



# Practical application of assessment tools for WRMSD risks: A case study in apiculture

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## Abstract:

**Introduction** – Effective risk management requires a systematic approach where risk is identified, assessed, and controlled. After controls have been introduced, they need to be reviewed for effectiveness. In addition to these steps, proactive health monitoring completes the approach. To date there has been little help for small- to medium-sized businesses, especially those in agriculture to actively manage their musculoskeletal risk factors. A barrier to compliance for the management of musculoskeletal risks has been the lack of resources to assess risk factors. This study investigated the use of three risk assessments which may be applicable to the agricultural sector.

**Material and methods** – The NZMAC (New Zealand Manual Handling Assessment Charts), NZART (New Zealand Assessment of Repetitive Tasks) and REBA (Rapid Entire Body Assessment) were applied to a variable agricultural task. The apicultural task of hive inspection was chosen as a case study example as it was representative of a frequently performed, non-linear task. Multiple worksite observations were undertaken in the North Island of New Zealand. Self-reported yearly prevalence of work-related musculoskeletal disorders amongst apiarists, obtained from a recent study, supported the choice of assessment method for key areas of low back (74%), neck (54.8%), shoulder (56.2%) and wrist/hand (47.9%).

**Results** – Not surprisingly, high risk factors were associated with the development of WRMSDs in high prevalence anatomical areas. The assessment tools used indicated that the physical risk factors were in the range of medium to high risk.

**Conclusions** – The NZMAC and NZART are suitable for use in assessing a task with fluctuating physical demands. There was a high agreement with the results from the REBA assessment. Further resources are needed to support small-and medium-sized businesses to assess and manage their WRMSD risks to reduce the personal and financial harm associated with WRMSDs.

## Practitioner summary

Managing health and safety risks is a requirement of legislation, but businesses, particularly SMEs have limited resources in terms of time, staff, and means to manage risks. One of these risks is WRMSDs which is pervasive and costly. Many tools are available for assessing WRMSD risk but some need training so this creates a barrier for use. As part of an update to musculoskeletal risk management guidelines, the MAC and ART assessment tools from the United Kingdom, were refined for use in the New Zealand context by the Human Factors/Ergonomics team at WorkSafe to make them relevant to the New Zealand context. This paper presents a case study of an apicultural task of hive inspection which was chosen as an example of a variable agricultural task. This study will provide a practical and theoretical application for researchers, health practitioners, and small to medium business owners, especially in the agricultural sector.

Keywords: musculoskeletal; risk assessment; NZMAC, NZART, REBA, WRMSDs

## Introduction

### Agriculture

Agriculture is one of the oldest occupations and remains a significant contributor to the global economy. An estimated one third of the global population is employed in the agricultural sector (Kumaraveloo & Lunner Kolstrup, 2018; López-Aragón et al., 2018; Wheeler & Lobley, 2022). In New

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Zealand (NZ) agriculture contributes over \$NZ12 billion to the economy through domestic and international markets as well as employment for agricultural workers and associated industries. Agriculture has been recognised as a high-risk industry for health and safety, and work-related musculoskeletal disorders (WRMSDs) have been recognised as one of the greatest risks (Barneo-Alcántara et al., 2021; Lovelock & Cryer, 2009; Naeini et al., 2014; Nilsson, 2016; Wheeler & Lobley, 2022; Widyanti, 2018).

Although agriculture has been prioritised as a high-risk occupation, management of musculoskeletal risk is not a priority and presents challenges. Agricultural work is characterised by seasonal workflows, unpredictable events and a high degree of physical demands. The heterogeneity of agricultural tasks and risk exposures has been a challenge for designing and implementing effective interventions for injury reduction. For example, the physical demands of an apicultural role are substantially different from a crop harvesting machine operator. This makes it difficult to develop a generic risk management assessment tool. Agriculture is predominantly made up of small- to medium-sized enterprises (SME) (Onegina et al., 2025). Managing health and safety risks may be seen as daunting, possibly because it is deemed low priority when other issues are more pressing. In addition, there are fewer financial and human resources for managing risk compared to larger enterprises (S. J. Legg et al., 2015). Musculoskeletal disorders are often tolerated as part of the role and are underreported and under treated among agricultural workers so are seen as low priority (Dean et al., 2011; Friesen & Lang, 2022; Pierce et al., 2025).

