The health, safety and health promotion needs of older workers

An evidence-based review and guidance

Report submitted to the IOSH Research Committee

Joanne O Crawford, Richard A Graveling, Hilary Cowie, Ken Dixon and Laura MacCalman
Institute of Occupational Medicine

research report
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Abstract

Changing demographics in the UK indicate that the working population is ageing and there is a need to maintain the over 50s in the workplace. The following review examines current research on the health, safety and health promotion needs of older workers by identifying age-related change, whether older workers need support and evidence of successful intervention in the workplace. Using a systematic review methodology, databases were searched identifying 179 publications. Each publication was screened and data were extracted for those included in the review. The review identified that there are a number of age-related physical and psychological changes with ageing. However, these changes can be moderated by increased physical activity, intellectual activity and other lifestyle factors. Sensory abilities are also subject to change but these can be accommodated via equipment or workplace adjustments. In reviewing accident data, although older workers are at a reduced risk of accidents, they are more at risk of fatal accidents. Ill health data show that although there is an increased risk of developing disease with age, many chronic diseases can be controlled and adjustments put in place in the work environment. A number of intervention studies were identified but few were of high quality. The research suggests that occupational health intervention can reduce the risk of early retirement from the workplace; health promotion interventions are seen as positive by older workers but it is important to ensure equal access to all workers in such promotions. In the UK there are still many research gaps, including a lack of longitudinal research; no further analysis on fatal accidents or understanding of the high prevalence of MSDs, stress and anxiety in older workers; and a lack of investigation into what interventions are going to be effective and occupationally relevant measurements of work capacity for both physical and mental work.

Executive summary

This review examines the evidence for health, safety and health promotion interventions in the workplace for older workers – ie those over 50 years old. Using a systematic review methodology, a search strategy was developed to address the questions addressed in the review.

Methodology

Search terms were collated to describe the population, intervention, outcomes, study designs and exclusion and inclusion criteria. Seventeen databases were searched using the search terms, together with five websites.

Results

The results identified an initial 180 papers. The process involved an initial screening of abstracts and titles. Where relevance to the review was unclear from these, the full documents were obtained for review. After screening and data extraction, 60 papers were included in the review; 118 documents were excluded and two books could not be obtained in the timescale. The main reasons for excluding papers were that they contained no new data, no relevant data or no intervention.

Age-related physical change

The initial sections of the review address the impact of age-related change on physical and mental ability. The research shows that for physical factors there are age-related changes but there are also large inter-individual differences in relation to change. The data show that there are reductions in aerobic capacity, reductions in stature and increases in body mass index (BMI), but that all of these can be improved by increased physical activity. Muscle strength was also found to reduce with age but again can be improved by training, and there is suggestion that a training effect may occur with specific muscle groups in those engaged in heavy physical jobs. An increased need for recovery was also identified in older workers. Higher rates for musculoskeletal disorders (MSDs) were found to be related to age. This highlights that work activity and overload must be considered; however, this increase in MSDs is not a straightforward relationship as age is also associated with longer duration of exposure to occupational risk factors. Balance (both postural and functional) was also found to be related to age but again there is a possible training effect that would suggest that balance could be improved. The research on thermal tolerance to heat has shown that age itself is not the main predictor of intolerance but it is related to changes in the cardiovascular system. In addition to this, diabetes in this population may also result in reduced thermoregulatory control.

Age-related psychological and psychosocial change

The review identified a number of psychological changes that occur with age, including reduced reaction time, increased accuracy and increased accumulated knowledge and experience. Again, large inter-individual differences are found in this research and applying the findings in the workplace environment can be problematic. The research does suggest that interventions for older people should include not only diet and exercise but also intellectual stimulation.

There was little research with regard to mental wellbeing in older workers but the two papers identified found that social support, risk reduction strategies for stress and improving coping strategies are important for this group of workers.

