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A SCIENTIFICALLY BASED MANUAL HANDLING RISK ASSESSMENT CHECKLIST & GUIDELINES AND USABILTY TESTING - ONE APPROACH

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The problem

One of the requirements of the Victorian Manual Handling Regulations (Department of Labour, 1988) is that "An employer must ensure that manual handling likely to be a risk to health and safety is examined and assessed" (p2). Pursuant to the Victorian Occupational Health And Safety Act, 1985 (Parliament of Victoria, 1985) it is intended that Codes of Practice such as the Victorian Manual Handling Code of Practice (Department of Labour, 1988) or the subsequent Victorian Manual Handling (Occupational Overuse Syndrome) Code of Practice (Occupational Health and Safety Authority, 1992) be consulted for practical guidance when conducting a manual handling risk assessment and developing risk control measures for the workplace.

Finch, Rechnitzer, Hodgson, Brumen and Caple (1996) propose that the two Victorian Manual Handling Codes of Practice "are consistent with their national (Australian) counterparts, though some of the specific details may be different" (p21).

In the experience of the author the two Victorian Manual Handling Codes of Practice have proven difficult for novices to use, a point supported by Finch et al (1996). These same authors suggest that the 'open-ended' format in the manual handling risk assessment checksheet can result in failure to record "the full parameters of the problem" (p71). Other critics such as Boucaut, Gun, & Ryan (1994), McDonald (1996) and O'Sullivan & Horrigan (1993) have complained of other shortcomings such as failure to provide a quantitative analysis of risk. Boucaut et al (1994) also make the point that the scientific basis for the National Manual Handling Code of Practice has not been formally documented and they doubt the effectiveness or accuracy of the risk identification checklist from that document.

A report to the NSW WorkCover Authority on the 'Developments of Prototype Performance Indicators for Back Injury' - *All systems WORKING WELL* (1996) quotes a focus group of workplace inspectors indicating that criticisms of the Code of Practice are a common experience. The inspectors suggest that "No-one has been able to comprehend the Code of Practice, nobody understands"… and that …"The Code is a difficult document to sell to people, it's just jargonistic. People are overwhelmed by it" (p51). Given that the purpose of a Code of Practice according to the Victorian Occupational Health and Safety Act (Parliament of Victoria, 1985) is to provide "practical guidance to employers, self-employed persons and employees" (Sect. 55(1)) this is indeed serious criticism.

Demand for a quantitative checklist appears widespread - McDonald (1996), O'Sullivan & Horrigan (1993), and Tesh, Symes, Graveling, Hutchinson and Wetherill, (1992). O'Sullivan & Horrigan (1993) also criticise

what they regard to be a lack of a 'true risk assessment checklist' in the Queensland Code of Practice: Manual Handling, 1991, and have developed an alternative quantitative risk assessment method.

In his 'Evaluation of Regulatory Strategies for Back Injury Prevention', Caple (1996) proposes that "a performance-based standard on its own lacks sufficient guidance without the inclusion of the research results which clearly provide more quantitative guidance to the users" (p24).

Research aims

The two basic aims of this research were:

- To investigate, discuss and, as far as possible, establish the scientific basis for a manual handling checklist and supporting guidelines, referred to as the OLGAs Checklist (Occupational Lifting & handling Guidelines & Assessment Checklist).
- To develop a manual handling checklist and supporting guidelines which also provides basic hints for controlling risk within a format which has been tested for usability by novices.

Supplementary aims were:

- To provide guidelines on weight and force limits which are more comprehensive than those in the current Victorian Manual Handling Codes of Practice.
- To integrate risk assessment requirements from the two Victorian Manual Handling Codes of Practice into one document, the OLGAs Checklist.
- To educate the user about potential injuries resulting from the risk factors.

Methods

A review of the literature was undertaken to establish the current scientific knowledge base concerning risk factors in manual handling from various research approaches including epidemiological studies, experimental designs, meta-analyses and case series reports. The literature includes 208 publications covering a 30 year period between 1967 to 1997 with 64% of publications published after 1990 and 28% in the late nineteen eighties.