## **Work-related musculoskeletal disorders (WRMSDs)**

The global impact of work-related musculoskeletal disorders (MSDs) has been of concern for decades. Musculoskeletal disorders impact on an individual's short- and long-term health and well-being, not only the physical impacts of discomfort and loss of function, but also financial impacts through reduction of income (Whelan et al., 2009), loss of productivity (Bevan, 2015; March et al., 2014; Pascual & Naqvi, 2008), and early retirement (Meyers et al., 2002; Mouchetrou et al., 2012). In NZ, work-related musculoskeletal disorders have been defined as "...injuries and conditions affecting the muscles, ligaments, bones, tendons, blood vessels, and nerves. WRMSDs occur then work demands lead or contribute to pain, discomfort, or injury." (Worksafe New Zealand, 2022). In NZ musculoskeletal harm is responsible for over 30% of health harm across all sectors (WorkSafe 2019), accounting for 28% of all lost-time injuries among agricultural workers (WorkSafe New Zealand, 2024). The estimated MSD costs account for more than 25% of healthcare spending (Bevan et al., 2012; Bossley & Miles, 2009), and indirect costs are estimated to be five times that of the direct costs of MSDs (OSHA, 2024). This represents a significant economic impact through increased healthcare costs, compensation, and reduced productivity due to work absence or presenteeism. The estimated financial and societal burden is not inconsequential, with estimates of up to 2% of GDP (Briggs et al., 2018; Coggon et al., 2013; Trask et al., 2016). WRMSDs are considered as the most serious, and under-rated, work-related problem in agriculture (Jones et al., 2021). They are the most common non-fatal occupational injury for agricultural workers (Firth et al., 2002; Momeni et al., 2020) with agricultural workers accounting for more than 56% of WRMSD reports (Kaewdok et al., 2021). WRMSDs are a significant concern for agricultural workers, particularly those undertaking physically demanding work tasks (Benos et al., 2020; Maina et al., 2016; Osborne et al., 2012; Rasoulivalajoozi et al., 2023).

## **Risk management**

Workplaces in New Zealand are covered by the Health & Safety at Work Act, 2015, which states the PCBU (person conducting a business or undertaking) must, as far as reasonably practicable, manage health and safety risks, including risks associated with WRMSDs. As part of a risk management process, risks need to be quantitatively identified and risk management implemented where it is practicable (Keyserling et al., 1991). This has been a challenge for small and medium sized agricultural enterprises who are at a disadvantage for managing health and safety requirements due to lack of knowledge and resources (Lamm, 2014; S. Legg et al., 2010; S. J. Legg et al., 2015).

### **1.4 Risk assessment**

In contrast to other occupational diseases which result from exposure to specific hazards, WRMSDs have a multifactorial origin. Identifying the key risk factors in a workplace is the first step in managing WRMSD risks. In addition to physical or biomechanical risk factors, other contributing factors such as psychosocial, organisational, environmental, and individual factors are associated with the development of WRMSDs. However, the focus of most risk assessments is on physical risk factors.

There is a plethora of generic WRMSD risk assessment tools which cover a range of purposes ranging from whole body assessment (e.g. OWAS – Ovako working posture analysing system, REBA – Rapid Entire Body Assessment) to anatomical regions (e.g. RULA – Rapid Upper Limb Assessment, OCRA – Occupational Repetitive Actions checklist) (David, 2005; Takala et al., 2010). In addition, a few risk assessment tools have been developed for specific agricultural sectors. The Washington State Ergonomics Checklist (Washington State Department of Labor and Industries, 2017) was developed for horticulture and crops but does not include tasks that involve stock management. In Korea a whole-body postural assessment tool was created (AWBA – Agricultural Whole Body Assessment) which combines previously created upper limb and lower limb assessments (Kong et al., 2015). The AWBA assesses shoulder and hip postures but does not include the trunk or wrist/hands.

Although there is no ‘gold standard’ for risk assessment, and no one tool covers all work situations, developing bespoke assessment methods may not be the answer (Takala et al., 2010; Wilson & Sharples, 2015). Creating new risk assessment tools takes time to develop, validate, and ensure reliability, as well as hindering comparisons between sectors. Refining existing risk assessment tools and ensuring they are relevant to the culture and legislative requirements of the communities being assessed is a better strategy. In addition, a comprehensive worksite assessment should include more than one assessment tool allowing for the inclusion of trunk and limbs (Danuta, 2014; Possebom et al., 2018). This approach was taken by the Human Factors/Ergonomics team at WorkSafe. After extensive research, they refined the set of tools from the Health and Safety Executive (HSE) in the United Kingdom to reflect NZ legislation and context. This included the MAC (Manual Handling Assessment Charts), ART (Assessment of Repetitive Tasks), and the RAPP (Risk Assessment of Pushing and Pulling) creating New Zealand versions of these (New Zealand Manual Handling Assessment Charts – NZMAC, New Zealand Risk Assessment of Pushing and Pulling – NZRAPP, New Zealand Assessment of Repetitive Tasks – NZART) (Hunter & WorkSafe New Zealand, 2025; WorkSafe New Zealand, 2025; WorkSafe New Zealand & Hunter, 2025).

In summary, WRMSDs are a significant challenge to the health of agricultural workers, and few practical resources are available for the sector to enable the identification and management of physical risks. In addition, there is a gap between research and practice as although the HSE tools MAC, RAPP, and ART tools have been validated, the NZMAC and NZART have yet to be applied in NZ. The aim of this article is to provide a practical guidance on the application of NZMAC and NZART to a variable work task. The Rapid Entire Body Assessment (REBA) was included to provide benchmarking and comparison. A secondary aim is to investigate the applicability of NZMAC NZART and REBA for use in the NZ context. Furthermore, this study will provide guidance for future researchers and health professionals involved in management and treatment of WRMSDs among agricultural workers.

## **Methods**

A case study approach was used that allowed for a detailed assessment of a task within a real-world context.

