Checking the checklist:

the effect of training on the application and effectiveness of checklist-based risk management

Report submitted to the IOSH Research Committee

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Abstract

This report details a programme of research undertaken on behalf of IOSH and intended to investigate the critical factors which control the effectiveness of checklist-based risk assessments. Through five research phases, partner companies from UK manufacturing industries provided case examples of current practice and a resource of participants to conduct user trials.

An extensive literature review revealed that previous research had focused on the effectiveness and reliability of checklists in risk assessment. However, very little research had been conducted in assessing the effectiveness of the actual design of checklists and the level of accompanying training that is required to ensure they are used correctly.

A questionnaire survey of 88 companies with more than five employees revealed the state of current practice and a wide range of resources and application of safety practices. From these companies, 15 were selected to undertake an in-depth walk-through involving a site inspection, interviews with health and safety professionals and an audit of health and safety practices.

From the audited companies, four were selected to take part in user trials involving the provision and evaluation of control checklists and accompanying training. This provided a large data set which could be scrutinised to identify the effective features of checklists and the benefits training may offer.

The results reveal a complex picture with numerous confounding influences. Specific features of checklists and training offer benefits in some circumstances and cause limitations in others. A lack of clear patterns suggests that the high degree of variability in companies and staff make prescriptive solutions unreliable as safety interventions.

This report includes some recommendations for assessing the content of checklists but reservations remain over the effectiveness of a single solution for use in any specific company.

Executive summary

This report details the work and findings of an extensive research programme exploring the impact of training on the use of checklist-based risk assessments and the design features which affect the usability of checklists for carrying out effective risk assessments in the UK.

The work is set against a backdrop in which risk assessment is the keystone of workplace safety. It is primarily a legal requirement and is inevitably the first tool that health and safety practitioners reach for when establishing safe working practices. Its ubiquitous nature has meant that there is a strong demand for ready-made resources which can be easily accessed and completed. This has been endorsed by the current ethos of involving all workers in the risk assessment process. This has resulted in the evolution of simple checklist-based tools which allow the user to work through a workplace activity and which should flag factors which may raise the level of risk to unacceptable levels. Because of the diversity of users, these tools are often simplistic if used generically, which reduces their precision. More specific tools have been developed for targeted user groups, such as enforcement agencies, which assume a greater degree of understanding on the part of the user and are hence more detailed and complex. Unsurprisingly, these tools often migrate into the industrial sector, where they may be used inappropriately.

While the use of checklist-based tools has been scrutinised in previous research, the design features of checklists have not. Similarly, the role of training in enhancing the efficiency and longevity of checklists has not been studied, largely due to the simple appeal of the checklist products. This research evaluates how effective the various checklist design features are and the impact training has on supporting the checklist in use. In particular, the study looks at the ability of different strata of the workforce to use a checklist-based risk assessment in conjunction with training to recognise risk factors and then to identify appropriate interventions.

The correct identification of interventions has historically been a shortcoming of the risk assessment process, which normally only highlights the presence of a particular range of risk factors.

The study took the form of five major components spanning a period of two years. The first of these was an extensive literature review. This established the current state of knowledge regarding risk assessment and associated training. It revealed that there is significant knowledge about the use of checklists in risk assessment but not about their design. Similarly, the use of training in workplace safety is well documented, but the role of training in supporting and enhancing the use of checklist-based risk assessments was largely unexplored. These findings were important given the widespread use of checklist tools and the range of training resources available. This review also identified the main checklist-based tools that are currently available.

The second phase of the study involved a wide survey of current practices in the workplace. After significant efforts to overcome industry reluctance, 381 were surveyed by questionnaire to assess their current attitudes and approaches to risk assessment and safety management. Of these, 88 responded, providing a wide cross-section of views and approaches. These companies were also asked to provide examples of the risk assessment tools that they currently use so that they could be further scrutinised. This revealed that companies are largely relying on a limited number of risk assessment tools, the majority of which were not necessarily intended for this purpose. It also revealed a wide range of errors in approach, ignorance in understanding and difficulties in practice when considering safety in the workplace.

In the third phase of the work, 15 companies were selected from those of the 88 that indicated that they would be willing to participate further. Walk-through audits were then conducted at these companies in conjunction with the health and safety manager. These took the form of semi-structured interviews conducted partly in an office-based setting and partly on the shop floor while observing the working practices.

The auditors examined the procedures and systems used, the reasons and justifications for those systems and the work activities they were being used with. These visits further illuminated the range of issues which affect the implementation of good safety practice. One of the main recurrent issues was the diversity of workers and problems with ensuring safety information was effectively communicated. Also apparent were problems with identifying and implementing interventions when risk factors had been raised. A consistent message was the lack of commitment (often financial) at boardroom level to support a ‘safety first’ corporate policy.

Phase four of the work contained the main bulk of the trials undertaken with representatives from four companies drawn from the 15 organisations that had been audited. These four companies were matched in terms of training approaches, structure, size and work tasks to allow cross-comparison. Line managers, line leaders and line workers all contributed to the trials, providing different perspectives on the content. A questionnaire survey of the participants established their current attitudes and approaches. Two risk assessment checklists were developed to examine risk factors for upper limb disorders associated with repetitive activity. These were based on popular intervention tools; one had a more detailed analytical approach while the other was in the form of a 'traffic light' assessment. These were presented to eight groups of workers either with or without training, which was provided by an IOSH-accredited trainer.

The results allowed comparison between the groups of trained and untrained users for each of the two checklists. By using the checklists to review videotaped activities, it was possible to evaluate how the different worker groups viewed the nature and level of risk and whether appropriate interventions could be identified. The opinions of the participants were validated against an expert panel of ergonomists and health and safety professionals who separately reviewed the taped activities, allowing 'success' rates to be established.

The final phase of the work took the form of a longitudinal study intended to establish whether training had any lasting effect on the attitudes and knowledge of the participants and to assess whether any changes to working practices had occurred as a result of participating in the study. This phase involved revisiting the organisations and the participants and repeating the questionnaire survey conducted in stage four. Furthermore a walk-through interview was undertaken with the health and safety manager to explore any changes, benefits or problems that had been revealed following the previous phases.

The main findings of the work were complex and correlated. It was clear that it is possible to identify good and bad design features in checklist-based risk assessments and hence optimise design for better performance. However, the features that were most effective differed according to the worker group undertaking the risk assessment. Clearly, where organisations are encouraged to involve all workers in this process, this is problematic. Similarly, it can be seen that training is effective in enhancing the identification of risk factors and in identifying interventions. However, the effectiveness of the training depends on how the content matches the trainees' abilities, and mixed groups are not particularly effective.

More importantly, other factors were identified as greater obstacles to effective safety management through the use of risk assessment tools. Primary among these was the motivation of the participants. It was clear that those individuals who were interested in, and motivated by, being part of the safety management process (as opposed to those who were 'drafted' or used it as an opportunity to avoid their routine duties) were much more receptive to training and were more adept at using any of the tools.

The report concludes by providing a range of best practice suggestions for developing and using checklist-based risk assessments as well as training resources. However, it is noted that there are serious barriers to the use of these tools being effective.

These include language and cultural obstacles, lack of financial motivation at executive level, the need for bespoke resources for the various strata of workers and the predisposition to rely on risk assessment alone to provide adequate levels of occupational safety.

Recommendations are made for greater outsourcing of risk management activities as well as greater education in the wider principles of safety and risk perception. By necessity this may preclude direct involvement of all types of worker in the process, although there remains a role for all workers in furnishing appropriate information. Nevertheless, it remains the case that the identifying and managing risks in the workplace are not simple problems and the expectation that simple tools and basic training can solve them is flawed.

1 Introduction

This report presents phases one to five of a research project funded by the Institution of Occupational Safety and Health (IOSH). The project investigates the effect of training on the application and effectiveness of checklist-based risk assessments. The research is driven by the need to understand the link between risk identification and risk control. It is hypothesised that this link is forged by the quality of the design of checklists and the correct identification, and by the provision of appropriate training in their use.

The project investigates the effectiveness of two different designs of risk assessment checklist for assessing musculoskeletal risks, and measures their performance with and without training by a range of users in the workplace. The project also investigates the effect of checklist design and training on the longer term results of identifying, implementing and accepting interventions to eliminate or reduce the risks of musculoskeletal disorders.

1.1 Project background

Employers in the UK are legally required under the Health and Safety at Work etc Act 1974 to carry out risk assessments in order to ensure, as far as is reasonably practicable, the health and safety of their workforce. Employers in other countries face similar requirements. Various health and safety bodies such as the Health and Safety Executive (HSE), the National Institute of Occupational Safety and Health (NIOSH), health and safety consultancies and other recognised organisations produce a variety of standard forms of risk assessment aimed at particular issues or tasks to help employers meet their legal duties. For example, standard forms of risk assessment are available for manual handling, display screen equipment, work-related musculoskeletal disorders, slips, trips and falls, and so on. These standard risk assessments are typically in a checklist format.

Checklists can provide a quick and effective means of assessing the specific hazards and the attendant risks involved in a given process. They can be used by a range of users and can vary from standalone tools (requiring only supportive reading for instruction in their use) to examples where staff may require more formal training. Checklists can also be easily adapted – individual companies often reformat standard checklists to suit their needs better.[1,2] As a result there are large numbers of checklist-based risk assessments in use which vary considerably in their design, rating system and means of prioritising risk, as well as in the information they provide about taking action, control and feedback. Because there are hundreds of different types of checklist-based risk assessment, this project focuses on checklists developed to assess work-related musculoskeletal disorder risks.

