., Colombini, M. and Occhipinti, M. (2008)
OCRA method: development of a new procedure for analysis of multiple tasks with infrequent rotations. *La Medicina del Lavoro*, **99**(3), 234-241.

Waters, T.R., Lu, M.L. and Occhipinti, E. (2007)
New procedure for assessing sequential manual lifting jobs using the revised NIOSH lifting equation. *Ergonomics*, **50**(11), 1761-1770.

Published by the Health and Safety Executive 06/10

HSE

Health and Safety Executive

Further development of a tool for the assessment of repetitive tasks (ART)

(March 2008 - March 2010)

The Assessment of Repetitive Tasks (ART) tool was developed to help Inspectors assess repetitive tasks of the upper limbs and some of the common risk factors in repetitive work that contribute to the development of upper limb disorders. In addition to retaining ART as an inspection tool, the aim of the project was to develop ART further to target a broader group of users with responsibility for the design, assessment, and management of repetitive work. This would include occupational health and ergonomics specialists; health and safety professionals with responsibility for ULD risk management, and others involved in the design and organisation of repetitive work.

The purpose of this report is to document further development of ART from March 2008 to its publication in March 2010. The work focussed on making improvements to the ART booklet, increasing the scope of the tool to take account of multiple repetitive tasks, and moving the training material to a more accessible web-based format.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

RR808

www.hse.gov.uk