### **2.1 Case study**

Apiculture was chosen as an agricultural example due to several considerations. Apiculture is an important sector in NZ, contributing to the economy not only through exports of honey and other bee products but also through pollination of food crops. Apicultural enterprises are mainly small business units with a few medium- to large-sized businesses. Recent research has identified a high prevalence of WRMSDs indicating there is an occupational risk (Pierce et al., 2025). Apiculture along with other agricultural sectors, has several unique elements, which alone or in combination contribute to increased risk of WRMSDs (Cryer et al., 2009; Fathallah, 2010). Apiculture relies on traditional methods and equipment, exposing apiarists to a range of physical and biomechanical hazards (Fels et al., 2019; Maina et al., 2016); which, despite advances in mechanisation, have been difficult to eliminate. Tasks are seasonal, with periods of intensive activity combined with long hours. Environmental hazards include working outdoors in remote locations with exposure to extreme weather conditions. Apiaries are located in diverse locations requiring on- and off-road driving for access. While there is a seasonal flow of apicultural tasks throughout the year, day-to-day tasks are modified by unpredictable factors such as weather and pests. For these reasons apiculture provides a good example of a variable task for assessment.

## 2.2 Task identification

As part of another study (unpublished) field observations of apiarists at work were undertaken at multiple apiaries over ten separate days in the North Island of New Zealand in spring and summer of 2022. Written informed consent was obtained for the observations and filming. The task of hive inspection was chosen for assessment as this is a core activity and is regularly done throughout the apicultural year to monitor for hive health, nutrition and pests.

## 2.3 WRMSD reports

To identify key WRMSD concerns, prevalence data was obtained from a recent study of 73 apiarists in New Zealand (Pierce et al., 2025). No reliable data was able to be sourced from ACC for comparison. The anatomical regions with the highest prevalence reports over the previous 12 months were low back (74%), neck (54.8%), shoulder (56.2%) and wrist/hands (47.9%). These reports further justified the choice of NZMAC (for back) and NZART (for upper limbs).

## 2.4 Filming protocol

The video was recorded for several cycles of the hive inspection task for several apiarists. This allowed for a clear view from different angles to ensure each body part was clearly visible, within constraints of the beekeeping PPE. It also identified any potential postures of interest for the neck, shoulder, upper extremity (elbow, wrist and hand), lower back, hips, and knees. One example of hive inspection was selected for assessment due to video clarity and consistency. Screenshots taken from the sample video were identified for use with REBA, NZMAC and NZART to provide for cross method comparison.

## 2.5 Risk assessment tools

### 2.5.1 Rapid Entire Body Assessment (REBA)

REBA was developed as a whole-body assessment that considers the physical risks of a task. It can be used for static or dynamic postures (Hignett & McAtamney, 2000). REBA is presented as a one-page assessment tool with two main sections comprising of 13 steps. Scores are allocated according to a pre-determined range of positions. For example, there are three options of positions for the neck, five for the trunk, four for the lower limbs, five for the upper arm, three for the lower arm, and three for the wrists. In addition, an adjustment to the score may be applied if there are further constraints on the postures.

The assessment is divided into two parts: Part A assesses postures of the trunk, neck and legs. Table A is used to take each of these individual scores to determine an overall score for this section. A force or load score may be added to this to give a total score for Part A (Table A). Part B assesses the upper arm, lower arm, and wrist postures. Table B is used to determine an overall score for this section. A hand coupling score may be added to this to give a total score for Part B (Table B). The final scores are then calculated in Table C by cross referencing the scores from Table A and Table B. An activity score can be added to the score from Table C, if it applies, to produce a final REBA score. The final REBA score indicates a level of risk, ranging from 1 (negligible) to 15 (very high) and there are corresponding suggestions for action levels that indicate the urgency needed to mitigate the identified risk (unnecessary to necessary now). (Hignett & McAtamney, 2000).

**Table 1 REBA risk levels**

| REBA score | Risk level | Action           |
|------------|------------|------------------|
| 1          | Negligible | Unnecessary      |
| 2-3        | Low        | May be necessary |
| 4-7        | Medium     | Necessary        |
| 8-10       | High       | Necessary soon   |
| 11-15      | Very high  | Necessary now    |

To apply the REBA, the video of the hive inspection task was examined to identify the essential physical demands for further assessment. Screenshots were taken of the key steps which represented separate elements of the task, and which may have the greatest potential to result in musculoskeletal discomfort. The worst-case scenario was assessed for this example.

### 2.5.2 New Zealand Manual Handling Assessment Charts (NZMAC)

The NZMAC, can assess lifting, carrying, or team handling tasks. For the hive inspection task, the lifting assessment was chosen to consider the handling postures. The lifting assessment was selected due to the high prevalence of low back pain and shoulder WRMSD reports from apiarists (Pierce et al., 2025). The risk factors considered within the NZMAC lifting task assessment are presented in Table 2.

Like REBA, the NZMAC has four levels of risk (Figure 1). This can be used to identify the parts of a task that are high risk. NZMAC has a scoring system, and the scores are added up at the end, but unlike REBA, the total score does not indicate a level of risk. It is used as a benchmark for comparison when risk management strategies are put in place, or as a comparison when several assessments of different tasks have been made and to help identify tasks that should be prioritised – a higher score indicating a greater priority.