Work-related musculoskeletal disorders constitute a large proportion of all reported work-related illnesses; in the UK they affected over 1 million people in 2005/06. The costs of work-related musculoskeletal disorders to the economy and to the individual are high. The estimated costs to UK business in 2005/06 were more than £200 million. Checklists are the most common type of tool used by companies to assess work-related musculoskeletal disorder risks.

Although the risks for work-related musculoskeletal disorders are now well recognised, research has shown that the interventions to prevent or reduce them are seldom successfully implemented.[3–5] Similarly, research concerning risk management in general (not restricted to musculoskeletal risk management) has shown that once risk assessments have been completed, and when the risks have been identified, actions required for risk control and risk reduction often fail to be implemented.[1,6] One of the pitfalls listed in a report by Gadd *et al.*[6] was the lack of links between hazard identification and risk control. The study noted that risk assessment is often just a paper exercise where the findings are noted but no action is taken as a result.

Critically, there is very little information on whether checklists successfully aid the risk assessment process – in other words, whether they go beyond simple risk identification and help with the generation and implementation of appropriate actions.

This project investigates the obstacles preventing the progression from risk identification (through the use of checklist tools) to implementing risk controls for work-related musculoskeletal disorder risks and is driven by the need to understand the link between risk identification and risk control.

1.2 Aims

This project focuses on musculoskeletal risk assessment and aims to:

- review current working practices in manufacturing industry regarding risk assessment and the implementation of interventions
- evaluate a representative sample of checklist-based risk assessments of varying designs
- identify design characteristics of risk assessment checklists which are most effective in risk identification and risk control
- evaluate whether accompanying training in the use of the selected checklists is beneficial in risk identification and risk control
- assess whether benefits from training vary for different designs of checklist and, if so, identify the types of checklists that would most benefit from training.

1.3 Objectives

The specific objectives of this project were to:

- carry out a literature review to establish the current state of knowledge
- use a questionnaire survey of representative companies in the UK manufacturing sector to establish current practices and attitudes to checklist-based risk assessment and the application of interventions
- collect a range of checklist-based risk assessments and undertake an expert review to:
  - determine the consistency of identification of risk between participants and experts
  - assess the selection of effective intervention strategies to eliminate or reduce risks
  - assess the implementation of risk reduction interventions
- undertake walk-through audits of volunteer companies to establish their working practices and their effectiveness in risk management and control
- undertake a series of trials using volunteer companies to evaluate design criteria for checklists and the impact of training on the use and implementation of those checklists
- undertake extended trials over a suitable period in order to evaluate the longer term effectiveness of the checklists and accompanying training.

1.4 Project structure

This report presents all the work of this research programme and reports on the following five phases.

1.4.1 Phase 1: literature review

In Phase 1, a review of the literature was conducted; this is presented in section 2 of this report. Phase 1 reviews previous research that has been conducted in:

- risk assessment
- checklist design
- the implementation of risk controls
- the current state of knowledge about checklist-based risk assessment and training.

1.4.2 Phase 2: survey of current musculoskeletal risk assessment practice

In Phase 2, a survey of 300 manufacturing companies was carried out. The survey probed issues relating to:

- current risk assessment processes
- the type of risk assessment employed
- levels of risk and subsequent interventions
- obstacles to conducting risk assessments
- implementation of interventions.

The participating companies were also asked to send in copies of their current risk assessment checklists for review. The results from the survey and a summary of key characteristics of the reviewed checklists are presented in section 4 of this report.

1.4.3 Phase 3: walk-through audits

Walk-through audits were conducted at 15 companies to provide further insight into current working practices in relation to risk assessment of musculoskeletal risks. In addition, measures of 'stage of change' and knowledge, experience and training in ergonomics and risk assessment were gathered to enable companies to be selected and matched for participation in the later phases of the project. The audits also provided baseline data on the number of high, medium and low risk jobs or tasks, and on attitudes towards health and safety, for 'before and after' comparisons to be made in Phase 5. The results from this phase of the project are presented in section 5 of this report.

1.4.4 Phase 4: risk assessment trials

In this phase of the project, the effectiveness of different checklist design characteristics and accompanying training was explored. Two checklists were developed incorporating the same underlying assessment criteria but with different design elements (developed using the results from Phases 1 and 2).

The consistency within and between different checklist-based risk assessments with and without training were evaluated in terms of identification of risk and selection of appropriate interventions. Focus groups were also used to discuss the perceived positive and negative design aspects of each checklist. The results of the risk assessment trials are presented in Section 9 of this report.

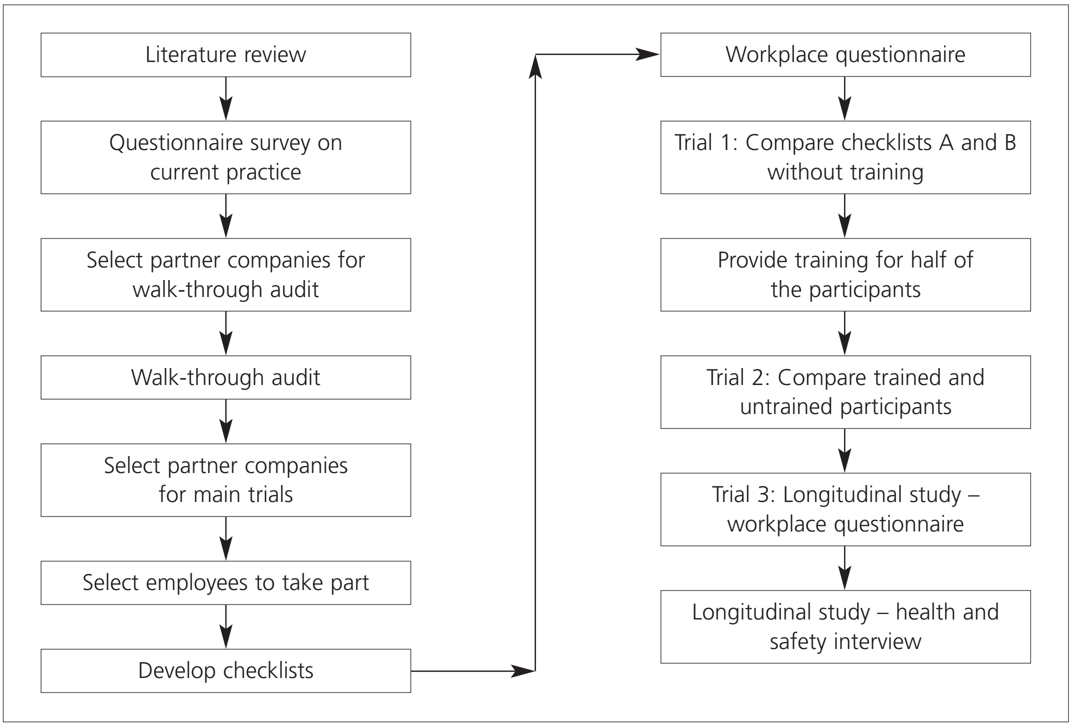
1.4.5 Phase 5: longitudinal study – implementation of risk reduction measures

Phase 5 of the project investigated the longer term effectiveness of the two checklist designs and level of training on the identification, implementation and acceptance of interventions to control or reduce risks. This phase also investigated whether training resulted in increased confidence, changes in attitudes to health and safety, or appropriate interventions, or whether similar or different obstacles in the implementation of interventions were encountered compared to those reported in Phase 3.

This report presents the findings of a five-phase research project funded by the Institution of Occupational Safety and Health (IOSH). The project investigates the effect of training on the application and effectiveness of checklist-based risk assessments focusing on checklists designed to assess musculoskeletal risk factors in the workplace. The research is driven by the need to understand the link between risk identification and risk control. It is hypothesised that this link is forged by the quality of the design of checklists and the correct identification, and implementation of appropriate training in their use.

The project investigates the effectiveness of two different designs of risk assessment checklists for assessing musculoskeletal risks (MSDs), and measures their performance with and without training for a range of users in the workplace. The project also investigates the effect of checklist design and training on the longer term outcomes of the identification, implementation and acceptance of interventions to eliminate or reduce the risks of musculoskeletal disorders. The overall structure of the project is outlined in Figure 1.1.

Figure 1.1
Flow chart of the overall structure of the project



1.5 Phase-specific aims

The aims of the five phases of the project were as follows:

- Phases 1, 2 and 3
  - establish the state of current knowledge and practice
  - evaluate a representative sample of checklist-based risk assessments of varying designs
  - review current working practices in industry regarding risk assessment and implementation of interventions
- Phases 4 and 5
  - identify those design characteristics of risk assessment checklists which are most effective
  - assess whether providing training in the use of the selected checklists is beneficial
  - assess whether the benefits from training vary depending on the checklist design and identify the types of checklist that would most benefit from training.

2 Phase 1: Literature review

A comprehensive literature review was undertaken and covered the following topic areas:

- the risk management process from risk identification to risk reduction
- the advantages and disadvantages of checklists
- the reliability and validity of checklists
- best practice in checklist design
- generic design characteristics of checklists
- the current state of knowledge in the areas of checklist-based risk assessment and training
- evaluation methodologies and effectiveness.

