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# Shifting to proactive risk management: Risk communication using the RAMP tool

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**Abstract.** Ergonomic risk factors are major contributors to work-related musculoskeletal disorders and quality deficiencies in the manufacturing industry. Due to lack of tools or systems that can support a systematic risk management of these production and health related factors, a new risk management tool (RAMP) was developed. In this paper, the risk communication system (the Results module) of this tool is presented along with a description of its development. An example of how it can be used, based on assessments performed in industry, is given. An evaluation of its usability, which included twenty practitioners active in the industry, gives support to the notion that the system is usable both for risk communication and as a decision base.

**Key words:** Risk assessment, risk reduction, manual handling, ergonomics.

## INTRODUCTION

Manual materials handling, repetitive movements and frequently adopting stressful postures are major risk factors for work-related musculoskeletal disorders (WMSDs) (Punnett & Wegman, 2004). These ergonomic risk factors are common in several industry branches, such as in the food and vehicle manufacturing industries, as well as in the transport sector, where a high prevalence of WMSDs has been reported (Schneider & Irastorza, 2010; SWEA, 2014). In addition to lost work days and human suffering, poor ergonomic working conditions have also been linked with increased financial cost for companies (Falck et al., 2010; Uegaki et al., 2011), for example, due to increased numbers of quality deficiencies (Eklund, 1995; Falck et al., 2010; Eklund & Yeow, 2015). In some production processes, poor ergonomic working conditions have been related to about 40% of the quality deficiencies (Axelsson, 2000). Information on production performance indicators, such as quality and productivity, is often visualised and reported back to different levels within the organisation and thereby enables the planning and steering of production. Despite the strong link between ergonomics and quality outcomes, there is a lack of visualisation of the 'ergonomic status' (e.g. occurrence of ergonomic risk factors) (Törnström et al., 2008). Feed-back on the ergonomic status of the work and the health status of the workers (e.g. discomfort, pain) is often delayed or lacking, and may instead show up later as sickness absence (Neumann et al., 2009). Because of the time lag, as well as often imprecise information on ergonomic risk factors and their link to a specific job or task, this may result in reactive measures (e.g. reintegration after sickness absence), instead of proactive measures (e.g.

preventing occurrence of sickness absence). However, in order to shift to a proactive mode, early feedback on these performance related factors is needed. By using systematic occupational health and safety management (OHSM), a significant reduction in musculoskeletal disorders has been reported (Cantley et al., 2014), as well as a reduction in the number of accidents (Paas et al., 2015). The commitment of management to this process is often seen as a key factor for an effective OHSM (Cameron & Duff, 2007b; Zanko & Dawson, 2012), and by the use of goal setting, management's safety performance can be enhanced (Cameron & Duff, 2007a, 2007b). Although several assessment tools exist for assessing physical ergonomic risks related to manual handling operations (MHOs) (e.g. Takala et al., 2010), most of them only support a part of the risk management process, usually the identification and evaluation of the risks. Few of them facilitate the OHSM process in terms of supporting design of action plans and design of measures. In addition, few of these tools have integrated systems for communicating their results at different levels of detail, in order to target the needs of the different stakeholders. Therefore, based on the needs from two global organisations in the food and vehicle manufacturing industry, and the identified gap in ergonomic tools, it was decided to develop a new risk management tool (the RAMP tool, 'Risk Assessment and Management tool for manual handling Proactively') (Rose et al., 2011; Lind et al., 2014), which included a system for risk communication.

The RAMP tool consists of two assessment tools (*RAMP I* and *RAMP II*), a risk communication system (*the Results module)* and a system for creating action plans (*the Action module* (Fig. 1). RAMP I can be used by the companies themselves (e.g. managers together with safety representatives) for quick screening of work tasks or work stations for physical ergonomics risks related to MHOs. If the screening using RAMP I identifies a potential risk, an in-depth assessment can be performed using RAMP II by e.g. occupational health and safety experts (e.g. ergonomists from the occupational health services, OHS). The results from RAMP I and RAMP II can then be displayed and communicated using the Results module (which is presented in this paper) at different levels of detail (e.g. from a single workstation or as a plot from multiple workstations). Based on this information, interventions can be designed and implemented with the support of the Action module (design of action plans and suggestions for measures). Using the Action module, the effect of the intervention can be evaluated against the ergonomic status prior to the intervention. Thus, the RAMP tool facilities the whole risk management process (ISO, 2009) including: identification and assessment of physical ergonomic risks, communication of risks to and between different stakeholders within an organisation, support for designing and implementing measures, and evaluations of their effect.

| **RAMP I**<br>Quick screening of potential ergonomic risks | **RAMP II**<br>In-depth assessment of ergonomic risks |
|---|---|
| **Results module**<br>Displays results at different levels of detail & scope | **Action module**<br>Action model, Action suggestions & Action plan |

**Figure 1.** The four modules of the RAMP tool: RAMP I, RAMP II, The Results module and the Action module.

The objective of this paper is to describe the risk communication system (the Results module) in the RAMP tool, its development, to give examples on how it can be used for risk communication within companies, and to describe how end-users perceive its usability.