**Figure 1 NZMAC Risk levels**

|                                   |  |
|-----------------------------------|--|
| <b>Low level of risk</b>          | Although the risk is low, consider the exposure levels for vulnerable groups such as workers who are new mothers, or pregnant, young workers, older workers, new to the job or workforce, or those that have a disability, significant health condition, injury, or are recovering from an injury. |
| <b>Medium level of risk</b>       | Examine tasks closely.   |
| <b>High level of risk</b>         | Prompt action needed. This may expose a significant proportion of the working population to risk of injury.  |
| <b>Unacceptable level of risk</b> | Such tasks may present a serious risk of injury and should be improved urgently.   |

Source: WorkSafe




Unlike REBA which requires the user to identify high risk postures, the NZMAC guides the user to provide examples for assessment. As with REBA worst-case scenarios are assessed and the user needs to consider not only the environmental issues on that day but also what other factors may be possible. For example, the day of assessment may occur during pleasant weather, but the work environment would be different if after heavy rain or during high winds.

### 2.5.3 New Zealand Assessment of Repetitive Tasks (NZART)

The NZART was designed to assess some common risk factors in repetitive work that contribute to the development of upper limb WRMSDs. It is suitable for tasks which require the repeated use of the shoulder and arms and specifically includes wrist and hands. The NZART has a similar format to the NZMAC. It guides the user to consider the worst-case examples for assessment, however only three risk levels are provided (Figure 2). The risk factors assessed are presented in Table 2.

The authors identified specific parts of the hive inspection task for assessment and screenshots of these from the video footage were captured.

## Figure 2 NZART Risk levels

|   |  |
|---|--|
|  | <p><b>Low level of risk</b><br/>Although the risk is low, consider the exposure levels for vulnerable groups such as workers who are new mothers, or pregnant, young workers, older workers, new to the job or workforce, or those that have a disability, significant health condition, injury, or are recovering from an injury.</p> |
|  | <p><b>Medium level of risk</b><br/>Examine tasks closely.</p>  |
|  | <p><b>High level of risk</b><br/>Prompt action needed. This may expose a significant proportion of the working population to risk of injury.</p>   |

Source: WorkSafe

**Table 2 Comparison of REBA, NZMAC and NZART**

| Method | Focus   | Risk factors included  | Output   | Advantages  | Limitations  |
|--------|---|--|--|---|--|
| REBA   | Whole body assessment including hand coupling, load and force   | Awkward postures of the neck, trunk, legs, shoulders, elbows and wrists.<br>Forces or loads handled.<br>Hand coupling.<br>Repetition   | Risk rating with five action levels<br>Body parts- trunk neck legs knees, upper and lower arms, wrists | One page, improves with practice, validated and reliable  | Does not assess duration. The right and left side need to be assessed separately. Not suitable for cyclical work tasks.<br>Only considers physical risk factors.       |
| NZMAC  | Focuses on the lower back.<br>Assesses three types of manual handling tasks:<br>Lifting and lowering<br>Carrying<br>Team handling | Load weight/frequency.<br>Hand distance from the lower back<br>Vertical lift zones.<br>Torso twisting and sideways bending.<br>Postural constraints<br>Grip on the load<br>Floor surface, and<br>Environmental factors | Traffic light risk level rating for individual risk factors with suggested action levels               | Able to assess whole task, step-by-step, easy to follow guide.<br>Includes environmental factors. Style and format have a similar layout to NZART which provides consistency. | Focuses on the lower back, does not consider upper or lower limbs.<br>Advises user to consider psychosocial factors but these are not scored so may easily be ignored. |
| NZART  | Tasks requiring repetitive upper limb movements   | Arm movements<br>Repetition<br>Force<br>Head/neck position<br>Back position<br>Arm position<br>Wrist position<br>Hand/finger grip<br>Breaks<br>Work pace   | Traffic light risk level for individual risk factors with suggested action levels                      | Style and format have a similar layout to NZMAC which provides consistency.   | Focuses on the upper limbs, does not consider lower limbs.<br>Advises the user to consider psychosocial factors but these are not scored so may easily be ignored.     |

## Results

This is the first study to use the NZMAC and NZART tools for an agricultural task and provides an example for future use among other agricultural sectors with non-standardised work processes. The results from the REBA, NZMAC and NZART assessments are presented in order.

After agreement on the screenshots to be examined the two authors independently assessed the postural examples using REBA, NZMAC and NZART. If there were differences in results they were discussed and resolved.

To aid understanding a brief explanation of the terminology and process is provided here:

- Supers: Are hive boxes used for bees to store honey


- Smoking hives: Helps calm bees as they are being disturbed during hive inspections or movements
- Cracking hives: Refers to the sound the wax seal makes when hives are being prised apart
- Removeable frames: frames are suspended in the supers for bees to store honey and can be added or removed
- Scraping: Is a housekeeping duty to remove buildup of excess wax




### 3.1 REBA




Several separate steps were identified in the hive inspection task including lifting and lowering of supers, smoking hives, cracking hives, releasing frames, lifting out frames, inspecting frames, replacing frames, scraping wax. A REBA assessment was conducted for each of these steps and the results are presented in Table 3. An example of the assessment worksheet is provided for the step of cracking hives Figure 3.

The level of physical risk assessed by the REBA ranged from medium risk to very high risk. No activities were assessed as low risk. As this assessment was undertaken in spring, and the hives were just beginning to thrive, additional supers (the boxes for honey) would be added as the season progressed to summer which is likely to increase the risk levels.