A literature search of the extensive in-house ergonomics databases was conducted using Loughborough University's online search facilities. This included searching the following databases:

- Ergonomics Abstracts
- Compendum
- ArticleFirst (OCLC) Database
- health and safety Science Abstracts (CSA Illumina)
- Web of Science
- OHSIS : Occupational health and safety Information Service

In all, 90 papers were reviewed. Findings and extracts from the relevant literature are discussed and presented in the following sections.

2.1 Musculoskeletal disorders

Musculoskeletal disorders are disorders which result from repeated exposure to musculoskeletal microtrauma. Repeat trauma results in the gradual wear and tear of the muscles, tendons, ligaments and so on, causing degeneration of these structures and often resulting in impaired function. Repeated episodes of trauma can lead to chronic injury, resulting in incapacity and disability.

Work-related musculoskeletal disorders occur when there is a mismatch between the physical requirements of the job and the physical capacities of the human body. The main risk factors are force, repetition, duration and awkward posture. In the literature many acronyms are used to describe disorders of the limbs, eg RSI (repetitive strain injury), WRULDs (work-related upper limb disorders) and WMSD (work musculoskeletal disorders). For the rest of this report these will all be referred to as MSDs.

Although not uniquely caused by work, MSDs constitute a major proportion of all registered and/or compensated work-related diseases. In 2005/06 an estimated 2 million people in the UK suffered from ill health which they thought was work-related. Of those it is estimated that 1,020,000 were suffering from musculoskeletal disorders. Of those cases, 437,000 mainly affected the back, 374,000 mainly affected the upper limbs or neck and 209,000 the lower limbs. In 2005/06 this resulted in 9,450,000 working days being lost due to musculoskeletal disorders.[7] Musculoskeletal disorders incur substantial costs to the economy and also to the individual, as not only do they act to injure the workforce, but they can also be the precursor to secondary problems such as:

- absenteeism
- work accidents
- compensation costs
- high turnover of staff
- poor working climate
- poor quality of work.

The cost of MSDs to UK employers in 2005/06 was estimated to be over £200 million.

Given the extent of the problem, the Health and Safety Commission instigated a priority programme for musculoskeletal disorders and set the following targets to be achieved by 2010:

- a 20 per cent reduction in the incidence of work-related ill health caused by musculoskeletal disorders

- a 30 per cent reduction in the number of working days lost due to musculoskeletal disorders.

However, although the causes of MSDs are now well understood and recognised, their incidence is still not decreasing; rather, injury rates have reached a plateau. Whysall *et al.*[8] suggest that this indicates that health and safety interventions are failing. Research has been conducted to investigate the reasons for the lack of decrease in rates and several studies have identified specific obstacles to addressing MSD risks in the workplace. These obstacles relate to problems in risk assessment and the implementation of appropriate controls. These are discussed in more detail in the next section of this review.

2.2 Risk assessment process

2.2.1 Five steps to risk management

The aim of carrying out a risk assessment is to gain an understanding of the level and significance of workplace risks. The risk assessment should then form the basis for making informed decisions relating to the implementation of appropriate risk control and reduction measures.[6] To assist employers in conducting risk assessments and risk management in the workplace, the HSE produced a guidance leaflet on risk assessment.[9] This was first published in 1994. The purpose of this leaflet was twofold:

- to encourage businesses in general and in particular small and medium sized enterprises (SMEs) to conduct risk assessments
- to demonstrate that risk assessment was a straightforward process that employers could undertake themselves without needing to pay for outside assistance.

The HSE's leaflet prescribes five simple steps to risk assessment, from identification to review:

1 identify hazards
2 decide who might be harmed and how
3 evaluate the risks and decide on precautions
4 record your findings and implement them
5 review your assessment and implementation.

The leaflet clearly states that one should prioritise and tackle the most important things (high risk tasks) first.

The HSE also provides more prescriptive guidance and risk assessment forms for specific work tasks, workplaces and risks, eg manual handling, repetitive work or dealing with hazardous chemicals. However, in all these cases, the 'five steps' approach to risk assessment is still applicable and forms the basis of any risk assessment process conducted in any workplace for any task.

2.2.2 Risk management of musculoskeletal disorders

There are general duties on employers under the Health and Safety at Work etc Act 1974 and the Management of Health and Safety at Work Regulations 1999 that require the risk of MSDs to be addressed. However, other than the draft standard (prEN 1005) on the biomechanics of manual handling, there is no European standard which primarily covers assessing or preventing MSDs. Over the past 10 years agencies in the USA have been trying to establish a standard for ergonomics (Draft Ergonomic Standard Z365) to tackle MSDs, but this is still in draft form and is still being publicly debated. To fill this gap, the HSE in the UK has produced extensive guidance on the management of MSDs in the form of HSG60, *Upper limb disorders (ULDs) in the workplace*.[10] HSG60 puts forward a seven-stage approach to management of MSD risks which incorporates the five steps to risk assessment but is more prescriptive about tackling MSDs specifically:

1 understand the issues and commit to action
2 create the right organisational environment
3 assess the risk of ULDs in the workplace
4 reduce the risk of ULDs
5 educate and inform the workforce
6 manage any episodes of ULDs
7 carry out regular checks on the programme's effectiveness.

Similar guidance on the management of musculoskeletal disorders has been produced in other countries (for example, in the United States by the Occupational Safety and Health Administration, WAC and NIOSH, and in Australia in the form of NOHSC 2013:1994[11]). All of these publications incorporate an overarching management approach based on a participatory model and incorporate the five steps to risk assessment. To assist in steps 1, 3 and 4, all of these guidance documents contain a checklist for assessing the risks of MSDs.

2.2.3 Obstacles to risk management

Neathey *et al.*[1] conducted a study to evaluate the effectiveness of the five steps to risk assessment leaflet and the risk assessment process in general. A total of 1,002 companies were surveyed and 30 more detailed case studies were conducted. The report highlights areas where the approach failed. These were mainly in steps 1 (identify hazards), 3 (evaluate the risks and decide on precautions) and 4 (record your findings and implement them). Failures in these steps to risk management related to resources, support from management and workers, training and problems in linking between risk identification and implementing controls. A growing body of research also demonstrates that risk management of MSDs encounters similar obstacles.

Research shows that despite the recognition and identification of the risks present and the potential utility of ergonomics for companies and employees, guidance and recommendations are rarely implemented to reduce the risks.[3–5,8,12,13] Obstacles reported in the literature centre round the following themes:

- training
- communication
- worker participation
- support from management and workers
- problems in linking risk identification to implementing controls.

Table 2.1 presents a summary of the failings of general risk management and risk management of MSDs reported in the literature. The identified failings are grouped under the following themes:

- resources
- support
- training
- communication in the workplace
- worker participation
- problems progressing through all five stages.

Table 2.1
Obstacles to general risk management and risk management of MSDs

Obstacles to general risk management	Obstacles to risk management of MSDs
Resources	
• Large and medium-sized establishments were more likely than smaller establishments to have a thorough risk assessment strategy[1] • Time needed[1,14]	• Perceived cost benefit: successfully reducing or eliminated MSD risk creates 'non-events' that make it difficult to calculate and present cost benefits[12,15] • Small and medium-sized companies are less likely to perceive interventions as providing benefits than large organisations[8] • Insufficient resources (ie money and time) available to conduct MSD risk assessment and any required changes[1]
Support	
• Gaining senior management and staff support for the approach was often difficult[1]	• Gaining senior management and staff support for the approach was often difficult[1]
Communication in the workplace	
	• Management and staff having different perceptions of the risks and safe working behaviour[16] • Poor inter-departmental communication, eg between health and safety staff and engineers or managers[12,15]

Table 2.1
continued

Obstacles to general risk management	Obstacles to risk management of MSDs
Training	
• Getting staff to understand the risk assessment process and its importance was seen as a particular challenge[1] • Staff confidence in conducting risk assessment was recognised as a particular concern[1] • Ensuring consistency across different sites[1]	• Management and staff having different perceptions of the risk and safe working behaviour[16] • Insufficient training and education of the workforce in risk identification of MSDs[17,18] • MSD issues (symptoms, severity, costs, effects of production, workstation design, working practices) across the workforce[17,18] • A survey of 609 safety representative in 2006 found that 75% felt that they could usefully contribute to a general health and safety risk assessment whereas only 40% felt that they could usefully contribute to an MSD risk assessment[14] • Safety representatives in companies with more than 1,000 employees were better trained in assessing MSD risks than those in smaller companies[14]
Worker participation	
	• Not involving the workforce in the risk assessment and risk control process[17] • Workforce reluctance to accept change in working practices[12,15] • Large organisations experience more resistance to change from the workforce than medium or small ones[8] • In cases where workers are involved and participate in risk identification and solutions they may not have enough knowledge or employees do not have enough influence to change their work situation[19]
Problems progressing through all five stages	
• Some companies saw risk assessment as only identifying risks[6] • Lack of linkage between hazard identification and risk control[6] • Tendency to conduct risk assessments as an occasional or one-off rather than an ongoing activity[1] • Making appropriate adjustments[1] • Maintaining compliance[1]	• Problems linking risk identification to risk controls[5,14] • Workforce reluctance to accept change in working practices[12,15] • Workers may not understand why the improvement is preferable[19]

2.3 Checklist-based risk assessments for assessing MSD risks

There are many methods available to assess the risk of MSDs, and these can be grouped into direct methods and indirect methods. Direct methods of analysis include the use of biomechanical or mathematical models, video analysis, electromyography or devices such as lumbar motion monitors or goniometers. Indirect methods focus on the collection of task variables which may give rise to mechanical exposure in the body. Simple analysis using indirect methods is fast and easy to conduct and is used by a large number of people and organisations for assessing MSD risks. They do not provide the same level of information as direct methods, but they do provide enough information for most companies to identify risks.[20] Malchaire & Cock[21] (cited in Graves *et al*.[22]) highlight the differences in user needs of the experts compared to practitioners (or health and safety representatives). They state that 'for those at company level the priority is to collect information in order to improve working conditions rather than scientifically quantify risks.' Consequently, many observational and indirect tools have been developed to assist in the identification of MSD risk factors in the workplace, the most widespread form being the checklist.[20,22,23]

Typically, checklists are used as a screening tool to identify tasks where risks are present, though they may also assist in identifying control interventions to reduce the risks. Checklists can also be used to establish when a more detailed assessment is required (eg when control interventions cannot be readily identified from the initial screening[10,24,25]). Checklists are quick to complete, provide a systematic means of recording risk information, assist in formalising a plan of action and can help guide companies to comply with health and safety legislation. Neathey *et al.*[1] states that in an attempt to overcome some of the obstacles to risk management such as linking risk identification to risk control and confidence in conducting risk assessment (discussed in section 2.2.3), a checklist approach should be encouraged.