Learning factors identified as important in older workers included the preferred learning medium of older workers and the fact that older workers do want to maintain and update their skills. It was also important to ensure that access to training is equal to all members of the workforce.

Work organisation

Two papers were identified in the review with regard to work organisation. The first identified that exposure to excessive overtime in physically demanding jobs would have an adverse effect on older workers. The second showed that work ability reduced in shift workers more quickly in women (aged 35) than in men. Thus shift work should be designed using ergonomic criteria and consideration should be given to whether frequency of health assessments should be increased in older workers undertaking shift work.

Sensory abilities

The review identified that although sensory abilities such as vision and hearing do change, these can be accommodated by the work, for example by improving the visual environment with overhead or task lighting or ensuring that hearing protection is used where required.

Accidents in older workers

With regard to accidents, older workers were found to be less of an accident risk than those aged under 24, but women over 55 had the highest estimated incidence rate. It was suggested that this was due to the typical occupations of women over age 55 rather than their age. For serious non-fatal injuries, the risk of injury was lowest in the over-55 cohort but injuries were more severe and recovery took longer. One paper stressed the importance of employer engagement and longer tenure time in ensuring a functional return to work.

The data on fatalities at work show that for older workers there is an increased risk in agriculture, construction and transport. The types of event involved were typically highway incidents, homicides, accidents on farm or industrial premises, being struck by an object and falls to a lower level.

Ill health in older workers

The research on ill health and ageing identified that although there is an increased risk with age of developing a disease, this is not necessarily a reason to exclude an individual from work. Certain diseases, such as heart disease or diabetes, can be controlled and reasonable adjustments can be made to keep the individual at work.

Although the largest cause of absenteeism at work is short-term, non-certified absence, both males and females over the age of 55 take more days off work due to self-reported ill health caused or made worse by work. The most common sources of new cases of work-related illness reported were musculoskeletal complaints and stress, depression or anxiety, with those over 45 having the highest estimated prevalence rate.

Where do older workers need support or risk reduction?

The review identified that although changes do occur with age, loss of physical capacity can be reduced by increasing physical activity and ensuring that job demands do not outstrip the abilities of the individual. It was suggested by one paper that the need for recovery is greater in older workers between both tasks and shifts. Changes in thermoregulatory ability also need to be assessed in relation to work, as although this does not have a direct association with age, it may be an indication of other cardiovascular or health changes.

With regard to psychological changes, there is a link between reduced reaction time and age but an increase in accuracy, accumulated knowledge and experience. Thus reducing reaction times may only be a problem in high-risk environments, but it is essential that an objective workplace assessment is made. The ability for older workers to learn is not in doubt, but the learning media, time for reflection and access to learning opportunities must be considered.

Workplace interventions for safety

Although no interventions were identified in the review with regard to safety, there are indications that it will be important in future research to analyse and understand current accident patterns and to establish whether experience has a positive impact on workplace safety behaviours.

Workplace interventions for occupational health

Interventions for occupational health were more numerous but the majority of them were of very poor quality, resulting in no quantifiable evidence. The interventions reviewed did demonstrate that occupational health interventions for those at risk of taking early retirement on health grounds can be effective. The intervention involved meeting an occupational physician, identifying cases where demands were too high and interacting with supervisors and personnel to improve work demands.

Workplace interventions for health promotion

Health promotion interventions were again limited in number and quality. The review showed that health checks, counselling and health condition tests were seen as positive by older workers. However, it is important to ensure participation by all workers in health promotion activities, not just those with an interest, and to maintain the programme after an intervention. One intervention study demonstrated that improvements in work ability were linked to changes in effect typology, ie empowering individuals to take control, telling them how they can help themselves and improving work relationships. Again, there is a lack of research in health promotion activities for older workers.

Data gaps

The data gaps identified in the review included a lack of longitudinal or good quality interventional research. There is a clear need for more in-depth analysis of accidents, rehabilitation and return to

work for older workers. In terms of occupationally related disease, a better understanding is needed of the prevalence and possible intervention strategies for the reduction of current self-reported levels of musculoskeletal problems and stress, anxiety and depression. The research also highlights a widespread failure to use objective, occupationally relevant measures for both physical and mental capacity.