**Table 3 REBA assessments for hive inspection**

| Activity                    | Illustration for scoring   | Score A | Score B | REBA score |
|-----------------------------|--|---------|---------|------------|
| Lifting and lowering supers |  | 9       | 6       | 11         |

|                         |   |          |          |          |
|-------------------------|---|----------|----------|----------|
| <p>Smoking hives</p>    |   | <p>6</p> | <p>4</p> | <p>7</p> |
| <p>Cracking hives</p>   |  | <p>8</p> | <p>8</p> | <p>8</p> |
| <p>Releasing frames</p> |  | <p>6</p> | <p>6</p> | <p>9</p> |

|                           |   |          |          |          |
|---------------------------|---|----------|----------|----------|
| <p>Lifting out frames</p> |    | <p>4</p> | <p>5</p> | <p>5</p> |
| <p>Inspecting frames</p>  |   | <p>4</p> | <p>5</p> | <p>5</p> |
| <p>Replacing frames</p>   |  | <p>4</p> | <p>5</p> | <p>5</p> |

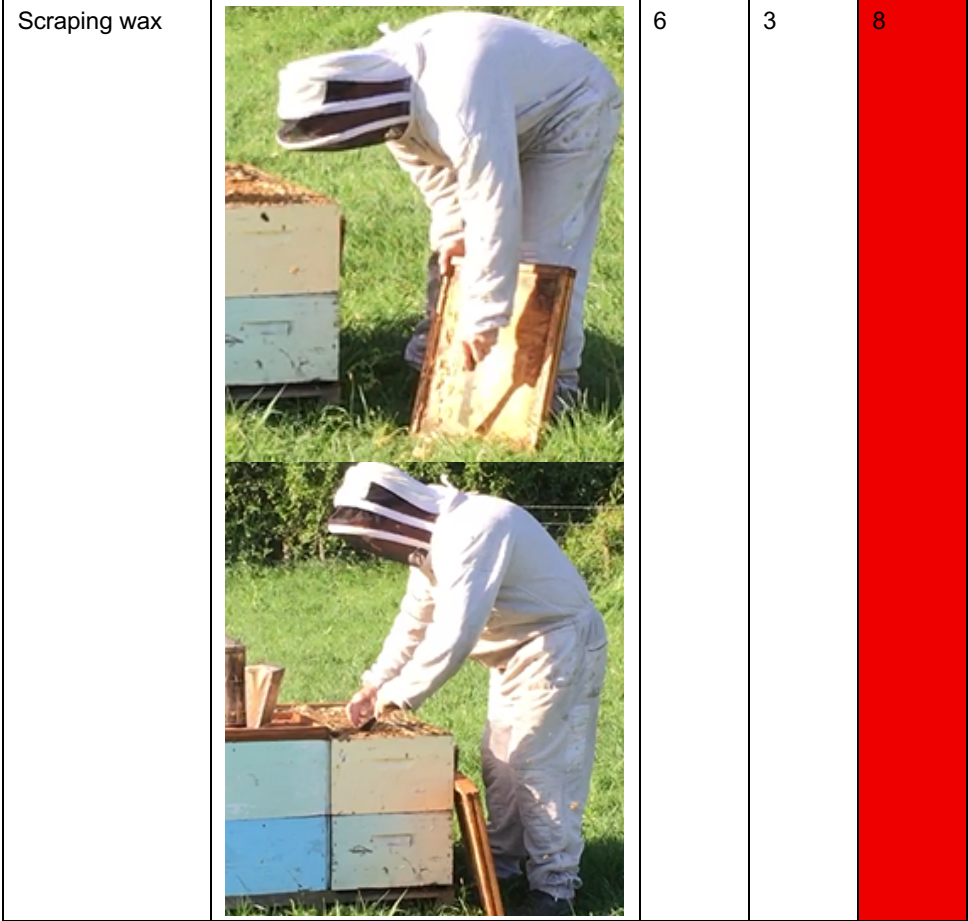


Figure 3 Example of REBA worksheet for lifting and lowering

**A. Neck, Trunk and Leg Analysis**

**Step 1: Locate Neck Position**

Step 1a: Adjust...  
If neck is twisted: +1  
If neck is side bending: +1

**Step 2: Locate Trunk Position**

Step 2a: Adjust...  
If trunk is twisted: +1  
If trunk is side bending: +1

**Step 3: Legs**

Adjust: +1 for shock or rapid build up of force; +1 for force.

**Step 4: Look-up Posture Score in Table A**

Using values from steps 1-3 above, Locate score in Table A

**Step 5: Add Force/Load Score**

If load < 11 lbs.: +0  
If load 11 to 22 lbs.: +1  
If load > 22 lbs.: +2  
Adjust: If shock or rapid build up of force: add +1

**Step 6: Score A, Find Row in Table C**

Add values from steps 4 & 5 to obtain Score A. Find Row in Table C.