The references were grouped according to risk factors as reflected in the excerpt shown in Table 1. This became the basis for questions used in the OLGAs Checklist. Those references supporting each of the risk factors were summarised in a tabular format outlining details of study design, methodology and findings.

In designing and developing the OLGAs Checklist it was intended that the document be compact with minimal words and yet be usable by novices. It soon became evident that these aims were very ambitious indeed. The desire for simple and short checklists is understandable. The literature review revealed impressive, quantitative and simple checklists such as RULA (MacAtamney and Corlett, 1993) and the ‘Traffic Light’ model (Heden and Bjurvald, 1995). However these methods require training of the user and include caveats requiring the user to consider certain other factors or conditions if they are present such as 'coupling', 'confined environment' and 'load asymmetry' (Heden and Bjurvald, 1995). Providing explanations for these terms inevitably adds bulk to a checklist and the less experienced the user, the greater becomes the bulk of the document. This occurred with the OLGAs Checklist.

Table 1 - Excerpt from OLGA's Checklist showing questions & supporting references

NB: Original research papers are indicated in normal type
Literature reviews including meta-analyses are indicated in *italics*

Question	Authors
Posture	
1. Is the load shared unevenly between both hands, or lifted by one hand only?	*Kemmlert (1996)*, *Garg et al (1991)*, *Ayoub & Mital (1989)*, Lavender et al (1989), Kim & Chung (1995).
2. Is there frequent or sustained reaching without support for the forearms or elbows: a) above shoulder height?	Aaras (1987), Chaffin (1973), Sakakibara (1987), Hagberg & Wegman (1987), Stenlund et al (1993), Ortengren et al (1991), Riihimaki (1991), *Sommerich et al (1993)*, Putz-Anderson (1988), Bjelle et al (1981), Keyserling et al (1988), Magnussen et al (1987), *Rempel et al (1992)*, Harms-Ringdahl (1986).
b) to the side of the body?	Aaras (1987), Chaffin (1973), Grandjean et al (1983), Keyserling et al (1988), Bjelle et al (1981), Hagberg & Wegman (1987), Hunting et al (1980), Sakakibara (1987), *Winkel & Westgaard (1992)*, Grandjean (1988), Genaidy & Karwowski (1993), *Sommerich et al (1993)*, *Hagberg et al (1995)*.
c) beyond forearm length in front of the body?	Grandjean et al (1983), *Hagberg et al (1995)*, Aaras (1987).
d) Any of the above whilst holding tools or other objects weighing more than 1kg?	Ortengren et al (1991), Chaffin (1973), Mital and Asfour (1983), Aaras (1987).
e) Any of the above whilst applying force?	Harms-Ringdahl (1986), *Hagberg et al (1995)*,Chaffin (1973).

It is also important to recognise the value of regular physical exertion as well as movement through a wide range of postures to maintain good health and specifically good musculo-skeletal health. Thus a risk assessment method should specify thresholds beyond which any exposures are deemed excessive. The OLGAs Checklist has done this by defining *frequent* and *sustained.* However, these criteria are derived from research studies such as Silverstein, Fine & Armstrong (1986) in which the values were used to dichotomise the exposures into high and low repetition for research purposes and not for the purpose of nominating safety parameters. Consequently, it is possible that injury might occur at frequencies below these values.

The attempt to provide Recommended Weight Guidelines was problematic as quantitative methods have serious scientific and practical limitations. Dul & Hilderbrandt (1987) reviewed ergonomic guidelines for the prevention of low back pain and concluded that the qualitative nature of the epidemiological material was not a suitable basis for developing quantitative methods. Kilbom (1994) claims that in guidelines for the upper extremity there is no objective basis for quantifying "static load and the external force parameter", the "posture parameter" or the "speed parameter" (p54-55). Westgaard and Winkel (1996) assert that "there is no consensus on quantifying mechanical exposure nor is there consensus on the operational definition of variables contributing to the exposure quantity" (p80). They define mechanical exposure as "the biomechanical forces generated within the body" (p80). The same authors also claim that it is not yet known how the variables of exposure level, frequency and duration can be combined in a total risk estimate. This view is shared by Hagberg (1992) who states that "There is no consensus on how different exposure variables should be pooled and interpreted as single estimates of cumulative exposure" (p97).