## MATERIALS AND METHODS

### Development of the risk communication system

The development of the risk communication system (the Results module) was integrated in the development process of the RAMP tool. An iterative process was used, based on close co-operation between researchers and practitioners, using an interactive research approach (Svensson el al., 2007) in which scientific 'knowledge' was combined with expertise of practitioners within the industry. Four companies, (two large, one medium, and one small-sized company) from the food and vehicle manufacturing industries, and the transportation sector, participated. All of these had work sites located in Sweden and had a large amount of jobs which required different types of MHOs, including heavy lifting, pushing and pulling. The development was initiated due to the need for a risk management tool that could be used by one of the large-sized companies and its occupational health services. Together with the other large-sized company with similar needs, and researchers at KTH Royal Institute of Technology the project was started (Rose et al., 2011). A reference group was connected to the project. It consisted of OHS experts from the two large-sized companies, representatives from the Swedish labour market parties (the Association of Swedish Engineering Industries and a labour union 'IF Metall'), an association within the transport sector in Sweden ('TYA'), the Swedish Work Environment Authority, and researchers at KTH (Rose et al., 2011). The role of the reference group was, for example to monitor that the needs for small and medium-sized enterprises (SMEs) were considered and the two small and medium-sized enterprises (SMEs) were recruited from the projects reference group. An inventory of the practitioners' needs (Rose et al., 2011) showed that the users requested a tool that: facilitates communication of the risk assessment to different stakeholders, supports a proactive approach, and presents suggestions of measures for improving the working environment (Rose et al., 2011). A clear presentation of the results (from the assessment) which are easy to interpret, was also seen as an important prerequisite for the efficient facilitation of risk communication.

The development was carried out using recurrent (usually weekly or monthly) workshops from the middle of 2010 to 2014. The number of participants varied, but usually involved a handful. In total, more than 80 practitioners and occupational health and safety experts participated, including managers, one CEO, production engineers, safety representatives, operators, ergonomists from the OHSs and researchers within the field of ergonomics. During visits to 13 production sites, several existing risk communication systems used in industry were examined and input from this was also used in the design process. In the development process, input and feedback from the participating companies were prioritised and influenced the module's structure and design. In addition, ten practitioners and researchers formed a 'usability group' to evaluate and give input on the usability aspect of the Results module. This iterative process continued until the participants signalled that the design of the Results module prototypes met the needs of the users.

**Usability survey**

Twenty practitioners and occupational health and safety experts (including, managers, safety representatives, OHSM personnel and ergonomists) volunteered to participate in an evaluation of the RAMP tool's usability in terms of communicating risks and facilitating risk management. The managers, safety representatives, and the OHSM-personnel were all employed at a large-sized manufacturing company (250 persons employed, EUROSTAT, 2014) and the ergonomists were all employed at the same OHS-organisation. A paper based questionnaire was distributed to each participant at the end of a half-day training session, where participants also had carried out assessments of three video-recorded work tasks using the RAMP tool. The questionnaire contained questions regarding the ease-of-use of making assessments with RAMP I and RAMP II, and questions concerning its usability. In this paper, two of the questions are reported: 1) how the results from the tools can be communicated (Risk communication), and 2) its usability as a decision base. The participants responded to these questions using a five-graded Likert scale (fully agree, partly agree, neutral, partly disagree or totally disagree).

## RESULTS AND DISCUSSION

**Communication of risks and prioritisation of measures**

Based on the workshops with involvement of the practitioners, a three-graded 'traffic light model' was developed for communication of risk and priority (action) level (RPL) (Fig. 2).