Guidance

From the review a short guidance document has been produced. This describes physical and psychological changes related to age, including capacity, shift work, heat tolerance, working environment and high risk industries. Although there is currently little good interventional research, the review has identified that further work is required for accident prevention for older workers and that occupational health interventions can reduce the risk of early retirement and sickness absence. For health promotion, occupational health is seen as positive but there is currently limited evidence for its effectiveness. Barriers have been identified in accessing health promotion, including ensuring all age groups are encouraged to take part, maintaining and encouraging attendance and allowing time during the working day to take part.

1 Introduction

1.1 Demographics and the changing population structure

The population of the UK in July 2007 was 60,975,000. For the first time in the UK, in 2007 the number of individuals over state pension age was larger than the number of those under 16.[1] These changes in demography in the UK are due to a number of factors, including a reduction in the fertility rate and increased longevity. In the past 25 years the number of individuals in the population aged 65 and over has increased from 8.5 million to 9.8 million, an increase of 16 per cent. This trend is expected to continue: by 2032 it is predicted that the number of people aged 65 or over will increase to 16.1 million and will account for around 23 per cent of the total population.

The demographic change will bring a number of challenges to the UK. While it is positive that individuals are living longer, the economically active population (those aged 16 to 64) is due to decrease from 65 to 60 per cent of the total population. This reduces the ratio of workers to pensioners, currently at 3.3 people of working age to each person above state pension age, to 2.9:1 by 2032.

By 2006, the employment rate for workers over the age of 50 had increased from 62 per cent in 1993 to 70 per cent.[2] In 2005 there were 582,000 economically active individuals in the UK over the age of 65 and this has been predicted to rise to 775,000 in 2020.[2] The increase in the numbers of individuals working beyond retirement age is probably due to the demographic changes reported previously, as well as to strong economic growth over the period in question. However, the impacts of global economic changes since 2006 make any future predictions difficult. Nevertheless, in the longer term, the demographic changes will remain.

Further investigation of the population group aged between 50 and retirement age in the 2001 census indicates that this group numbers 9 million people, or 17.5 per cent of the population. At the time of this report (2004), employment was rising among this group; there are no current data to indicate whether this has continued since 2004 or since the start of the current recession. Examination of the employment characteristics of over-50s in the UK reveals that employment rates reduce with age, with only 50 per cent of people being in work one year before state pension age.[3] Of people aged between 50 and state pension age who are working, 19 per cent are self-employed and 25 per cent work part time. In 2005, there were 2.7 million individuals aged over 50 who were not working; of these, 49 per cent were dependent on incapacity benefit, 9 per cent had occupational pensions and 18 per cent had involuntarily retired early with limited choices or distorted incentives.[4] A number of barriers to work have been identified in this group, including health, caring responsibilities, lack of relevant work experience, transport difficulties and local labour market conditions.[5] Several initiatives have been introduced across government departments, including the NHS, the Department for Work and Pensions, the Department for Business, Innovation and Skills and the Department for Children, Schools and Families, to try to improve retention and return to work in this age group.

1.2 Extending working life

The current situation in the UK is not economically sustainable and measures need to be taken to encourage the over-50s back to work and to help them to stay in work longer. The economic costs with lower levels of employment among the over-50s are estimated to be between £19 billion and £31 billion in lost output and taxes and increased benefit payments.[5,6] But these economic costs do not include estimates of both human and social costs, including the impact of poverty, inequalities and low self-esteem leading to depression, disillusionment and ill health. The shortfall in pension provision in the UK has been reported by the Pensions Commission and has raised difficult questions about future provision, including the possibilities of raising taxes, increasing savings, extending working life or accepting that the number of poor older adults in society will increase. The last mentioned, however, is not likely to be acceptable.