Neathey states that the 'HSE has developed an interaction tool designed to take managers through the process of conducting risk assessment in an office environment via a checklist'. He further suggests that:

> ...similar guidance on other work environments, made available online and in simple hard copy (eg in the form of checklists that could cover the majority of common risks in any specific working environment) would seem likely to meet the needs of many employers wanting additional support.

The US Occupational Safety and Health Administration (OSHA) also recognises the benefits of encouraging the use of checklists in risk assessment. OSHA states that:

> well designed checklists when used in the context for which they are intended, do provided a range of employers, especially small businesses, with an effective alternative to hiring a consultant.

OSHA is currently proposing an ergonomics programme standard to address the significant risks of MSDs.[26] As part of this process OSHA has requested information on the usefulness of checklists to help small businesses conduct job hazard analyses. Specifically, the survey asked whether OSHA should require that employers, or small employers, use checklists and whether OSHA should provide checklists as compliance materials at the time of the final rule of the OSHA ergonomics standard. In the UK the HSE already provides a checklist to assist employers in assessing MSD risks. This is provided in the appendix to HSG60.[10] NIOSH and Washington State Ergonomics Rule (WAC) also provide a checklist to assist in the risk management of MSDs.

2.3.1 Advantages and disadvantages of checklists

The advantages and disadvantages of observational techniques that apply to checklists (in general – not specifically to MSDs) are presented in Tables 2.2 and 2.3. The main advantages reported in the literature are:

- efficiency
- ease of use
- creation of a framework to ensure risk assessments are systematic
- low resource requirements
- provision of a means of maintaining consistency in risk assessment
- likelihood of increasing the user's confidence in conducting a risk assessment thoroughly through the use of prompts to ensure that all risk factors are accounted for.

The disadvantages of checklists reported in the literature include:

- difficulties in classifying small and fast motions and angles of the smaller joints (such as the wrists)
- intra-observer and inter-observer variability of results generated by checklists.

However, studies have indicated that inter-observer variability can be reduced by training and by improvements in checklist design.[23,34] These aspects are discussed in more detail in section 2.4.1 and are also investigated in Phases 4 and 5 of this study.

Although on a scientific level checklists appear to have limitations in quantifying the risks, this has not inhibited their development and use because users want to have tools that are quick, clear and user friendly.[22]

Table 2.2
Advantages of checklists

Advantages of checklists
Efficient and unobtrusive
• They are simple to undertake and provide a quick answer[23] • Postural assessment can be made in a confined workplace without disruption to the workforce[23] • A simple checklist is easy and fast to administer[26]
Good at classifying particular postures and motions
• They are most useful for jobs where body postures are held for longer periods of time, or the body movement follows a simple pattern that is repeated during work[23] • Effective in analysing larger joints (shoulder and back) and variables that have quantitative measures, eg mass, force[20]
Reliability and consistency
• They provide prompts for both expert and non-expert on which factors to observe[27]
Provide a written record
• If employers have more than five employees the results of a risk assessment must be written down. Checklists offer an efficient way of helping employers confirm that they did a proper check, as completing the checklist generates a written record[1]
Requires few resources
• Checklists are relatively inexpensive to carry out[23] • A simple checklist can be administered by a person with limited training and can provide an effective alternative to hiring a consultant[26]

Table 2.3
Disadvantages of checklists

Disadvantages of checklists
Difficulties in classifying particular motions
• The observation methods lack precision and are less reproducible in dynamic work situations[28] • Can be poor in analysing movements that are hard to define, eg twisting, rapid rotation, posture of smaller joints (wrists and elbows) were poorly analysed[20] • Postures quantified in degrees are difficult to measure[23] • Problems in classifying due to inability to measure joint angles and in estimating the duration of non-neutral postures[29] • People have difficulties assessing small movements of small joints[27] • Difficulties in assessment of fast-moving small body parts such as the wrist[30]
Intra-observer and inter-observer variability
• Subject to intra- and inter-observer variability[28] • Open to subjective judgment[31] • Users often do not have adequate scientific knowledge to carry out detailed task analysis; nor do they have the facilities or time to carry out the analysis[23]
Training
• Training is often needed for using an assessment method – but as the quality of training may vary, so may the assessment result[23] • Users often do not have adequate scientific knowledge to carry out detailed task analysis[23]
Resources
• Time issues[23] • Too much detailed paperwork[23] • Users often do not have adequate facilities or time to carry out the analysis[23]

Table 2.3
continued

Observation techniques
• The optimum number of observations for low and high repetitive tasks is still unclear[32]
Simplicity
• A simple checklist may omit questions that are important for a particular job. Some checklists are not designed to capture complex situations. It may be under-inclusive, erroneously exclude a hazardous job or treat it as no more hazardous than other jobs. However, making a checklist more thorough and accurate would make it harder to use and more costly and complex[26] • Overly simplistic checklists can be open to interpretation by users and may limit the scope of the assessment[33]

2.3.2 Reliability and validity of checklist-based risk assessments

The reliability of a checklist concerns the degree to which the checklist can be repeated and gain the same result.

There are two sorts of reliability: inter-observer reliability, or the extent to which a similar result can be obtained by different observers when assessing the same event, and intra-observer reliability, or the extent to which a similar result can be obtained when the same person makes repeated observations of a given event over a period of time. To ascertain inter-observer and intra-observer reliability, the results from pairs of assessments are compared, typically by using the kappa statistic or correlations and analysis of variance (ANOVAs).

The validity of a checklist is defined by the extent to which a measuring instrument measures what it is intended to measure. In the case of validating checklists for musculoskeletal risks, previous studies have ascertained their validity by comparing checklist results to results gained from an existing and previously validated assessment method, actual reports of discomfort, MSD cases or direct measures such as detailed postural analysis using video, electromyography, goniometry and so on.

Ten relevant studies were found that investigated the reliability and validity of different checklists. The reviewed studies date from 1992 to 2005. Eight of these included an investigation of inter-observer reliability; of those, one looked at the effect of training[34] and five examined the effect of experience (experts vs non-experts).[23,27,29,34,35] Three studies included an investigation of intra-observer reliability.[23,30,35] Three studies investigated the validity of particular checklists.[20,23,36] The methods and conclusions from each of the reviewed studies are briefly summarised in Table 2.4.

There were several overall findings from the studies.

- Checklists are poor in analysing movements that are hard to define, eg twisting, rapid rotation, posture of smaller joints (wrist and elbows). Checklists investigated: RULA, OSHA draft checklist and Keyserling checklist, MORF.
- There were difficulties in using the tool in some situations, eg dynamic tasks, rapid but non repetitive actions. Checklists investigated: Quick Exposure Check (QEC).
- When experts and non-experts were provided with the same accompanying training or briefing session, the results gained from the two groups did not differ significantly. Checklists investigated: Quick Exposure Check (QEC), Manual Handling Assessment Charts (MAC), Keyserling checklist. The manual handling code developed in 2000 contains a risk assessment worksheet called RAW.
- Training had a significant effect and improved inter-observer reliability. Checklists investigated: Manual Handling Assessment Charts (MAC).

The last finding is supported by Kemmlert[36] (cited in Li & Buckle[23]) who states: 'To be honest, reliability and validity tests [of an exposure tool] are actually testing the educational level of the observers.' Li & Buckle expand on this and state that the format of the tool itself as well as the training materials that come with it will affect the quality of the assessment.