**Scoring**

1 = Negligible Risk  
2-3 = Low Risk. Change may be needed.  
4-7 = Medium Risk. Further Investigate. Change Soon.  
8-10 = High Risk. Investigate and Implement Change  
11+ = Very High Risk. Implement Change

**Table A: Scores**

|         | Neck |   |   |   |   |   |   |   |   |   |   |   |
|---------|------|---|---|---|---|---|---|---|---|---|---|---|
|         | 1    |   |   |   | 2 |   |   |   | 3 |   |   |   |
| Legs    | 1    | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Trunk   | 1    | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 3 | 3 | 5 |
| Posture | 2    | 2 | 3 | 4 | 5 | 3 | 4 | 5 | 6 | 4 | 5 | 6 |
| Score   | 3    | 2 | 4 | 5 | 6 | 4 | 5 | 6 | 7 | 5 | 6 | 7 |
|         | 4    | 3 | 5 | 6 | 7 | 5 | 6 | 7 | 8 | 6 | 7 | 8 |
|         | 5    | 4 | 6 | 7 | 8 | 6 | 7 | 8 | 9 | 7 | 8 | 9 |

**Table B: Lower Arm**

|           | Upper Arm |   |   |   |   |   |
|-----------|-----------|---|---|---|---|---|
|           | 1         |   | 2 |   | 3 |   |
| Wrist     | 1         | 2 | 3 | 1 | 2 | 3 |
| Upper Arm | 1         | 1 | 2 | 2 | 1 | 2 |
| Score     | 2         | 1 | 2 | 3 | 2 | 3 |
|           | 3         | 3 | 4 | 5 | 4 | 5 |
|           | 4         | 4 | 5 | 5 | 6 | 7 |
|           | 5         | 6 | 7 | 8 | 7 | 8 |
|           | 6         | 7 | 8 | 8 | 9 | 9 |

**Table C: Score A and Score B**

| Score A | Score B |    |    |    |    |    |    |    |    |    |    |    |
|---------|---------|----|----|----|----|----|----|----|----|----|----|----|
|         | 1       | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 |
| 1       | 1       | 1  | 1  | 2  | 3  | 3  | 4  | 5  | 6  | 7  | 7  | 7  |
| 2       | 1       | 2  | 2  | 3  | 4  | 4  | 5  | 6  | 6  | 7  | 7  | 8  |
| 3       | 2       | 3  | 3  | 3  | 4  | 5  | 6  | 7  | 7  | 8  | 8  | 8  |
| 4       | 3       | 4  | 4  | 4  | 5  | 6  | 7  | 8  | 8  | 9  | 9  | 9  |
| 5       | 4       | 4  | 4  | 5  | 6  | 7  | 8  | 8  | 9  | 9  | 9  | 9  |
| 6       | 6       | 6  | 6  | 7  | 8  | 8  | 9  | 9  | 10 | 10 | 10 | 10 |
| 7       | 7       | 7  | 7  | 8  | 9  | 9  | 9  | 10 | 10 | 11 | 11 | 11 |
| 8       | 8       | 8  | 8  | 9  | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 |
| 9       | 9       | 9  | 9  | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 12 | 12 |
| 10      | 10      | 10 | 10 | 11 | 11 | 11 | 11 | 12 | 12 | 12 | 12 | 12 |
| 11      | 11      | 11 | 11 | 11 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| 12      | 12      | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |

**Table C Score** 10 + **Activity Score** 1 = **REBA Score** 11

**B. Arm and Wrist Analysis**

**Step 7: Locate Upper Arm Position:**

Step 7a: Adjust...  
If shoulder is raised: +1  
If upper arm is abducted: +1  
If arm is supported or person is leaning: -1

**Step 8: Locate Lower Arm Position:**

**Step 9: Locate Wrist Position:**

Step 9a: Adjust...  
If wrist is bent from midline or twisted: Add +1

**Step 10: Look-up Posture Score in Table B**

Using values from steps 7-9 above, locate score in Table B

**Step 11: Add Coupling Score**

Well fitting Handle and mid range power grip, **good: +0**  
Acceptable but not ideal hand hold or coupling, acceptable with another body part, **fair: +1**  
Hand hold not acceptable but possible, **poor: +2**  
No handles, awkward, unsafe with any body part, **Unacceptable: +3**

**Step 12: Score B, Find Column in Table C**

Add values from steps 10 & 11 to obtain Score B. Find column in Table C and match with Score A in row from step 6 to obtain Table C Score.

**Step 13: Activity Score**

+1 1 or more body parts are held for longer than 1 minute (static)  
+1 Repeated small range actions (more than 4x per minute)  
+1 Action causes rapid large range changes in postures or unstable base




Original Worksheet Developed by Dr. Alan Hedge, Based on Technical note: Rapid Entire Body Assessment (REBA), Hignett, McAtamney, Applied Ergonomics 31 (2000) 201-205





### 3.2 NZMAC

The linear approach provided in a NZMAC assessment is different to that of REBA and provides guidance on the risk factors which may be present. The NZMAC assessment indicated that there are medium and high levels of physical risks associated with WRMSDs in the task of hive inspection (Table 4).

Unlike REBA, the total score in NZMAC does not provide a summary of the level of risk or an action level, rather a level of priority for management. For example, if five different tasks were assessed the highest overall scores would indicate the task with highest priority for action. The value of this single assessment for hive handling is that it clearly identifies which parts of the task require risk reduction measures.