In the current climate of trying to maintain and improve the health of the working population, the review by Waddell & Burton[7] identified positive aspects of being in work. That work should be healthy and safe and should offer employees influence over the work process and give them a sense of self-worth. Therefore, keeping older workers in employment or returning them to good jobs is likely to be beneficial both before and after retirement.

1.3 The aim of the review

With the increase in the older population in the UK, there is a need both to keep older workers in employment and encourage those who have left to return to work. However, concurrently, it is necessary to assess whether those aged over 50 need to be considered differently from other workers with respect to their health and wellbeing at work. Thus the aim of the present review is to identify the health, safety and health promotion needs of older workers using a systematic review methodology.

2 Search strategy

2.1 Questions to be addressed in the review

1 What are the health, safety and health promotion needs of older workers?
   a What are the occupational health needs of older workers?
   b What are the health promotion needs of older workers?
   c What are the safety needs of older workers?

Part of the scoping process of this review identified that it was necessary to understand the ageing process (as a natural process) and what happens to people as they age, with regard to functional ability (both physical and mental). This included:

- fitness
- mobility
- dexterity
- thermal tolerance
- cardiorespiratory fitness
- strength
- psychological factors (eg memory, processing)

It was also necessary to ask what older workers find harder to do and what they are more at risk from, and to evaluate the accident and sickness absence rates for older workers as compared to other groups of workers. This part of the process aimed to identify what the needs of older employees are.

2 How are those needs being addressed?
   a Workplace intervention studies to improve occupational health, safety and health promotion opportunities

3 Do safety initiatives affect health, and vice versa, in this group of workers? In addition, does health promotion affect occupational safety and health, and vice versa?

4 Is the research reviewed applicable to the UK situation?

5 What data gaps are there?

2.2 Search strategy

The following terms were collated and used as search terms for the review.

2.2.1 Population

- worker
- employed
- employee
- ageing worker
- older worker
- at work
- economically active
- greying workforce
- active ageing models

2.2.2 Intervention

- measurement of impact of health promotion initiative
- measurement of impact of occupational health initiative
- measurement of impact of occupational safety initiative
- ergonomics
- health promotion
- occupational safety
- occupational safety and health
- occupational health
- occupational medicine
- occupational hygiene
- worker protection

- risk control
- risk reduction
- training for employees
- training for managers
- age management
- workplace interventions

2.2.3 Outcomes

Each study with a relevant population was included and the outcome measures were assessed in relation to the list below.

- reduction/increase in ill health
- reduction/increase in sickness absence reporting
- reduction/increase in accidents
- extended working life
- improvement/decline in retention of workers
- improvement/decline in morale
- improvement/decline in work ability
- improvement/decline in management style
- improvement/decline in mental wellbeing

2.2.4 Study designs

- randomised controlled trials
- quasi-experimental
- observational
- cross-sectional
- case reports
- qualitative research

2.2.5 Inclusion criteria

- participants aged 50 years and over
- employed
- economically active

2.2.6 Exclusion criteria

- participants aged less than 50 years
- economically Inactive

2.3 Search databases

The following search databases were used to identify relevant papers:

- ASSIA (Applied Social Science Index and Abstracts)
- Barbour Index
- CINAHL (Cumulative Index of Nursing and Allied Health Literature)
- Cochrane Central Register of Controlled Trials
- Cochrane Database of Systematic Reviews (CDSR)
- Database of Abstracts of Reviews of Effectiveness (DARE)
- EMBASE
- Environline (Environment, useful for Physical Activity)
- Ergonomics Online
- MEDLINE
- PsycINFO
- Scisearch
- SIGLE: System for Information on Grey Literature in Europe
- Sociological Abstracts
- Social Science Citation Index
- Social Policy and Practice
- EBESCO

Websites searched included the Health and Safety Executive (HSE), the European Agency for Health and Safety at Work, NIOSH, CIPD and others indicated by the steering group.