Table 2.4
Summary of the methods and conclusions from each of the reviewed studies

Studies	Statistical analysis	Key findings
Keyserling (1992)[29] developed a checklist and compared the results gained from shop floor workers (with one week's training in the use of the checklist and general ergonomics principles) to 'expert' results. Subjects assessed tasks in the workplace. Expert results were generated from computer-aided video postural analysis.	Correlation	Keyserling points out a flaw in the study: the direct comparisons were prone to measurement error as the task analysed by shop floor workers and the experts differed in the operators observed carrying out the tasks. Therefore the results from the assessments by experts and shop floor workers may have varied due to differences in the anthropometry and individual work methods of the operator observed. Keyserling states that this may have contributed to poor correlation between expert and shop floor workers' results. Keyserling concludes that the checklist was found to be an effective rapid screening tool. The study illustrates the potential of checklists to provide useful output if reliability is improved.
Kemmlert (1995)[36] assessed the validity of the PLIBEL checklist by comparing its results to results gained from the German ergonomics job analysis procedure AET. 24 subjects with 'considerable' ergonomics knowledge performed the PLIBEL on four videoed tasks.	Percentage agreement. Kappa	When comparing the result of PLIBEL and AET the agreement between matching items was considerable. However, the modifications of AET scores for a dichotomous coding (yes/no) could not completely eliminate the differences between the methods. PLIBEL was more sensitive to ergonomic hazards. The inter-observer reliability yielded kappa values expressing fair to moderate agreement.
Brodie & Wells (1997)[20] conducted a study testing the validity of three previously developed checklists: RULA, the OSHA draft risk factor checklist and the posture and upper extremity checklist developed by Keyserling *et al*. Checklist outputs were compared to MSD injury data, self-reported pain and discomfort, ranking by supervisors regarding job turnover and detailed video postural analysis. To allow comparison of the different checklists, results were converted using a three-point scale to represent the risk of each task. Subjects were trained for 20 minutes in the use of the checklists and analysed the same tasks via video.	ANOVA, correlation	They found that the checklists were reliably valid in analysing larger joints (shoulder and back) and for variables that have quantitative measures, eg mass and force. But reliability was poor in analysing movements that were hard to define, eg twisting, rapid rotation, posture of smaller joints (wrists and elbows). The researchers conclude that caution is needed before checklists are adopted as a component of an ergonomics programme.
Neumann *et al.* (1998)[30] investigated the inter-reliability of a checklist modified from the one proposed by OSHA called MORF (Manufacturing Operations Risk Factor). Seven workers from a foam manufacturing plant were trained for 7–10 hours in the use of the checklist and then each observed eight jobs in the workplace.	ANOVA, Intra-class correlation coefficient	ICC intra-class correlation provides an index similar to the kappa statistic. It was found to be poor for the upper limbs, moderate for the torso and lower limbs, and good for the assessment of manual material handling. Observations of the smaller fast-moving body parts such as arms and wrists were particularly unreliable.
Li & Buckle (1999)[23] checked inter-observer reliability, sensitivity and measurement validity of the Quick Exposure Check (QEC) by comparing results between different users and within users to results gained from simulated 3D analysis. Assessments were made of videoed tasks and also of tasks observed in the workplace.	Kappa, percentage agreement	In the laboratory trials, intra-observer tests gained kappa values indicating 'fair agreement' for most of the checklist items. For the shoulder/arm posture this increased to 'moderate agreement'. Percentage agreements supported the kappa results. The inter-observer reliability in laboratory trials resulted in 'moderate agreement'.

Table 2.4
continued

Studies	Statistical analysis	Key findings
Li & Buckle (1992) continued		When the QEC exposure tool was applied to tasks conducted in the field, agreement between practitioners (inter-observer reliability) was 76–91% for most of the items, an acceptable level of accuracy. The assessment tool was relatively low for some items, particularly back posture (54%), shoulder/arm movement (77%) and neck posture (76%). This suggests that there were difficulties in using the tool in some situations, eg dynamic tasks or rapid but non-repetitive actions. The researchers conclude that the study suggests that the intra-observer reliability of the exposure tool is high. They also suggest that people with or without previous experience in assessing exposure are able to reach an assessment agreement at more or less the same level. They also stated that training could improve reliability and validity of the tool.
Burt & Punnett (1999)[37] investigated the inter-observer reliability of a quantitative observational method of assessing non-neutral postures. Two observers independently evaluated 70 jobs using a procedure that included observations of 18 postures of the upper extremities and back. Data record sheets recorded 18 different postures involving the hands, arms, shoulders and back.	Percentage agreement, kappa, intra-class correlation coefficients and generalised linear mixed modelling	Findings from this study suggest that inter-observer reliability of postural observations can be optimised when operational definitions are simple and unambiguous, longer and multiple training sessions precede data collection, the level of detail is limited, and real-time observations are limited to jobs that do not involve rapid dynamic movements. The study also concludes that percentage agreement is an inadequate measure, because it does not account for chance and can lead to inflated measures of reliability. The study stated that assessing real jobs in real time may have reduced inter-observer reliability, as variation in the assessment may have resulted from the assessor observing workers at different times of the day and/or different workers.
Lee & Ferreira (2003)[34] conducted a study to evaluate the usability and reliability of the Manual Handling Assessment Charts (MAC) when used by non-regulatory professionals with and without training. The non-regulatory professionals were people who had some level of responsibility for assessing manual handling tasks. The study also compared the subjects' results to expert results. The subjects assessed a range of tasks from video recordings.	Kendalls Coefficient of concord-ance, Mann-Whitney U test	The study found that the non-briefed subjects had significantly lower scores than briefed and expert groups. Briefed and expert groups gained similar results (no significant difference).
Quirk *et al.* (2004)[27] used a manual handling code developed in 2000 containing a risk assessment worksheet called RAW to investigate differences between experts and non-experts when assessing a range of tasks from video recordings.	T-test of means of correct answers	The study found a high overall usability of RAW and found no significant difference between experts and non-experts

Table 2.4 *continued*

Studies	Statistical analysis	Key findings
Winnermuller *et al.* (2004)[35] investigated the ability of supervisors and workers to accurately assess MSD risk factors using a 14-item checklist. Inter-observer reliability was investigated between the experts, supervisors and workers. Intra-observer reliability was also investigated with an interval of several weeks between repeated assessments.	Kappa, percentage agreement	Inter-observer reliability was calculated using percentage agreements. Agreement of workers to experts was 71% and of supervisors to experts 81%. Overall, supervisors and workers overestimated the presence of risk factors. Intra-observers reliability was assessed using the kappa statistic and found that items were good to excellent reproducibility. The study concludes that supervisors and workers to assess MSD risk in initial ergonomics assessment appear promising.
Park *et al.* (2005)[38] investigated inter-observer reliability of four experts using the same checklist (PATH method).	Kappa, percentage agreement	Agreement among the observers was higher for jobs with less rapid hand activity and for the analysts with more ergonomics and job analysis experience.

2.3.3 Recommended best practice in checklist design

There are no standards specific to the design of checklists used for conducting risk assessment. However several studies have been conducted to investigate different designs of checklist used for assessing MSD risks. These studies have produced qualitative data on the effectiveness and usefulness of different design features. These findings are presented in Table 2.5, which groups the study findings under the design characteristics of format, wording, link to interventions, rating system, illustrations and unobtrusiveness.

2.3.4 Common checklist design features

A search of the web was conducted using the word ‘checklist’. Results were selected at random to produce a sample of different checklists from all fields (ie not restricted to MSDs). These checklists were then reviewed and a list of checklist design features constructed. These elements have been used to construct checklists for use in Phase 4 of the study (risk assessment trials). Table 2.6 presents a list of features. A tick in the right-hand column indicates those characteristics that previous studies have demonstrated to be effective (see section 2.3.3).

2.3.5 Paper-based MSD checklists

There are hundreds of checklists. This section presents only a small selection of them and is limited to those developed to assess MSDs. The selected checklists demonstrate the variations in design and approaches and processes encompassed. This section gives a brief description of the tools, their design characteristics, who they are aimed at, and what level of experience or training is required. At the end of this section, Table 2.8 shows the design characteristics used in a range of checklists and enables a quick comparison to be made of the different checklists and their features.

HSG60 Upper limb disorders (ULDs) in the workplace checklist

Description

HSG60 provides a method for identifying and assessing risk in the form of two checklists. One is a filter for conducting an initial screening of work tasks. If the initial screening tool has identified potential risk tasks, the guidance states that a more detailed risk assessment should be conducted. The guidance provides a series of checklist worksheets to conduct this more detailed assessment. It is this checklist which is discussed here.

The checklist is presented in landscape over seven pages of A3 paper. The first page asks for preliminary information about the task, including frequency, other tasks undertaken by workers that may pose a risk of MSDs, how long the task is typically performed for without breaks, and so on.

The checklist is split into six columns: the check item (with or without definition/illustration), response column (to be completed by the assessor), description of the problem or probable cause (to be completed by the assessor), column for noting control options (to be completed by the assessor), a column titled ‘Control options’ (the column presents a list of hints of possible controls and provides reference to specific sections in the accompanying guidance).