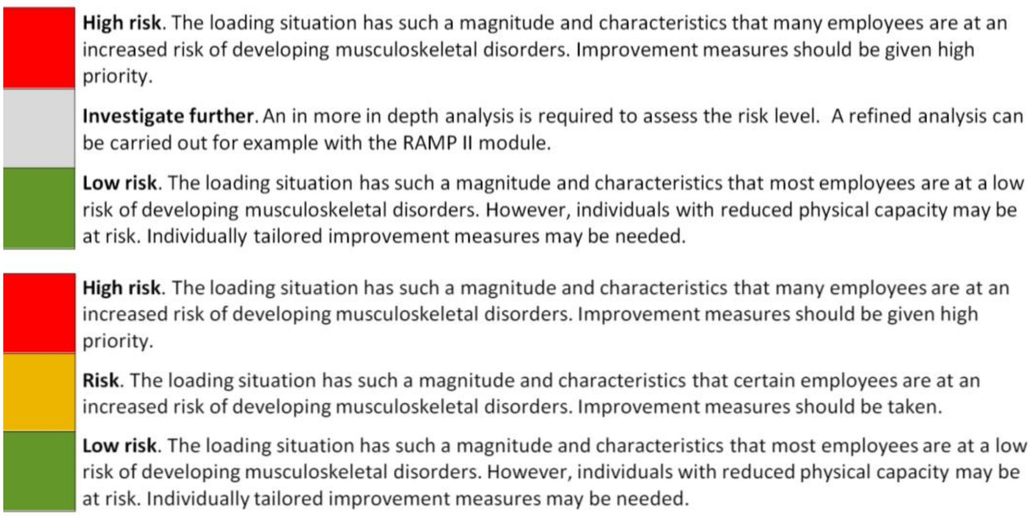


**Figure 2.** The three-graded 'traffic light model' for communication of risk- and priority-level used in RAMP I (top) and RAMP II (bottom). Screenshots from the RAMP tool, https://www.kth.se/sth/forskning/halso-och-systemvetenskap/ergonomi/framtagna-verktyg/ramp/om-ramp-1.511671 (Retrieved 12.2.2016).

The result from RAMP I is communicated using a green, grey, and red colour code representing a low RPL, an unspecified RPL (investigate further) and a high RPL. The result from RAMP II is communicated using a green, yellow, and red colour code, representing a low RPL, intermediate RPL and a high RPL. The use of a three-graded colour code was highlighted by several ergonomists and practitioners as an important facilitator for communicating risks and has been used in several other ergonomic risk assessment tools (Hägg, 2003; Koningsveld et al., 2005, SWEA, 2012). The choice of using a grey colour code instead of a yellow for representing an unspecified RPL (which requires further investigation to settle the RPL) emerged after discussing the practitioners' perceptions of the yellow colour code in a similar risk model (red-yellow-green) from the Swedish Work Environment Authority (SWEA, 2012, p. 35). Using this model from SWEA, several of the practitioners interpreted 'yellow' as an intermediate risk although it is stated that a more in-depth assessment is required to determine if the risk can be regarded as acceptable or not. To avoid potential confusion about the intermediate level in RAMP I, a grey colour code was used signalling that further investigation is needed to assess the risk level. In addition to the colour code in RAMP II, each risk factor (Fig. 4a, factor 1.1–7.1), has an accompanying score (see Fig. 3 for an example). The score allows for a refined risk evaluation and risk communication within each RPL category (red-yellow-green), due to the multiple scale increments. However, when using these for prioritisation, the score is subordinate of the colour.

| | |
|---|---|
| 4 hours or more | **10** |
| 3 to < 4 hours | **7** |
| 2 to < 3 hours | **5** |
| 1 to < 2 hours | **3** |
| 30 minutes to < 1 hour | **2** |
| 5 to < 30 minutes | **1** |
| < 5 minutes | **0** |

**Figure 3.** Example of scores and colour assessments of duration of stressful trunk postures using RAMP II, displayed at the detailed risk-factor level. Screenshot from the RAMP tool, https://www.kth.se/sth/forskning/halso-och-systemvetenskap/ergonomi/framtagna-verktyg/ramp/om-ramp-1.511671 (Retrieved 2016-02-12).

### The Results module and a case

In order to illustrate the Results module, assessments completed at eleven workstations at a manufacturing site in Sweden are used. At the site, the production is carried out at multiple departments and several of the job tasks consist of MHOs. The names of the departments and workstations have been altered for anonymisation. Using the Results module, assessment performed with RAMP II (or RAMP I) can be displayed at several levels of detail: from a single workstation (Fig. 4) to multiple work stations at a one or several departments (Fig. 5) or sites (Fig. 7). As shown in Fig. 4, each of the assessed factors (number 1.1–7.1) is accompanied by a colour code and a score. As shown at the bottom of the figure, the number of green, yellow and red assessments (RPLs) is summarised, as well as the total score. In this example, the assessment of *Workstation A* using RAMP II has resulted in twenty-nine green and five yellow assessments and a total (risk) score of twelve.