2.4 Screening papers and data extraction

An initial screening process was carried out, whereby the title and abstract of candidate papers were screened against the inclusion criteria. Where it was unclear from the title or abstract whether a paper should be included, a conservative approach was taken and the full paper was ordered for review. During the screening process a further five papers were identified as possibly relevant from the references in other documents.

On completion of initial screening, abstracts were reviewed and compared with the inclusion and exclusion criteria. Where the abstracts fitted the inclusion criteria, full documents were obtained and reviewed, and data extracted.

Data extraction was carried out for all papers included in the review. The literature was split into research that explores the impact of age-related change and research providing data on the effectiveness of interventions.

For the included studies, a quality assessment was made based on the following criteria:

*** Strong evidence, provided by consistent findings in multiple, high quality scientific studies
** Moderate evidence, provided by generally consistent findings in fewer, smaller or lower quality scientific studies
* Limited or contradictory evidence, produced by one scientific study or inconsistent findings in multiple scientific studies
- No scientific evidence

3 Results

3.1 Results of searches

The complete searches identified 180 papers, which were stored, with abstracts, in Ref Works software. Reviewing these abstracts resulted in the inclusion of 60 papers for the review, the use of two papers as a source of definitions for the review (eg 'mental wellbeing')· and the exclusion of 118 papers. The excluded papers are listed in the Appendix. The research team was not able to source two books for the review; these are listed below. As both publications are books rather than primary research sources, it was felt that their exclusion from the review was unlikely to result in a loss of interventional data.

- Camp C J. Applied gerontology. In: Infeld D L. *Disciplinary approaches to aging. Volume 2: Psychology of aging*. Routledge, 2002.
- Drenth P J D, Thierry H and Wolff C J. *Handbook of work and organizational psychology*. Psychology Press, 1998.

3.2 Age-related change in healthy ageing

3.2.1 Physical capacity

Aerobic capacity

Shephard[8] reports that aerobic power declines over the duration of working life from 50 mL kg^{-1} and 40 mL kg^{-1} for young men and women respectively to 25–30 mL kg^{-1} in 65-year-olds. It is estimated that the change is a 10 per cent reduction in aerobic power per decade of life.[8,9] In a longitudinal study by Savinainen *et al.*,[10–12] aerobic capacity was measured over a 16-year period in 95 municipal workers. The study found that there was a reduction in women from 31.6 to 26.9 mL min^{-1} kg^{-1} (significance $p < 0.001$) and a reduction in men from 33.2 to 28.8 mL min^{-1} kg^{-1} (but this was not significant). It was noted in the results that aerobic capacity was higher in the active groups and remained better among women without disease. Gall and Parkhouse,[13] in their study of 40 male power line technicians, found a significant difference in VO_2 max between those under 39 and those over 50 years ($p < 0.05$). VO_2 max is the measure of the maximal volume of oxygen that can be utilised in one minute during maximal physical exercise. It is associated with cardio-respiratory and aerobic fitness. The results indicated a reduction from 45.3 mL min^{-1} kg^{-1} below 39 years to a mean of 32.5 mL min^{-1} kg^{-1} for the over-50s. Although this was a small study and compared separate age cohorts simultaneously rather than following a group of workers as they aged, it does indicate the reduction in aerobic capacity that occurs through age.

Various hypotheses have been advanced as to why this change occurs. Shephard[8] suggests that it is due to the inevitable changes associated with ageing, including a decrease in ventilation rates, maximal cardiac output and peak heart rates. However, this change must be put into the context of physical work. Shephard[9] also reports that where machine-paced tasks are set at 32 per cent of maximal aerobic power for a 40-year-old, this can result in a 65-year-old man working at 105 per cent of maximal aerobic power and a 65-year-old woman at 140 per cent. However, reports of fatigue from older workers are not frequent and Shephard suggests a number of reasons for this. These include the possibilities that experience may increase manual efficiency, that those who no longer fit physical requirements may opt for lighter jobs, and that because age is linked to experience and seniority in the workplace, older workers may be able to choose lighter tasks in the workplace.