Table 2.5 Recommended best practice in checklist design

Design characteristics
Format
• Readily coded for computer storage and analysis[39,23] • Cheap and easy to use[40,23]
Wording
• Improve wording of questions[20] • Descriptive terms rather than angles should be used, eg almost neutral, moderately flexed or twisted, excessively flexed or twisted. However, these terms need to defined somewhere as regions (eg 0–20 degrees) and by frequency[23] • Use site specific example[20] • Use landmark descriptions – estimating degrees of deviation from neutral is more difficult than using landmarks, such as hands are below the hips or hands are above the shoulders[37]
Link to interventions
• A checklist should also provide suggestions for redesign[41] • Subjects preferred the placement of guidelines immediately adjacent to the checklist[33] • Subjects preferred the use of a 'hints for risk control' section on each page of the guidelines throughout the OLGAs checklist[33] • Subjects preferred to progressively record risk control ideas as they came to mind during the RA process, therefore notes space should be provided next to each item[33]
Rating system
• Ranking system using intuitive system should be sued. Such as green, yellow, and red or 1, 2 and 3[29] • Colour coding is effective in demonstrating the risk to the proprietor[42] • Develop decision criteria[20] • It is advantageous to provide some numerical guidance values for users. Firstly they provide an indication to employers about aspects of tasks that potentially pose a higher risk and secondly assist in prioritising actions to control the risks identified[43] • Scoring systems should be developed to help establish priorities for the workplace interventions[44] • Traffic light system should be used for rating[33] • Although exposure-response relationships are difficult to ascertain, the current knowledge base does allow us to identify workers at high risk of MSDs, therefore rating systems can be adopted[23] • Scoring systems help establish priorities for the workplace interventions – the current scoring systems are popular with practitioners and managers as they assist communication and decision making[44]
Illustrations and diagrams
• Items in a checklist should be illustrated especially by pictures[41] • Pictures should be included as they can enable an assessor to show an operative a range of postures and ask them to pick out the particular lifting technique that they use[42] • Addition of graphic representations to the questions or demonstration of motions and postures could improve design[45]
Unobtrusive
• The recording equipment should not interfere with the movements being recorded[46]

Table 2.6 Design features of checklists

Design feature or characteristic	Previous studies indicate effective?
• Who conducts the assessment	
Background information	
• Asks whether injuries or problems reported	
• Records whether a body part discomfort questionnaire has been completed and the results	
• Number of tasks observed in making the assessment	
• Number of employees conducting this type of task	
• Records other task employees are likely to perform in addition to this task	
• Records total duration conducting task (without break)	
• Records length of breaks	
• Comes with additional information or guidance pages/ booklet	
• Provides definition of terms in additional booklet/pages	
Format	
• Flow diagram format	
• List format	
• Multiple choice responses	
• Dichotomous	
Phrasing and presentation of check items	
• Uses numerical figures to describe joint angles	
• Uses words to describe joint angles	Yes
• Uses numerical figures to describe repetition and/or frequency rates	
• Uses words to describe repetition and/or frequency rates	Yes
• Uses numerical figures to describe weights/force	Yes
• Uses words to describe weight/force	Yes
• Uses numerical figures to describe duration	
• Uses words to describe duration	
• Provides definitions of terms on the checklist	
Visual aids	
• Illustrations of angles	Yes
• Illustrations of postures	Yes
• Illustrations of motions	Yes
• Provides space or requests for photo of risk action/tools/workstation	
Recording risk details	
• Space for notes of reported problems	
• Space for notes on risks/probable cause	Yes
Ratings	
• Means of rating risk of individual items:	Yes
○ Colour coding	
○ Symbol coding	
○ Numerical	
○ Words: eg Low/Medium/High, Good/Satisfactory/Poor/Unacceptable	
• Gives an overall score	Yes
• Means of prioritising tasks for action:	Yes
○ Yes	
○ Yes but requires reference to other materials	
Controls/interventions per check item	
• Asks whether action is required	
• Space for notes on potential actions	Yes
• Provides hints/suggestions for redesign/ control interventions to reduce the risks	

Table 2.6
continued

Design feature or characteristic	Previous studies indicate effective?
Controls/interventions for the task (as a whole)	
Asks whether action is required Space for notes on potential actions Provides hints/suggestions for redesign/control interventions to reduce the risks	
Action plan	
Space for notes on action to be implemented Provides space or table to plan actions i.e. what required, by whom and date Enables recording of whether action implemented Date for next assessment	

The checklist consists of 50 items, which are grouped in terms of risk factors, eg repetition, posture, force. The response to each item is dichotomous (ie yes or no). The assessor progresses through all the check items and makes notes in the corresponding columns.

At the end of the checklist there is a table outlining the construction of an action plan to aid in implementing the control interventions identified through conducting the checklist. The action plan has columns to be completed by the assessor. The heading for these columns are 'Controls to be implemented', 'Priority', 'Who is responsible for implementing controls', 'Target implementation date' and 'Date of re-evaluation'.

To calculate priority for action, the checklist instructions state that assessors should add up the number of yes ticks; tasks with a higher number of ticks indicate a higher priority for control interventions.

Who should complete it?
It does not say specifically. However in a paper explaining the development of the tool[22] it is stated that the HSG60 checklist is targeted at non-specialists who are unlikely to have expert or trained help.

What level of training/experience does it specify?
The risk filter and risk assessment checklist do not require specific training. The guidance states that before undertaking the assessment the assessor should read the chapter entitled 'Assess the risk of ULDs in your workplace'. This is an 11-page document.

PLIBEL

Description
PLIBEL is a method for the identification of musculoskeletal stress factors which may have injurious effects. It is designed to be used as a screening tool. It is conducted when an injury has been reported and is aimed at ascertaining the cause in terms of physical work actions. It is presented in landscape format on an A4 page and consists of 17 questions which are asked for various parts of the body depending on which area has been injured. It is a self-explanatory subjective assessment method, registering only on a dichotomous level. It does specify, however, that a solid ergonomics understanding is required.

Who should complete it?
Knowledgeable and experienced observers.

What level of training/experience does it specify?
A handbook is provided which presents the scientific background for each item and also provides information to help the assessor identify the cut-off points for 'yes' and 'no' answers. However, in a study investigating the reliability of the checklist[36] one week of training was provided which included training in the use of the checklist and general ergonomics principles.

Washington State Ergonomics Rule (WAC)
Description: The checklist is used to assess jobs that have already been identified as a 'caution zone job' from applying the screening criteria provided in WAC documentation (page 3 of the WAC document). When a job has been identified as a 'caution zone job' the employer must analyse it to identify MSD hazards. A MSD hazard is classed as a physical risk factor when it exceeds the criteria provided in the WAC checklist. The main checklist comprises four sub-checklists presented in portrait layout on A4 paper. The four checklist components refer to:

- awkward posture (7 check items)
- high hand force (6 check items)
- highly repetitive motion (4 check items)
- repeated impact (2 check items).

All the checklists are identical in format. Each checklist is the form of a table with four columns entitled 'Body part', 'Physical risk factor', 'Combined with', and 'Duration'. Some items are illustrated. The illustrations show different postures with angles of motion to help define the check item.

What level of training/experience does it specify?
The WAC document only states the level of training required for those workers supervising or working in a caution zone job. It does not state outright the training requirements for conducting the checklist assessment.

However, training of individuals supervising or working in caution zone jobs includes providing information on MSDs and all the risk factors include in WAC, the types and symptoms, information on identifying MSD hazards and common measures to reduce them.

NIOSH

Description
This comprises two checklists in portrait format on A4 paper. The first checklist, 'General ergonomics risk analysis checklist', consists of 56 items which are grouped under the headings 'Manual handling', 'Computer', 'Physical demands', 'Other musculoskeletal demands', 'Environment', 'General workplace', 'Tools', 'Gloves' and 'Administration'. This first checklist acts as a filter and directs the assessor to one or more of five other more in-depth and task-specific checklists. These are:

- workstation layout
- task analysis
- hand tool analysis
- material handling
- computer workstation.

The accompanying guidance states that one or more checklists or items within several checklists can be used or combined to compose a form that is most appropriate for the particular work situation.

Each of the five checklists consists of dichotomous response (yes/no), where 'no' indicates a potential problem area deserving more investigation. In another section in the accompanying guidance, 'Evaluating job risk factors', each risk factor is explained and provides references to relevant standards and information to help the assessor identify potential controls to reduce the risk. There is no direct link between the checklists and the section 'Evaluating job risk factors'. Prioritising tasks is calculated using a table that is provided in the guidance documentation.

Who should complete it?
NIOSH does not specifically state who should fill in the checklist but it does say 'When checklist data are gathered by persons familiar with the job, task, or process involved, the quality of the data is generally better.'

What level of training/experience does it specify?
The NIOSH document does not specifically say what level of training is required to complete the checklist, although it does state that employee training complements efforts to address workplace safety and health problems, including those focusing on ergonomics hazards and related concerns. Ergonomics training may take different forms for various categories of employee. It can range from

awareness training for all employees, especially those in a suspected problem job, to more intensive training for those expected to undertake job analyses and problem solving.

Quick Exposure Check (QEC)

Description
The Quick Exposure Check comprises two check sheets: one that is to be completed by the assessor, the other by the operator/worker. The checklist completed by the assessor consists of eight check items which are grouped by body part: back, shoulder/arm, wrist/hand and neck. Definitions for some items are provided and responses are multiple choice. The check sheet completed by the operator/worker is a multiple choice questionnaire that consists of seven questions. Results from both check sheets are transposed onto a third sheet, the 'scoring sheet'. The scoring sheet comprises matrices for each check item. The matrices enable the assessor to cross reference the assessor's results with the worker's to gain a single score. The scores from all the matrices for a particular body region are then summed, to give a total indicative risk score for that body region.

The QEC is designed to be used to assess the effects before and after an intervention has been implemented, to monitor and ensure that a reduction in risk has been achieved.

Accompanying the checklists is a three-page A4 guidance leaflet which provides more detail, giving clear definitions of each check item and, where appropriate, diagrams. For example, it provides specific angles and diagrams illustrating the postures and range of motion and also explanations of particular terms such as deviated, neutral and so on.

Who should complete it?
The tool was developed so that it could be used by 'naïve' or 'inexperienced' users (ie those with little or no knowledge of ergonomics and who are inexperienced in making exposure assessments in the workplace).

What level of training/experience does it specify?
A short (three-page) and simple training package is attached to the tool which explains the meaning of terms and assessment items.

Posture checklist - Ergonomic risk factor checklist for awkward posture of the legs, trunk and neck.