| Department | | Dep.A |
|---|---|---|
| Workstation | | A1 |
| **1. Postures** | | |
| 1.1 Posture of the head - forwards and to the side | yellow | **2** |
| 1.2 Posture of the head - backwards | green | **0** |
| 1.3 Back posture - moderate bending | green | **1** |
| 1.4 Back posture - considerable bending and twisting | green | **1** |
| 1.5 Upper arm posture - hand in/above shoulder height* | green | **0** |
| 1.6 Upper arm posture - hand in/outside outer work area* | green | **0** |
| 1.7 Wrist posture* | green | **0** |
| 1.8 Leg and foot space and surface | green | **0** |
| **2. Work movements and repetitive work** | | |
| 2.1 Movements of the arm* | green | **0** |
| 2.2 Movements of the wrist* | green | **0** |
| 2.3 Type of grip* | green | **0** |
| 2.4 Shorter recovery/variation | green | **0** |
| 2.5 Longer recovery/variation | green | **0** |
| **3. Lifting** | | |
| 3.1 Lifting (average case) | green | **0** |
| 3.1 Lifting (worst case) | green | **0** |
| **4. Pushing and pulling** | | |
| 4.1 Pushing and pulling (average case) | green | **0** |
| 4.2 Pushing and pulling (worst case) | green | **0** |
| **5. Influencing factors** | | |
| **5.1 Influencing physical factors hand/arm** | | |
| a+b. Hand-arm vibrations | green | **0** |
| c. Manually handling of warm or cold object | green | **0** |
| d. Hand used as impact tool | green | **0** |
| e. Holding hand-tools weighing > 2.3 kg, > 30 min. | green | **0** |
| f. Holding precision tools weighing > 0.4 kg > 30 min. | green | **0** |
| **5.2 Other physical factors** | | |
| a+b. Whole body vibrations | green | **0** |
| c. Insufficient visual conditions | green | **0** |
| d. Hot, cold or draughty environment | green | **0** |
| e. Prolonged standing or walking on hard surfaces | yellow | **2** |
| f. Prolonged sitting | green | **0** |
| g. Prolonged standing | yellow | **2** |
| h. Kneeling/squatting | green | **0** |
| **5.3 Work organizational and psychosocial factors** | | |
| a. No possibility to influence the work pace | green | **0** |
| b. No possibility to influence the work setting | yellow | **2** |
| c. Difficulties in keep up with the work tasks | green | **0** |
| d. Employees work rapidly in order to take longer breaks | green | **0** |
| **6. Reports on physically strenuous work** | | |
| 6.1 Documented reporting on physically strenuous work | green | **0** |
| 6.2 Type of work that has led to reporting: | green | **0** |
| **7. Perceived physical discomfort** | | |
| 7.1 Perceived physical discomfort | yellow | **2** |
| 7.2 The worst task: | | |
| Total score | | 12 |
| **Number of red assessments - High risk/action level** | **0** | |
| **Number of yellow assessments - Risk/action level** | **5** | |
| **Number of green assessments - Low risk/action level** | **29** | |

**Figure 4.** The results from an assessment of workstation A1 (using RAMP II), displayed at risk-factor level using the Results module.

In the next example, eleven workstations from two departments have been assessed using RAMP II, and the results are displayed using the Results module (Fig. 5). This presentation indicates that lifting, and pushing/pulling operations have been categorised as high RPL, and that a reduction in the exposures should be given high priority. Prolonged standing or walking on hard surfaces was, additionally identified as a risk (Fig. 5, factor 5.2e) at all of the assessed workstations. This means that this hazard could not be eliminated by introducing work rotation between these eleven workstations. Instead other measures are needed, such as changing the floor type, or enlarging the rotation schedule to other types of work tasks with lower exposure to hard floors.