It appears that, in part, compression of the intervertabral disc is the focus of biomechanical modelling because other modelling options do not exist. This view is supported by Genaidy and Karwowski (1993)

who suggest that this approach is due to "(1) simplicity of testing; (2) low margin of error in measurement; and (3) lack of practical means to assess other forms of biomechanical stress in the workplace" (p416). Notwithstanding the above there is some basis, although contentious, for quantitative manual handling risk assessment. It is this author's view that given the limitations of the supporting research such methods only offer a general indication of risk. The revised NIOSH lifting equation (Garg, Rodgers and Yates, 1991) formed the basis for the Recommended Weight Guidelines used in the OLGA's checklist. For improved usability and to minimise calculations required by the users the Recommended Weight Guidelines utilised a format having pre-calculated graphics and an accompanying checklist.

Recommended Force Guidelines have been included in the OLGAs Checklist based on the psychophysically determined tables of Snook & Ciriello (1991).

The two Victorian Manual Handling Codes of Practice and the *draft* OLGAs checklist were then compared for usability. By designing the checklist in a manner which makes it more usable it is intended that it will be used more widely and gain better acceptance. The International Standards Organisation cited in Jordan and O'Donnell (1992) defines usability as "the degree to which specific users can achieve specific goals within a particular environment; effectively, efficiently, comfortably, and in an acceptable manner." (p405). Neilsen (1993) defines usability as "how well users can use .. (system).. functionality" (p25). Ravden and Johnson (1989) define usability as "the extent to which an end-user is able to carry out required tasks successfully, and without difficulty, using the …..system" (p9).

It is necessary to specify the various attributes of usability in order to understand and achieve the correct document design criteria. For the purposes of this study the following attributes were identified in the literature and selected for use: acceptability/attitude, accuracy, learnability, flexibility, effectiveness and usefulness. Owing to resource limitations several attributes were not able to be explored in this study - those being accuracy, flexibility and effectiveness. It was possible to obtain some indication of accuracy during initial review of the risk assessment results but a formal analysis has not yet been conducted. Flexibility and effectiveness are best determined through field testing and lie outside the scope of this study.

The usability trials used in this study were of a heuristic style. Lindgaard (1994) defines a 'heuristic evaluation' as "an informal, subjective usability analysis, conducted from the perspective on intended, typical end users." (p120). Lindgaard (1994) suggests that it is the best means of obtaining a "quick and relatively coarse usability input into a project because it tends to uncover many potential user problems in a reasonably short period of time and with comparatively little effort" (p120). To evaluate software usability Ralph (1993) used a structured questioning and observation process to evaluate novice user interaction with a 'system', determining areas of difficulty for the user such as poor comprehension of the product and /or its application.

The decision on sample size for the usability trials was guided by information taken from tables provided by Lewis (1994) and was an iterative process in that there was a juggling of the various parameters (probability of problem detection, sample size, and percentage of total errors detected) to achieve the optimal end result: A balance between desired outcomes and commitment of resources. The probability for detection of problems was set at 0.25: The process must be rigorous enough to detect problems which are relatively difficult to find. The expected proportion of problems to be found was set at 0.82 (or 82%). Therefore according to Lewis (1994) in Table 2 (p374), the sample size should be set at 6 subjects. Using the same table, identification of 90% of problems (given the same probability for problem detection) would have required a further two subjects with a time requirement of another 12 hours which was unacceptable.

Six subjects participated. Three of these were either managers or supervisors and three were employees, all with experience in different industries and occupations. None of the subjects had previous experience or training in the conduct of manual handling or other risk assessments. It should be noted that the subjects were known to the author and this could potentially bias the outcomes.