Description
This is a one-page A4 checklist used for evaluating ergonomics risk factors associated with awkward postures. It is a screening tool to identify jobs with potentially harmful exposures to ergonomic stress. It was designed to be biased, more likely to classify an 'acceptable' job as a problem job (a false positive). It is not designed to be a diagnostic tool. The checklist consists of 15 items designed to evaluate the presence and duration of exposure to awkward postures. For each item there is a multiple choice of responses consisting of never, sometimes or one-third of a cycle. Definitions of these terms are presented in the 'supplemental note page' accompanying the checklist. The responses to each question result in a stress rating from a three level qualitative scale (Table 2.7). Once the checklist is completed, the number of checks (✓) and stars (★) are summed to produce an overall score of postural stress. Any job receiving one or more stars is a high priority for additional investigation. The accompanying page of guidance provides further definition for some of the terms used in the checklist items and also presents some diagrams to illustrate specific postures and angles of motion.

Who should complete it?
The checklist was designed to be used by people with limited ergonomics training.

What level of training/experience does it specify?
It does not specifically state the training that is required, but it does say that it was designed to be used by people with limited ergonomics training.

2.3.6 Summary of paper-based checklists
From the aforementioned checklists it can be seen that there are distinct differences in not only the design features but also the extent of the risk management process each checklist encompasses. For example, HSG60 encompasses risk identification through to risk control and identifying solutions (control interventions), whereas PLIBEL and the NIOSH checklist just identify risk actions.

Table 2.7
Stress rating system for the Posture checklist

0	Insignificant risk of injury
✓	Moderate exposure to postural stress was present, indicating a potential risk of injury to some workers
★	Substantial exposure to postural stress was present, indicating significant risk of injury

Table 2.8 presents eight checklists for assessing MSD risks against the design features identified in Section 2.3.4. It enables quick comparisons of the features of each of the checklists to be made. Features shaded are those that the literature indicates are effective, as described in section 2.3.3.

Table 2.8
Different checklists and their design features

Checklists	HSG60	NIOSH	WAC	VDU	QEC	Keyserling	PLIBEL
Design feature or characteristic							
Who conducts the assessment	✓			✓	✓		
Background information							
Asks whether injuries or problems reported				✓			✓
Records whether a body part discomfort questionnaire has been completed and the results							
Number of tasks observed in making the assessment							
Number of employees conducting this type of task	✓						
Records other tasks employees are likely to perform in addition to this task	✓						
Records total duration of task (without breaks)	✓						
Records presence of and length of breaks	✓			✓			✓
Comes with additional information or guidance	✓	✓		✓	✓	✓	
Provides definition of terms in additional guidance	✓	✓	✓	✓	✓	✓	✓
Format							
Flow diagram format or similar							✓
List format	✓	✓	✓	✓	✓	✓	
Multiple choice responses					✓	✓	
Dichotomous (yes/no)	✓	✓	✓	✓			✓
Phrasing and presentation of check items							
Uses numerical figures to describe joint angles			✓				
Uses words to describe joint angles	✓	✓	✓	✓	✓	n/a	✓
Uses numbers to describe repetition and/or frequency rates	✓		✓		✓	n/a	
Uses words to describe repetition and/or frequency rates	✓	✓			✓	n/a	

Table 2.8
continued

Checklists	HSG60	NIOSH	WAC	VDU	QEC	Keyserling	PLIBEL
Phrasing and presentation of check items *continued*							
Uses numbers to describe weight and force	✓		✓		✓	n/a	
Uses words to describe weight and force	✓	✓	✓		✓	n/a	
Uses numbers to describe duration	✓		✓		✓		
Uses words to describe duration	✓	✓	✓		✓	✓	
Provides definitions of terms on the checklist	✓		✓		✓		
Visual aids							
Illustration of angles			✓				
Illustrations of postures	✓		✓	✓			
Illustrations of motions	✓		✓	✓			
Provides space to describe task or asks for photo of action, tools or workstation	✓						
Recording risk details							
Space for notes of reported problems	✓			✓		✓	
Space for notes on risks and probable causes	✓			✓			
Ratings							
Means of rating risk of individual items:							
colour coding						✓	
symbol coding							
numerical					✓		
words (eg Low/Medium/High)							
words (eg Good/Satisfactory/Poor/Unacceptable)							
Gives an overall score	✓				✓		
Includes means of prioritising tasks for action:							
yes	✓				✓	✓	
yes but requires reference to other materials			✓				
Controls or interventions per check item							
Asks whether action is required	✓			✓			
Space for notes on potential actions	✓			✓			
Provides hints or suggestions for redesign or control interventions to reduce the risks				✓			
in checklist	✓						

Table 2.8
continued

Checklists	HSG60	NIOSH	WAC	VDU	QEC	Keyserling	PLIBEL
Controls or interventions per check item *continued*							
In accompanying guidance document	✓	✓					
Provides references for guidance/information		✓					
Action plan							
Space for notes on actual action to be implemented	✓			✓		✓	
Provides space or table to plan actions, ie what is required, by whom and by when	✓						
Enables recording of whether action has been implemented	✓			✓			
Date for next assessment	✓						

2.3.7 New developments

ART

The HSE is currently developing a new risk assessment tool called 'Assessment of repetitive tasks of the upper limbs' (ART). It is in a similar style to the HSE risk assessment tool for assessing manual handling tasks (the MAC tool) and consists of a set of check items which are colour-coded by risk level (green for low risk, amber for medium and red for high). Numerical scores are also attributed to each item. At the end of the assessment all scores are collated and an overall level of risk is calculated. ART is currently in draft form and trials will be run later in the year. The tool has been developed to be used by HSE inspectors; however, it is envisaged that it will later be released for general use in companies by people responsible for health and safety.

Technological developments

There are several computerised assessment programmes which can be used to evaluate the risks of MSDs, such as the Ovako Working Position Analysing System (OWAS), MORF and Rapid Upper Limb Assessment (RULA). These programmes are designed to be used by experts. Although they include a series of check items, they are typically much more complicated and cannot be compared to the checklists under consideration in this study. They do, however, illustrate a development in the use of technology in the assessment of MSD risks.

No research was found to have been conducted in the development of computerised assessment techniques for non-experts to use to assess MSDs. However, a review of the literature did find that new developments are being made in the construction industry with the use of mobile technologies to assist in conducting health and safety work site assessments. These studies provide an insight into the potential benefits of using mobile technologies for conducting checklist assessments.

It is easy to see how some of the findings from these studies could be transferred to the development of similar systems for the assessment and management of musculoskeletal disorders. May,[47] Kimoto *et al*.[48] and Abdullah & Thai[49] investigated the user requirements of conducting assessments on construction sites through the use of mobile IT devices. Table 2.9 provides a list the potential benefits of using mobile technology to conduct assessments on construction sites based on findings from the literature.

In a conference entitled 'Assessing musculoskeletal disorders at work: which tools to use when' (2003), it was reported that one of the potential negative aspects of using computerised assessment techniques is that scoring via a laptop/handheld computer may obscure the process so that the assessor has no understanding of the various contributory factors of the score and how the combined effects may be reduced.

Table 2.9
Potential benefits of using mobile technology to conduct assessments on construction sites

Potential benefits
• Can provide structured checklists to support novice or less experienced inspectors[47] • Enable easy addition of voice, text or graphic annotations at the time of data capture to add richness and context to the data[47,49] • The device can incorporate a camera[48] • Enable real time data exchange[48] • Can use location-based service to ensure that information is relevant to the current location[47] • Provide ways of tagging and coding images at the point of capture to maximise the use of photos. Particularly useful in monitoring changes[47] • Can be programmed to calculate priority for action[47] • Easy to compare results over time and across different worksites, work areas, tasks etc[47,48] • Increased productivity of inspectors enables assessments to be centralised and standardised[48,49] • Aids in the communication of problems to relevant people/departments[49] • Can be linked to other software packages for analysis and presentation, eg scheduling software, redesign[48]

It was argued that such an understanding is needed to inform effective interventions. Other issues with the use of mobile technologies concern the size of screen, the ease of inputting data using a stylus as opposed to a mouse, visibility issues and speed of connections.

2.4 Checklist-based risk assessment and training

2.4.1 Training in the use of checklists for assessing MSD risk

The Management of Health and Safety at Work Regulations 1992 (amended in 1999) state that 'Employers are solely responsible for ensuring that health and safety people are competent'. 'Competent' means that they have an understanding of relevant current best practice, are aware of the limitations of their own experience and knowledge and have the willingness and ability to supplement existing experience and knowledge where necessary by obtaining external help and advice. Therefore people that conduct risk assessments must have this basic competence in addition to any specific training required in the use of the checklists.

The level of training required to conduct risk assessments using checklists varies. For example, HSG60 and QEC only require that the person using them read the accompanying guidance booklets, whereas for other checklists more in-depth training is suggested. For example, the Keyserling checklist, intended to be used by plant personnel, requires one week of training.

It is argued that checklists should be designed as standalone tools that require limited training.[10,23,26] The reasons for this are to encourage their use by keeping the resources required to a minimum and not relying on one specific individual to conduct the risk assessments (as assessments can be conducted by a range of workers). Studies comparing checklist results gained by experts and non-experts support this. Several studies show that checklists designed as standalone tools can be used effectively and reliably by non-experts.[23,27,29,35]

Li & Buckle[23] acknowledge that in the case of the QEC further research into the level of training required is needed. They report that:

> It is anticipated that experience and training can improve the assessment reliability, but questions remain as to how much training is needed and what type of training should be given, for practical use of the exposure tool.