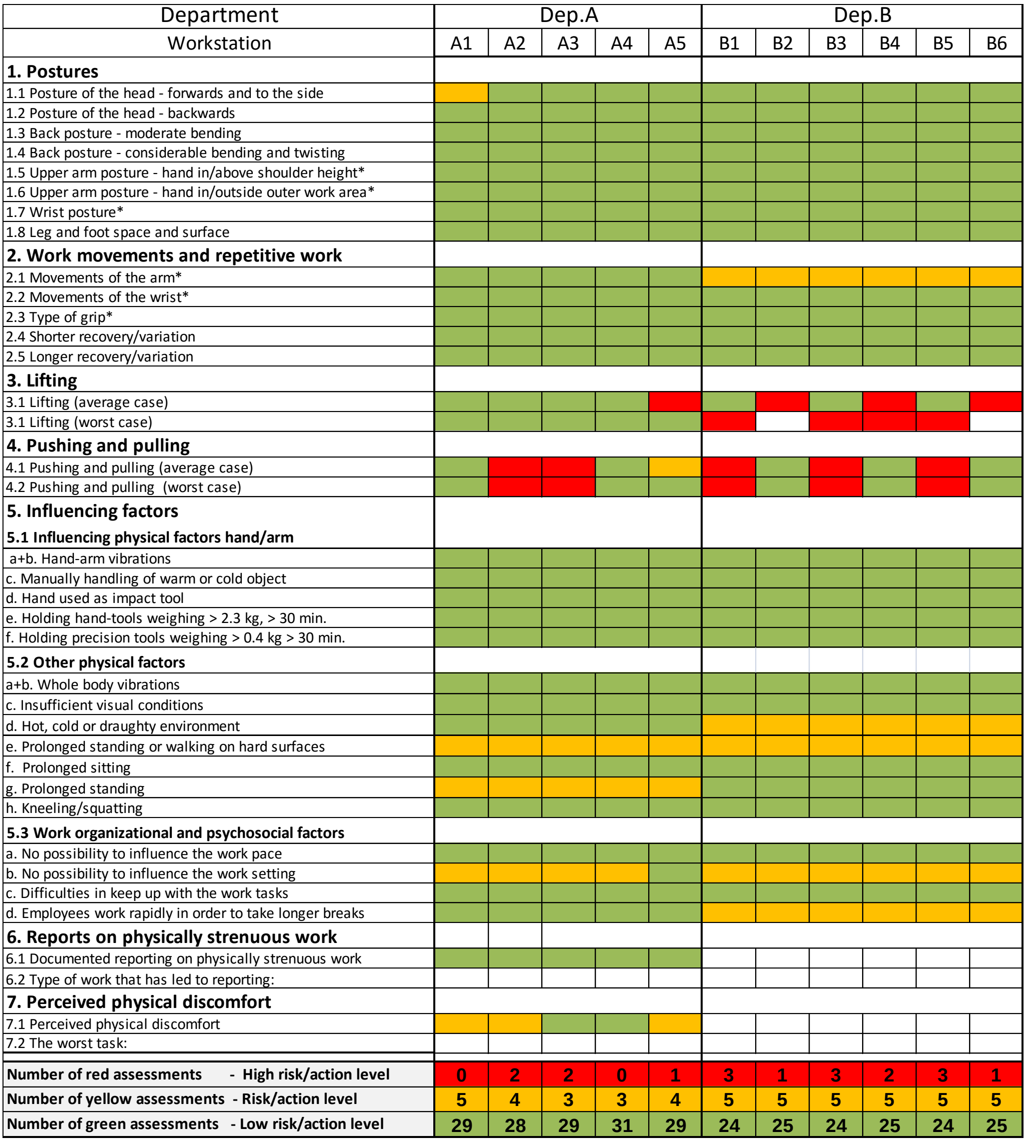


**Figure 5.** The results from assessments of eleven workstations from two different departments (using RAMP II), displayed at risk-factor level using the Results module.

At department B (Fig. 5), movements of the upper arm were categorised as a risk (yellow RPL) at all of the workstations (B1–B6). As shown in Fig. 5, the RPL-level cannot be reduced to an acceptable level (low RPL) by simply introducing work rotation between these six workstations. Other measures are needed, e.g. engineering controls (redesign of work). To communicate the cause of the risk in more detail, an in-depth analysis of each factor can be made using the RAMP tool. In order to illustrate this, factor 2.1 (*Movements of the upper arm*) from workstation B1 is used. This factor (2.1) was given a score of '2' due to the movement pattern of the left and right arm (see the white boxes in Fig. 6), which resulted in a yellow RPL level. In order to reduce the RPL level, measures targeting altering the movement pattern for both arms are needed.

**2.1 Movements of the arm (upper and lower arm)**

How are the movements of the arm generally?

| | Left | Right |
|---|---|---|
| Constant movements mainly without pause | 5 | 5 |
| Frequent movements with some pauses | 2 | 2 |
| Varied movements, movement now and then (up to 2/min) | 0 | 0 |
| | 2 | 2 |

**Figure 6.** The results from an assessment of the arm movement pattern at workstation B1 (using RAMP II), displayed at detailed risk-factor level.

The assessment can also be displayed at a less detailed level (Figs 7 and 8). The assessments from the two departments (A and B) are displayed in Fig. 7 at risk-category level. This level facilitates a quick overview of the seven risk categories, and, in addition, the total number of red, yellow and green assessments at each workstation. According to the assessments (Fig. 7), both lifting and pulling/pushing have been identified as high risk (high RPL) at the two departments.