**Table 4 NZMAC assessment for handling supers**

| Risk factors                        | Score (colour band and numerical score)   | Illustration for score   |
|-------------------------------------|---|--|
| *Load weight/frequency              | A/4                                       | Weights lifted during task 24kg, seldom  |
| Hand distance from the lower back   | R/6<br>Hands far from low back            |  <p>Lifting two supers</p>  |
| Vertical lift zones                 | A/1<br>Hands between knee and floor level |  <p>Lifting two supers                      Lifting one super</p>                |
| Torso twisting and sideways bending | A/1<br>Torso twisted                      |  <p>Placing super on hive                      Lifting outer lid from ground</p> |


|                       |                             |   |
|-----------------------|-----------------------------|---|
| Postural constraints  | A/1<br>Postural constraints |  <p>Lifting super onto hive – lift determined by height of hive and requirement to reach away from body to place hive</p> |
| Grip on the load      | R/2<br>Poor grip            |  <p>Grip to hold super</p>  |
| Floor surface         | R/2<br>Poor floor surface   |    |
| Environmental factors | R/2<br>Two or more factors  |  <p>Weather – wind, humidity and heat; bees; stock in field</p>   |
| Total score           | 19                          |   |

### 3.3 NZART


The NZART assessment indicates that the task of hive inspection poses a medium to high risk for the development of WRMSDs for the upper limbs (Table 5). This correlates with the self-reports for WRMSDs prevalence over the last year for the neck, shoulder and wrist/hands. As indicated for the NZMAC, the exposure score is not an indicator of the level or risk but provides a comparative point for post intervention assessments or with assessments of other tasks.

**Table 5 NZART assessment**

| Risk factors      | Left arm score (Colour band and numerical score) | Right arm score (Colour band and numerical score) | Illustration for score   |
|-------------------|--|---|--|
| 2.1 Arm movements | R/6  | R/6   | <div style="display: flex; justify-content: space-around; align-items: center;">    </div> <div style="display: flex; justify-content: space-around; margin-top: 10px;"> <span>Levering open inner lid</span> <span>Reaching for smoker</span> <span>Loosening frames with hive tool</span> </div> |
| 2.2 Repetition    | G/0  | G/0   | Similar motion of the arm and hand (not fingers) repeated 10 times per minute or less  |
| 2.3 Force         | R/6  | R/6   | <div style="display: flex; justify-content: space-around; align-items: center;">    </div>   |

|                        |   |     |   |  |  |
|------------------------|---|-----|---|--|--|
|                        | Worst case – cracking hives                                     |     | Smoking hive<br><b>G/0</b>  | Levering out frames with hive tool<br><b>A/2</b>                                     | Cracking open hive<br><b>R/6</b>   |
|                        |   |     | Light force about half the time (40%–60%) – smoking hive                            | Moderate force part of the time (15%–30%) – levering out frames with hive tool       | Strong force infrequent – cracking hives   |
| 2.4 Head/neck position | R/2   | R/2 |   |   |   |
|                        | Neck bent or twisted more than half of the time (more than 50%) |     | Lifting frame out of hive   | Inserting hive tool to lever out frame   | Inspecting frame   |
| 2.5 Back position      | R/2   | R/2 |  |  |  |

|                    |  |     |  |                                |                     |
|--------------------|--|-----|--|--------------------------------|---------------------|
|                    | Torso bent forward or twisted for more than half of the time |     | Placing frame on ground  | Picking out varroa strip       | Reaching for smoker |
| 2.6 Arm position   | A/2  | A/2 |     |                                |                     |
|                    | Arms raised away from the body part of the time              |     | Scraping wax off inner lid   | Scraping wax off top of frames |                     |
| 2.7 Wrist position | A/1  | A/1 |    |                                |                     |

|                      |   |     |  |   |                            |
|----------------------|---|-----|--|---|----------------------------|
|                      | Bent or deviated part of the time                   |     | Levering out frames with hive tool   | Holding and turning frame                 | Placing frame next to hive |
| 2.8 Hand/finger grip | A/1   | A/1 |    |   |                            |
|                      | Pinch or wide finger span grip for part of the time |     | Grasp on hive tool and pinch on frame  | Hold hive tool and grip on smoker bellows |                            |
| 2.9 Breaks           | A/2   | A/2 | <p>Hive inspections alternate with driving to the next apiary. In a team situation, one apiarist is the driver and the others are passengers.</p> <p>Alternative activities are loading and unloading equipment (boxes, frames, queen excluders) from the vehicle.</p> <p>Drink breaks can be taken at will, but the apiarist needs to away from the hives and remove their hood.</p> <p>Lunch and tea breaks are generally taken at the beginning or end of an apiary inspection.</p> |   |                            |
|                      | One hour to less than 2 hours                       |     |  |   |                            |
| 2.10 Work pace       | A/1   | A/1 | External pacing such as distressed bees, weather changes, workload.  |   |                            |

|                          |   |     |  |
|--------------------------|---|-----|--|
|                          | Sometimes difficult to keep up with the work    |     |  |
| 2.11 Other factors       | R/2   | R/2 | Heat, livestock, wind, multiple bees, sticky residue on fingers, gloves.<br>Task requires fine precise movements of fingers.<br><br>R/2 for both right and left hand |
|                          | Other factors that might be present in the task |     |  |
| Task score               | 25  | 25  |  |
| 2.12 Duration multiplier | x1  | x1  | Duration: x1 (4 – 8 hours) as other tasks such as driving and loading/unloading happen in between hive inspections.  |
| Exposure score           | 25  | 25  |  |

## Discussion

Three tools, NZMAC, NZART and REBA were applied to a hive inspection task to assess physical risks associated with WRMSDs. Results from all three tools show that apiarists are potentially exposed to significant WRMSD risk factors which supports the apiarists' self-reports of musculoskeletal discomfort from a previous study (Pierce et al., 2025). The concurrence of the prevalence reports and results of the risk assessment tools contributes to the validity of these assessments (Takala et al., 2010).