One of the important aspects of conducting risk assessment is to identify risk and then to identify potential control interventions. This is often not achieved. Research has shown that, typically, risk assessments are completed but often remain as a paper-based exercise resulting in little effective action.[6] Studies by Care *et al.*[42] and Jones *et al.*,[50] which looked at the effects of providing training in addition to the written guidance provided with standalone checklists, showed that training can improve inter-observer reliability and validity of their results of checklists. Furthermore, research shows that in addition to providing training in completing a particular checklist, training in 'general ergonomics' can also further enhance the reliability and, importantly, the identification of control interventions.

Jones *et al.*[50] investigated the ability of non-ergonomists to make manual handling risk assessments with and without additional training and to implement changes to the work environment. The study reported that training was needed. Jones states that:

> It was felt that use of checklists in isolation was insufficient and that a focus for discussion was required – which was provided by the training.

In a study by Ketola *et al.*,[51] cited in Greene *et al.*,[52] it was found that risk exposure was reduced in a group that received an intensive ergonomics training programme compared to a group who only received training to use a workstation checklist. There was no improvement in risk exposure in the group that received only training in the use of the checklist.

Devereux *et al.*[53], cited in Saleem *et al.*,[54] documented a case study in which ergonomics training was not provided to workers. Control subjects redesigned the job with relatively fewer benefits than subjects who received a fundamental level of ergonomics training.

Saleem *et al.*[54] conducted a study of 48 novice subjects. In total 16 subjects were given ergonomics training, 16 subjects were given instruction in how to use the tool (the NIOSH lifting equation) and 16 subjects acted as the control group, receiving no training. Subjects had to analyse a job for potential risk factors and then redesign the job to eliminate or reduce the risks they had identified. More risks were eliminated by the group that had received ergonomics training than those that had received training on the use of the checklist alone. This study showed that training in ergonomics was more effective in eliminating risks than just providing training in the use of the tool.

In studies by Tauok[55] and Hal[56] a risk assessment process was introduced as a package in which training in the use of a risk assessment checklist was also provided. Tauok and Hal recognised the importance of training. However in each of these studies no comparison was made to assess how effective the training had been compared to when no training was given.

2.4.2 Who should receive training and/or assess the risks - workforce participation

HSG60, NIOSH, OSHA, and Z365 all emphasise and encourage worker/employee involvement in the management of MSDs, recommending that employers provide employees with knowledge and understanding of MSDs and their associated risks. Involving the workforce in the management of MSDs is a participatory approach. The basic concept of participative ergonomics is to involve workers in improving their workplaces to reduce injury and increase productivity. In this way the expert knowledge workers have of their own tasks is utilised to assist in risk assessments and controls.

Potential benefits of the participative approach include:

- improved flow of useful information within an organisation
- an improvement in the meaningfulness of work
- more rapid technological and organisational change
- improved acceptance of change
- enhanced performance
- reductions in work-related health problems.[10,19,54,57,58]

From the reviewed literature it appears that there is evidence for involving the workers in the assessment of risks. For example, studies investigating the effect of manual handling training on reducing risk and injury indicate that training workers in correct working methods was ineffective.[18,59,60] Hignett[17] states to effectively reduce risks and injury from manual handling, workers need to be trained in recognising and assessing risk. Furthermore, Hignett[61] recommends restricting the involvement of 'experts', suggesting instead that their input be limited to auditing large departmental checklist assessments and giving help where necessary. This gives a basis to the argument that workers should be actively involved and potentially conduct risk assessments.

Zalk[62] reports that:

> Checklists have frequently been the ergonomics tool of choice within participatory ergonomics interventions. Regardless of the intricacy of the tool (checklist) workers should fully assist in gathering and analysing data then in identifying and implementing solutions.

This argument is supported by both NIOSH and the HSE. NIOSH states that 'when checklist data are gathered by persons familiar with the job, task or processes involved, the quality of the data is generally better'. Similarly, HSG60 reports that risk assessment requires input from people who conduct the task. Carrivick *et al.*[63] conducted a study that indicated that an interactive participatory process does not have to be complex and that a small group of unskilled personnel with training and guidance can effectively assess risk and address risks of manual handling.

Similarly, in a study by Winnemuller *et al.*,[35] it was concluded that the ability of supervisors and workers to assess MSD risk in initial ergonomics assessment using checklists appeared promising; results showed that supervisors' and workers' results did not differ significantly from those of experts. In a report by Cameron,[64] it was reported that trained workers were found to be better equipped for identifying hazards.

Research suggests that there are significant benefits in getting workers from the shop floor trained to conduct risk assessments and that checklists appear to provide the ideal tool to enable this. Studies have shown that by educating workers in the MSD risk and getting workers to conduct MSD risk assessments the following benefits can be gained:

- workers co-operatively identify and report safety and health problems to management or supervisors[65,66]
- workers employ better working techniques (change of behaviour)[65]
- improved compliance with health and safety procedures[66,67]
- improved worker acceptance of intervention and changes in work practices[15,58]
- encouragement of shared mental models between management and workers leading to improved agreement in actions and the perceived need for action[16]
- demonstration of management commitment to workers' health, safety and wellbeing[16]
- support and development of the ability of workers to recognise problems and solutions, which they are often best placed to do.[54]

Many of these possible benefits could potentially overcome some of the difficulties in the management of MSDs previously outlined in section 2.2.3. In particular, these benefits could offset the obstacles relating to training, worker participation, support from workers and problems of linking risk identification to risk controls.

However, there are downsides to involving members of the workforce at this level. Neathey[1] comments on people's concerns about being liable. Jones *et al.*[50] comment that in their study (which investigated the ability of non-ergonomists to carry out manual handling risk assessments after training), although the subjects could reliably conduct the risk assessments, most of the assessments were felt to be inadequate in terms of setting up long term plans for monitoring and so on. Jones reported that this, in part, might have been affected by non-managerial participants being unaware of the need for, or how to deal with, such measures. Jones *et al.* conclude that this points to the need for assessments to be undertaken by subjects with managerial authority.

To summarise, research suggests that training the workforce in risk assessment will be of benefit in supporting the risk management of MSDs, from risk identification through to controls and monitoring. Even if workers themselves do not conduct the risk assessments, training in risk assessment would still appear to be potentially useful. Research suggests that training the workers in risk assessment would encourage and actively involve them, making them more aware of the risks and encouraging the use of safe work practices.

2.5 Evaluation methodologies and effectiveness

The problems, benefits and limitations of intervention evaluation in an occupational setting and relating to workplace health and safety are well documented by Robson *et al.*[68] This work identifies common threats to the success of studies which attempt to collect real world data and makes numerous recommendations for ways to design, manage, improve and review strategies, approaches and analysis.

Because of the complex nature of projects attempting to address this area of research, the best practice approaches detailed in this report provide a valuable resource for researchers.

2.6 Conclusions of literature review

Numerous checklist assessment tools have been developed to assess the risk of MSDs. Research has been conducted to assess the effectiveness and reliability of these checklists in identifying the risk factors. Previous research has focused on:

- comparing the validity of different risk assessment tools[44,69,70]
- comparing inter-observer reliability and intra-observer reliability of risk assessment tools[71,72]
- investigating inter-observer reliability between checklist results of non-expert and experts.[23,27,29,34,35]

However, very little research has been conducted to assess the effectiveness of the actual design of checklists and the level of accompanying training that is required and/or is sufficient to ensure they are used correctly.

2.6.1 Design features of checklists

This review of the literature shows that although numerous checklist tools exist, only a few incorporate some of the good practice design features identified in section 2.3.3. Furthermore, the recommended design features are only supported by qualitative data typically being identified from focus groups with users or discussion with experts. No research was found which limited itself to only exploring the effects of design characteristics rather than the checklist criteria (items). Therefore there is a need to determine the effectiveness of the design recommendations reported in section 2.3.3.

Moreover, the review has also shown that checklists vary in the extent of the risk assessment process they encompass. For example, some checklists combine risk identification with identifying solutions and producing an action plan, whereas others cover only the identification of risk. There is therefore a need to investigate the effect of this design feature further.

2.6.2 Training in conducting checklist-based risk assessments

Research has shown that standalone tools can be used effectively by non-experts. This is important as there is a move towards a more participative approach to MSD management. A participative approach may result in a greater range of people (other than health and safety practitioners or representatives) conducting risk assessments. Research has demonstrated that there are significant benefits to be gained from involving a broader range of the workforce in assessing the risks of MSDs. Primarily these are worker acceptance of change, improved support from workers, improved reporting of risks and problems, improved communication and improved solution generation. A study by Care *et al*.[42] showed that training in conducting checklist risk assessment can significantly improve reliability of the results when checklists are completed by non-experts. The training needs of these individuals require further investigation. Furthermore, studies by Saleem[54] and Ketola *et al*.[51] have shown that the reliability of checklist results and the progression from risk identification to identifying and implementing control interventions can be significantly improved when training in more general ergonomics principles is included (in addition to training in conducting checklist-based assessments).

Research is needed to evaluate the effectiveness of training a broader range of the workforce and whether this would overcome some of the current obstacles that have been identified as preventing the successful management of MSD risks.

In summary, from the literature review the following gaps in research have been identified:

- there is a need to determine the effectiveness of the design recommendations reported in section 2.3.3
- it is necessary to identify the training needed to engage a broader range of the workforce in the risk assessment process
- the effectiveness of training a broader range of the workforce in risk assessment needs to be evaluated.