In Fig. 7, a hypothetical case of an overview of assessment made at an enterprise with production sites in both Sweden and in Canada is displayed. The overview shows that departments G:A (in Gothenburg) and T:B (in Toronto) have a large amount of factors categorised as high risk (high RPL). This information can be used within the company for prioritising resources and measures targeted at these two departments.

| Department | Dep.A | | | | | Dep.B | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Workstation | A1 | A2 | A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 |
| **1. Postures** | 1 | | | | | | | | | | |
| **2. Work movements and repetitive work** | | | | | | 1 | 1 | 1 | 1 | 1 | 1 |
| **3. Lifting** | | | | | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| **4. Pushing and pulling** | | 2 | 2 | | 1 | 2 | | 2 | | 2 | |
| **5. Influencing factors** | 3 | 3 | 3 | 3 | 2 | 4 | 4 | 4 | 4 | 4 | 4 |
| **6. Reports on physically strenuous work** | | | | | | | | | | | |
| **7. Perceived physical discomfort** | 1 | 1 | | | 1 | | | | | | |
| **Number of red assessments - High risk/action level** | 0 | 2 | 2 | 0 | 1 | 3 | 1 | 3 | 2 | 3 | 1 |
| **Number of yellow assessments - Risk/action level** | 5 | 4 | 3 | 3 | 4 | 5 | 5 | 5 | 5 | 5 | 5 |
| **Number of green assessments - Low risk/action level** | 29 | 28 | 29 | 31 | 29 | 24 | 25 | 24 | 25 | 24 | 25 |

**Figure 7.** The results from assessments of eleven workstations from two different departments (using RAMP II), displayed at risk category level using the Results module. The colours at the top of the figure show the highest RPL (red, yellow or green) for each risk-category (1–7) and its quantity (e.g. *two* red RPLs for 'Lifting' at workstation B4). At the bottom of the figure, the total number of red, yellow and green assessments are shown for each workstation.

| Country | Sweden | | | | | Canada | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site | Stockholm | | | Gothenburg | | Toronto | | | Montréal | |
| Department | S:A | S:B | S:C | G:A | G:B | T:A | T:B | T:C | M:A | M:B |
| Number of red assessments - High risk/action level | 6 | 3 | 10 | 30 | 10 | 10 | 20 | 8 | 15 | 12 |
| Number of yellow assessments - Risk/action level | 16 | 10 | 20 | 60 | 15 | 18 | 35 | 14 | 30 | 20 |
| Number of green assessments - Low risk/action level | 148 | 191 | 242 | 182 | 145 | 176 | 149 | 148 | 227 | 138 |

**Figure 8.** A hypothetical exaple of assessments of ten departments at four sites in two countries, displayed as an overview at site and country level.

The Results module can be used for both prioritisation and goal setting. For example, resources can be targeted at first hand at those workstations or job tasks which have been evaluated as constituting a high risk, and thereafter at those evaluated as moderate risk level (yellow). In addition, at the overview level, the presentation of results s (e.g. Figs 5, 7 and 8) can be used for goal setting (e.g. of a certain reduction of 'red' or 'yellow' workstations), to enhance management's safety performance (Cameron & Duff, 2007a, 2007b). Although the RAMP tool facilitates assessment and communication of a broad range of physical ergonomic factors, several other types of risks may need to be addressed. Therefore, this tool should be complemented with other methods or tools, e.g. observational based risk assessment tools, measurements, observation and interviews (David, 2005). The assessment and communication of risk is aimed at risks at group level, and assessment of individual risk is not supported by the tool. Furthermore, the risk levels used within the RAMP tool should be treated with some caution. The aetiology of WMSD is complex and a clear cut-off between a low risk exposure, a moderate risk exposure and a high risk exposure is currently not sufficiently supported (Viikari-Juntura, 1997; Fallentin, 2003; Lind et al., 2015; Lind, 2016; Coenen et al., 2016).

**Usability survey**

The results from the evaluation (Fig. 9) show that a majority (90% and 95%) of the respondents fully agreed or partly agreed that the RAMP tool (RAMP I and RAMP II respectively), presented the results clearly. About the same proportion (84% and 85%) also agreed (fully or partly) that the tool is usable as a decision base. These results indicate that the RAMP tool is usable in the risk management process for communication of risks and as a base for decisions and both aspects might be important in order to integrate ergonomics in the decision process for implementing measures. Easiness to interpret the results for the client was rated as one of the most important qualities of ergonomic assessment tools among ergonomists (Eliasson et al., 2016). Several methods have been criticised for lack of involvement of the needs of end-users (practitioners) in the development process (David et al., 2008). The development of this tool included more than 80 practitioners and the iterative development process with feedback from the end users was seen as an important prerequisite of the final design of the tool. Most of the practitioners (non-ergonomists) from the manufacturing industry came from large-sized companies, which may result in that primarily the large-sized companies' needs were prioritised.