The variable task presented a range of postures to be assessed therefore a range of risk factors were present. This was achieved in the REBA by identifying key steps in the role. The NZMAC and NZART have a different approach by allowing for the user to identify the key risk factors. A worst-case scenario was used for both assessments although REBA has an option for assessment of the most frequently adopted posture. Both assessments provide guidance for use within the tool itself. In addition, WorkSafe has accompanying resources to support the use of the NZMAC and NZART and recommend the inclusion of a supplementary assessment for non-physical factors (WorkSafe New Zealand, 2024).

Assessment methods are often criticised for assessing a worst-case scenario rather than sections of the task which do not reach that threshold which may appear to provide an overestimation of risk (Joshi & Deshpande, 2019). The worst-case posture may have a higher risk level but be transient, so the risk level may not apply to the whole task. However, repeated sub-threshold activities are also associated with cumulative harm and are harder to identify.

REBA scores are used to identify the level of risk, however scores created by NZMAC and NZART do not imply a risk level. A low score may infer that there is less risk than a higher score, but it is not possible to quantify a 'safe' level of physical risk due to the influence of a myriad of other factors (Li & Buckle, 1999). Furthermore, it is not possible to assess the risk of latent effects of physical activity.

This is the first known published study that applies the NZMAC and NZART to a variable agricultural work task and to compare it to a REBA assessment.

### 4.1 Limitations

The observations of the apicultural tasks were taken in spring which will have determined the hive heights and weights. Later in the season there would potentially be higher hives as more supers would be added, altering the range of working height and weights. It is anticipated this would increase the level of risk.

Although this study focused on the physical risk factors, it is acknowledged that the development of WRMSDs is multi-factorial. For this reason, WorkSafe recommends the inclusion of a checklist for contributing factors associated with musculoskeletal risks (WorkSafe New Zealand, 2024) which screens for other influential factors.

### 4.2 Strengths

First, two reviewers were involved in the assessments and arrived at consensus for the risk levels. Secondly, this study is a practical application of research knowledge applied to a real-world work situation.

The assessment tools, REBA, NZMAC and NZART, indicated similar physical risks indicating that NZMAC and NZART would be useful and accessible tools for the assessment of physical risk factors in the workplace.

### 4.3 Implications for practice

While the fundamentals of effective workplace risk management are to identify, assess and control, options for assessment are affected by resources, skills and pragmatic restrictions. Each sector has its own unique challenges and specific risks. There is not one single generic risk assessment that can be used across sectors. However, the advantage of using tools like NZMAC and NZART is that users can identify the type of manual task such as lifting, carrying, or repetitive upper limb tasks and apply these tools to their specific situation.

To reduce WRMSD harm and to ensure that risk assessment and management is achievable, further practical and easy to use resources should be developed to support the informed choice and appropriate use of risk assessment methods and effective controls. A participative approach is

needed with input by knowledgeable representatives of high-risk occupations. However, there has been little tangible support for this to occur. Risk management is not a core skill set of many SMEs and these businesses are more vulnerable to harm.

At a regulator level, WorkSafe's main objective, under the WorkSafe Act (2013), is identified as having a proactive approach for 'promoting and contributing to a balanced framework for securing the health and safety of workers and workplaces.' Despite the ubiquitous nature of WRMSDs they appear to be deemed low priority for action as they are unlikely to be fatal but have a high rate of disability (Sebbag et al., 2019). The Crown entity of ACC is tasked broadly with 'injury prevention', however they have a reactive approach and their contribution to musculoskeletal harm is focused on recovery. Neither entity provide reliable data for benchmarking and neither incentivise active risk management practices. Furthermore, the roles and responsibilities of WorkSafe and ACC need to be clarified to ensure a coordinated systems approach to the management of controllable WRMSD risks to reduce the personal and financial burden of harm from WRMSDs.

While risk assessments will identify the likelihood of harm for musculoskeletal disorders, how to change the work may require additional human factors and ergonomics expertise. Research from EU OSHA highlighted that while organisations are carrying out risk assessments, control measures were more difficult to implement and put into the "too hard basket" (Crawford & Davis, 2020). This is often down to a lack of knowledge and training (Yazdani & Wells, 2018). While a participatory approach with workers is essential to identify musculoskeletal risk and both potential solutions and what is acceptable to the workers, workplace changes should be implemented by those with the expertise.

## Conclusions

This study provides a benchmark for future research and will be beneficial to businesses, particularly in the agricultural sector, for the assessment of manual tasks. The findings provide a better understanding of the applicability of NZMAC and NZART and REBA for assessing physical risk factors in a non-standard agricultural task. The identification of physical risk factors was aligned to the self-reports of WRMSDs over the previous year which strengthened the validity of these tools.

It is recognised that eliminating all physical risk factors in this task may not be possible, however the tools successfully highlight the key risk factors of the hive inspection task which are associated with the development of WRMSDs. Our findings indicate there is an unmistakable physical requirement for the role of apiarist.

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