Each subject was required to conduct a risk assessment of two videotaped tasks and then develop a risk control plan for each. This process was then repeated several days later with these same two tasks but this time using a second risk assessment method. By randomly assigning the subjects into two groups the order of risk assessment method used was reversed for one group thereby acting as their own controls for a training effect. One of the risk assessment methods used was the *draft* OLGAs Checklist. The other method required the use of one of the Codes of Practice. (Both were given to the subjects). No guidance was

provided to subjects on which Code of Practice to use because it was assumed that this support would not be available in the workplace and that the documents should reasonably be expected to indicate which one was appropriate. The subjects were required to select 'as they saw fit' either the Victorian Manual Handling Code of Practice (1988) or the Manual Handling (Occupational Overuse Syndrome) Code of Practice (1992).

The videotaped tasks were taken from the training package in the Victorian Health & Safety Organisation publication 'Managing Manual Handling Risk - A Resource Package (1995).

Throughout the usability trials questions or prompts using standardised phrasing were used where it was apparent that the subject was either looking for something, trying to understand something or was finding it difficult to proceed. The times taken for each phase of the trial was recorded on a pro-forma document. Upon completion of the trial each subject was required to complete a questionnaire which used visual analogue scales for responses.

Results & discussion

The median reading time (in minutes) required for the subjects to feel comfortable to proceed with the risk assessment was around 50% longer for the Code of Practice compared with the *draft* OLGAs Checklist (35.5 minutes & 25.83 mins respectively).

The median time (in minutes) taken for the subjects to complete the risk assessment and develop a risk control plan was 28% & 17% longer (tasks 1&2 respectively) for the *Draft* OLGAs Checklist compared with the Code of Practice (64.2 minutes & 41.83 minutes respectively). These times should be seen in the context of novice users. There appeared to be several possible explanations for this:

- Some of the subjects completed most of the manual handling risk assessment checksheet with little reference to the guidance material provided in section 7 of the Manual Handling Code of Practice. This made the risk assessment process shorter.
- The weight and force sections of the *draft* OLGAs Checklist were very demanding of the subjects and posed a lot of difficulty. These sections, particularly weight, caused considerable delays as they persevered with the process.
- Most of the subjects (4 of the 6) used the Manual Handling Code of Practice for the second task, when the other Code of Practice was more appropriate (and none of the subjects selected the correct combination for both tasks). Because there are less questions involved with the former document, the risk assessment process in the trials was shorter than it would have been if the correct Code of Practice had been used. Reasons for subjects choices might be:
    a) That subjects found that it was too difficult to distinguish which tasks might cause occupational overuse syndrome. This is understandable given the obscure distinction between risk factors for manual handling and occupational overuse syndrome. The Occupational Overuse Syndrome Code of Practice proposes that tasks identified as having "repetitive movement or sustained postures or both" are likely to be a risk to health and safety.

    b) That the Codes of Practice do not provide sufficiently clear guidance in selecting the appropriate document for risk assessment purposes. This would seem to be a fair criticism as this important information is not readily evident when referring to the Codes of Practice. For example: a suitable heading in the Occupational Overuse Syndrome Code of Practice might read "How to decide which Code of Practice to use".

    c) That the Occupational Overuse Syndrome Code of Practice is very difficult to use. There was some evidence to support this explanation as some subjects demonstrated an initial preference for the occupational overuse syndrome risk assessment checklist and when the need to cross - reference became evident they reverted to the Manual Handling Code of Practice risk assessment checksheet.

For the second task, the subjects did not take as long to perform the risk assessment and risk control as they did for the first. For the Code of Practice this meant a 63% reduction in the median time taken and a

reduction of 77% for the *draft* OLGAs Checklist. It would seem reasonable to expect further reductions in these durations as user experience develops over time. Additional trials would be necessary to determine the magnitude of this effect.

Other findings:

- The risk control page used in the usability trials was common to both methods of risk assessment and subjects found the format difficult to follow. In addition, it was found to be poorly linked to both the *draft* OLGAs Checklist and to the Codes of Practice.
- The Codes of Practice are perceived by subjects to be more 'wordy' than the *draft* OLGAs Checklist despite the fact that the *draft* OLGAs Checklist is as voluminous as the Codes of Practice. The structure and format of the *draft* OLGAs Checklist results in information being more readily accessible than it is in the Codes of Practice. The actual number of words used may be less critical than the manner in which it is formatted.
- The Occupational Overuse Syndrome Code of Practice was undoubtedly the most criticised document used, principally because it seemed repetitive and there was a need to cross-reference to the Manual Handling Code of Practice and uncertainty about how this should work. This further highlights the need to use one document or at least link two documents much more effectively.
- The integrated Manual Handling and Occupational Overuse Syndrome risk assessment format as used in the *draft* OLGA's Checklist was preferred by subjects.
- Graphics are a valuable means of conveying task information and were well received by subjects in the Codes of Practice and the *draft* OLGAs Checklist.
- That quantitative methods as used in the *draft* OLGAs Checklist have limited application with novices.
- That subjects preferred:
    - the placement of guidelines immediately adjacent to the checklist;
    - the use of a 'hints for risk control' section on each page of the guidelines throughout the OLGAs Checklist;
    - to progressively record risk control ideas as they came to mind during the risk assessment process. These were then collated in the final risk control section. This practice does not appear to result in a fragmented approach to controls although a formal analysis of risk control outcomes has not been completed.

The comments made by subjects during the usability trials were regarded as forming a trend when at least three subjects (half of the subjects) were in accord with one another. On this basis the subjects perceived the Codes of Practice as having good illustrations on ideas for risk control and mechanical aids and presented well the process of hazard identification, risk assessment and risk control. However, they found the documents to be verbose, disjointed and confusing. The *draft* OLGAs Checklist was felt to have good layout, was easy to use and was comprehensive although the weight and force sections were very difficult to use (only one subject used these sections).

The exit questionnaires revealed a consistently more favourable response from subjects towards the *draft* OLGAs Checklist compared with the Victorian Manual Handling Codes of Practice and this is indicated in the aggregate scores for each question in Table 2. The subjects regarded the *draft* OLGAs Checklist as being comparatively easy to learn and to use, notwithstanding their dislike for the 'Weight' and 'Force' sections.

The *draft* OLGA's Checklist was modified as a result of the usability trials and input of the expert panel. The final OLGA's Checklist has the following characteristics:

- An integrated manual handling and occupational overuse syndrome risk assessment format.
- The threshold 'frequency' and 'duration' of exposure for risk factors is specified at each page and defined.
- Guidelines explaining the rationale for each checklist question are placed on the immediately adjacent page.

- Hints for risk control are provided with the guidelines. These are also relevant to the adjacent checklist.
- Questions in the 'weight' and force sections of the checklist have been simplified, perhaps even too much so. However novice users were unable to cope with the quantitative approach developed in this study. The scientific basis for one of the general weight recommendations in the OLGAs Checklist is based upon the research of Kelsey et al (1984) who identified that handling of objects weighing more than 11.5 kg whilst bending and twisting more than 25 times per day was associated with increased risk of disc prolapse. This is but one possible 'at risk' scenario and a similar risk is likely to exist if the weight is only 9kg and the bending and twisting occurs 50 times per day. However, the scenario is valid and reflects the interaction between posture, frequency and external loads.
- The quantitative approach to assessing weight and force is now optional and located at the appendices. The format of the quantitative sections has been modified to further improve usability.
- For those who have gained proficiency using the full checklist (and therefore don't require frequent support from the guidelines) an abbreviated checklist is provided at the appendices.
- The process of identification, assessment and control has been outlined in the introduction to the document.

Table 2 - Exit Questionnaire Responses from the usability trials

A comparison of question scores for both methods. ***(Note: the maximum possible score is 30).***	
Question 1 - I feel comfortable enough to use this method on other manual handling tasks in my workplace.	
Codes of Practice Score Count 1 2 ** 2 1 * 3 0 4 2 ** 5 1 * **Aggregate score 17/30**	Draft OLGAs Checklist Score Count 3 2 ** 4 2 ** 5 2 ** **Aggregate score 24/30**
Question 2- I am satisfied with my ability to use this method for manual handling risk assessments.	
Codes of Practice Score Count 1 2 ** 2 1 * 3 0 4 2 ** 5 1 * **Aggregate score 17/30**	Draft OLGAs Checklist Score Count 2 1 * 3 0 4 5 ***** **Aggregate score 22/30**
Question 3- I could find everything I needed when I needed it.	
Codes of Practice Score Count 1 2 ** 2 0 3 2 ** 4 1 * 5 1 * **Aggregate score 17/30**	Draft OLGAs Checklist Score Count 2 1 * 3 1 * 4 3 *** 5 1 * **Aggregate score 22/30**
Question 4- I have a better understanding of why manual handling risk assessments are necessary.	
Codes of Practice Score Count 3 2 ** 4 3 *** 5 1 * **Aggregate score 23/30**	Draft OLGAs Checklist Score Count 4 2 ** 5 4 **** **Aggregate score 28/30**