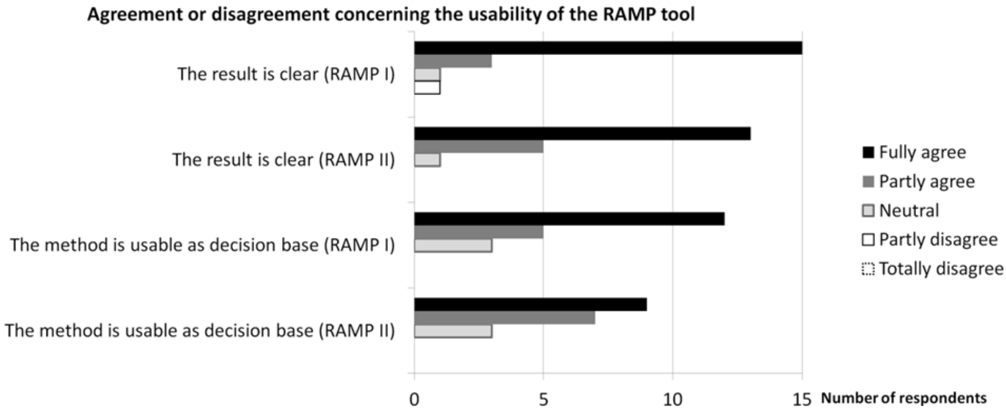


**Figure 9.** Results from the questionnaire evaluating RAMP I and II display results for RAMP I, while 3 and 4 display results for RAMP II. (n = 20).

Therefore, efforts were also made to ensure that the needs of the SMEs were addressed. This was done during recurrent discussions of the needs of the SMEs with the reference group, and with the two participating SMEs. In addition, the inclusion more than 30 ergonomists in the development process is also likely to enhance the usability for SMEs. It should be noted that the usability evaluation was only based on answers from twenty practitioners. These results should therefore not be generalised to other potential users. The RAMP tool is presently being implemented in several European countries as well as in South America, something that gives support to its overall usability.

## CONCLUSIONS

A risk management tool ('RAMP') was developed to facilitate practitioners in risk management of manual handling activities. It includes a module for risk communication (the Result module). To accommodate the users' needs, an iterative development process was used which included participation from more than 80 practitioners. The Result module is presented and described together with examples of how it can be used at companies in the manufacturing industry, and how risk assessments in industries can be visualized. An evaluation of its usability, which included twenty practitioners active in industry, gives support to the notion that the system is usable both for risk communication and as a decision base.

CONFLICTS OF INTEREST. The authors declare no conflicts of interest.

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## REFERENCES


Axelsson, J.R.C. 2000. Quality and ergonomics: towards successful integration. Ph.D dissertation No. 616. Linköping University. Linköping. ISBN 91-7219-652-1, pp. 225–244.

Cameron, I. & Duff, R. 2007a. Use of performance measurement and goal setting to improve construction managers' focus on health and safety. *Constr. Manage and Econ.* **25**, 869–881.

Cameron, I. & Duff, R. 2007b. A critical review of safety initiatives using goal setting and feedback. *Constr Manage and Econ* **25**, 495–508.

Cantley, L.F., Taiwo, O.A., Galusha, D., Barbour, R., Slade, M.D., Tessier-Sherman, B. & Cullen, M.R. 2014. Effect of systematic ergonomic hazard identification and control implementation on musculoskeletal disorder and injury risk. *Scand. J. Work Environ. Health* **40**, 57–65.

Coenen, P., Douwes, M., van den Heuvel, S. & Bosch, T. 2016. Towards exposure limits for working postures and musculoskeletal symptoms – a prospective cohort study. *Ergonomics*, 1–11.

David, G.C. 2005. Ergonomic methods for assessing exposure to risk factors for work-related musculoskeletal disorders. *Occup. Med.* **55**, 190-199.

David, G., Woods, V., Li, G. & Buckle, P. 2008. The development of the Quick Exposure Check (QEC) for assessing exposure to risk factors for work-related musculoskeletal disorders. *Appl. Ergon.* **39**, 57–69.

Eklund, J.A.E. 1995. Relationships between ergonomics and quality in assembly work. *Applied Ergonomics* **26**, 15–20.

Eklund, J.A.E. & Yeow, P.H.P. 2015. Integrating Ergonomics and Quality Concepts. In Wilson, J.R. & Sharples, S. (ed): *Evaluation of Human Work*: 4th Edition. Boca Ranton: Taylor & Francis (CRC Press), pp. 931–956. ISBN: 9781466559615.

Eliasson, K., Lind, C.M. & Nyman, T. 2016. Usage of observational risk assessment methods among ergonomists – which, when and why? Manuscript.