Question 5- It was very easy to learn how to use this method.	
Codes of Practice	Draft OLGAs Checklist
Score Count	Score Count
1 2 **	4 5 *****
2 1 *	5 1 *
3 1 *	
4 1 *	
5 1 *	
Aggregate score 16/30	**Aggregate score 25/30**
Question 6- I can do manual handling Risk Assessments quickly using this method.	
Codes of Practice	Draft OLGAs Checklist
Score Count	Score Count
1 1 *	4 5 *****
2 3 ***	5 1 *
3 0	
4 1 *	
5 1 *	
Aggregate score 16/30	**Aggregate score 25/30**
Question 7- This method will cause unnecessary costs and time in Risk Assessments and risk control.	
Codes of Practice	Draft OLGAs Checklist
Score Count	Score Count
1 1 *	4 4 ****
2 1 *	5 2 **
3 0	
4 3 ***	
5 1 *	
Aggregate score 15/30	**Aggregate score 26/30**
Question 8- This method will be useful in my workplace.	
Codes of Practice	Draft OLGAs Checklist
Score Count	Score Count
1 1 *	4 3 ***
2 1 *	5 3 ***
3 0	
4 3 ***	
5 1 *	
Aggregate score 20/30	**Aggregate score 27/30**

CONCLUSION

The first aim of this research was "to investigate and discuss the scientific basis for a manual handling checklist and supporting guidelines". The literature review and subsequent discussion identified the risk factors which should be considered in a risk assessment of manual handling tasks. However, significant limitations to the scientific knowledge are evident. For example, it is unresolved how the synergy or interaction between different risk factors can be accounted for in risk assessment methods and this is apparent in the case of static loading of the shoulders where it is unclear as to what extent each variable (the external load, posture or duration) contributes to muscle fatigue or injury. This is particularly problematic for quantitative methods because by definition they seek to place specific values on these effects.

Whilst being cognizant of the above limitations of quantitative methods the appendices of the OLGA's Checklist provides quantitative Recommended Weight and Force Guidelines. For novices the body of the document offers a more simplistic but usable set of assessment criteria for weight and force. This offers a substantial advance over the current Victorian Codes of Practice.

The OLGA's Checklist comprises a manual handling checklist and supporting guidelines as well as providing basic hints for controlling risk. The format has been tested for usability by novices and the results indicate that the subjects find the document more usable than the current Victorian Codes of Practice. This

has been achieved partly through the integration of occupational overuse syndrome risk factors and general manual handling risk factors - an artificial distinction in the view of the author.

The author suggests that there are aspects of the Victorian Manual Handling Codes of Practice which require a substantial review. The usability trials indicate that there is a need for integration of the two Codes of Practice and any guidelines in those documents should be located immediately adjacent to checklist questions as occurs in the OLGAs Checklist. Whilst users should be encouraged to provide written details of risk factors to assist those with limited literacy skills, provision should be made for ticking or circling of questions to indicate that a risk exists.

There is substantial evidence that the Victorian Manual Handling Code of Practice may suffer accuracy problems owing to the format of the checksheet which is separated from the guidance material. This layout is a likely cause of shortcuts taken by users who might feel frustrated by the frequent cross-referencing required when completing the checksheet.

OLGA's Checklist now requires field testing in a variety of industries to establish the document's flexibility. The duration of risk assessment in the usability trials was excessive but the significant changes, particularly to the weight and force sections which caused most user problems, should result in substantially quicker risk assessments using this method. There is still potential for further abbreviation of the checklist but this must be done in formal trial settings so that any potential sacrifices in accuracy or effectiveness can be measured.

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