EUROSTAT. 2014. Glossary:Enterprise size. *http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Enterprise_size*. Accessed 23.2.2016.

Falck, A.C., Örtengren, R. & Högberg, D. 2010. The impact of poor assembly ergonomics on product quality: A cost-benefit analysis in car manufacturing. *Hum. Factors Man* **20**, 24–41.

Fallentin, N. 2003. Regulatory actions to prevent work-related musculoskeletal disorders – The use of research-based exposure limits. *Scand. J. Work Environ. Health* **29**, 247–250.

Hägg, G.M. 2003. Corporate initiatives in ergonomics – An introduction. *Appl. Ergon.* **34**, 3–15.

International Organization for Standardization (ISO). 2009. 31000:2009 Risk management – Principles and guidelines. Geneva.

Koningsveld, E.A.P., Dul, J. Van Rhijn, G.W. & Vink, P. 2005, Enhancing the impact of ergonomics interventions. *Ergonomics* **48**, 559–580.

Lind, C., Rose, L., Franzon, H. & Nord-Nilsson, L. 2014. RAMP: Risk management Assessment tool for Manual handling Proactively, *11th International Symposium on Human Factors in Organisational Design and Management (ODAM) and 46th Annual Nordic Ergonomics Society Conference (NES)*. Copenhagen, Denmark, 17–20 Aug, 2014.

Lind, C., Eklund, J. & Rose, L. 2015. A practitioner model for assessing manual lifting and lowering operations – included in the RAMP tool, *Proceedings of the 19th Triennial Congress of the International Ergonomics Association , 'Reaching Out', Melbourne*. *http://ergonomics.uq.edu.au/iea/proceedings/Index_files/papers/611.pdf*. Accessed 11.2.2016.

Lind, C.M. 2016. Pushing and pulling: An assessment tool for OHS practitioners. Submitted manuscript.

Neumann, W.P., Ekman, M. & Winkel, J. 2009. Integrating ergonomics into production system development – The Volvo Powertrain case. *Appl. Ergon.* **40**, 527–537.
Paas, Õ., Reinhold, K. & Tint, P. 2015. OHSAS 18001 contribution to real and formal safety elements in safety management system in manufacturing. *Agronomy Research* **13**, 1260–1274.
Punnett, L. & Wegman, D.H. 2004. Work-related musculoskeletal disorders: The epidemiologic evidence and the debate. *J Electromyogr. Kinesiol.* **14**, 13–23.
Schneider, E. & Irastorza, X. 2010. OSH in Figures: Work-related Musculoskeletal Disorders in the EU – Facts and Figures. European Agency for Safety and Health at Work. Luxembourg: Publications Office of the European Union. *https://osha.europa.eu/en/tools-and-publications/publications/reports/TERO09009ENC*. Accessed 11.2.2016.
SWEA (Swedish Work Environment Authority). 2014. *Work-Related Disorders 2014*, Arbetsmiljöstatistik ISSN 1652–1110. Stockholm.
Svensson, L., Ellström, P-E. & Brulin, G. 2007. Introduction – on interactive research. *Int J Act. Res.* **3**, 233–249.
Rose, L., Lind, C., Franzon, H., Nord-Nilsson, L. & Clausén, A. 2011. Development, implementation and dissemination of RAMP: Risk management Assessment tool for Manual handling Proactively, in: Lindfors, J., Savolainen, M., Väyrynen, S. (ed.), *43rd Annual Nordic Ergonomics Society Conference (NES)*. Oulu, Finland, pp. 255–260.
Takala, E.P., Pehkonen, I., Forsman, M., Hansson, G.A., Mathiassen, S.E., Neumann, W.P., Sjogaard, G., Veiersted, K.B., Westgaard, R.H. & Winkel, J. 2010. Systematic evaluation of observational methods assessing biomechanical exposures at work. *Scand. J. Work Environ. Health.* **36**, 3–24.
Törnström, L., Amprazis, J., Christmansson, M. & Eklund, J. 2008. A corporate workplace model for ergonomic assessments and improvements. *Appl. Ergon* **39**, 219–228.
Uegaki, K., De Bruijne, M.C., van der Beek, A.J., van Mechelen, W. & van Tulder, M.W. 2011. Economic evaluations of occupational health interventions from a company's perspective: A systematic review of methods to estimate the cost of health-related productivity loss. *Occup. Rehabil.* **21**, 90–99.
Viikari-Juntura, E.R.A. 1997. The scientific basis for making guidelines and standards to prevent work-related musculoskeletal disorders. *Ergonomics* **40**, 1097–1117.
Zanko, M. & Dawson, P. 2012. Occupational Health and Safety Management in Organizations: A Review. *Int J Manag. Rev.* **14**, 328–344.