While it is apparent that aerobic capacity does reduce with age, continuing an active lifestyle can maintain capacity. In relation to work environments, no individual can work at 100 per cent of capacity. The level of physical exertion needed in the workplace is also changing, with a reduction in the prevalence of heavy physical work.

Anthropometry

Savinainen *et al.*,[10–12] in a 16-year follow-up study of 95 middle-aged individuals from 1981 to 1997, identified a number of physical changes. The evidence from these studies is presented in Table 1. The group consisted of 25 women and 20 men with an average age of 51 at the start of the project. It was shown that body mass index (BMI)* increased significantly over time ($p < 0.001$). At the start of the study, the mean BMI for the women was 26.2, which increased to 28.3 by the end of the project. The

* The BMI is calculated by dividing a person's weight in kilograms by the square of their height in metres. The range of BMI considered 'normal' (ie neither under- nor overweight) is 18.5–25.

mean BMI for men increased from 25.7 to 27.2. This was accompanied by significant increases in weight – 3.2 kg on average for women and 3.7 kg for men – and decreases in height of approximately 1 cm for women and 2 cm for men.

Gall and Parkhouse,[13] in a study of 40 male power line technicians, also found significant ($p < 0.05$) differences, with those over 50 being heavier, having an increased BMI and lower stature than those in the age groups 40–49 and 39 and under. This study was a cross-sectional study and does indicate physical differences between the age cohorts studied.

Age-related change in BMI is evident from current research. Changes in stature also occur as people get older. However, there are currently no data available to demonstrate whether changes in stature and other anthropometric data should affect current guidance on workplace design.

3.2.2 Strength and endurance

Physical strength and endurance are very specific to each individual. Age-related decline in muscle strength and endurance can be improved at any life stage. It is unclear from the research what impact age itself has on physical capacity, but it is clear that physical activity can improve both maximal oxygen uptake and muscle strength. With regard to muscle strength, Shephard[8] reports that peak muscle force remains constant until the age of 40 but reduces slightly between 40 and 65 years. However, this change is reflected by different changes in different muscle groups.

Savinainen *et al.*[10–12] carried out a longitudinal survey of 95 Finnish workers employed in municipal occupations. Measures were made of spinal flexibility, isometric trunk strength, and hand grip strength. Spinal flexibility was assessed in a standing posture and was found to be significantly reduced. Spinal flexibility was found to reduce by 21.8 mm in women and 14.2 mm in men over the 16 years of the study. Isometric trunk flexion strength was measured and both males and females showed a significant decrease ($p < 0.001$) in trunk flexion over the same period. At all stages of measurement throughout the study, men had greater strength in their trunk flexors than women.

Table 1
Studies relating to changes in physical capacity

Author and date	Study design, research type and quality	Research question	Information provided
Gall & Parkhouse 1994[13]	Cross-sectional experimental study with three age groups; $N = 40$ (*)	Changes in physical capacity in heavy manual work	Reduced aerobic capacity in the older worker group aged over 50; increased body weight and lower stature in over-50s
Savinainen *et al*. 2004[10]	Longitudinal study; $N = 95$ (**)	Changes in physical capacity in middle-aged workers over an 18-year period	Significant reduction in female aerobic capacity and a non-significant reduction in males. Significant increase in BMI and weight and reduction in stature as age increases
Savinainen *et al*. 2004[11]	Longitudinal study; $N = 95$ (**)	Changes in physical capacity in middle-aged workers over an 18-year period	Significant reduction in female aerobic capacity and a non-significant reduction in males. Significant increase in BMI and weight and reduction in stature as age increases
Savinainen *et al*. 2004[12]	Longitudinal study; $N = 95$ (**)	Changes in physical capacity in middle-aged workers over an 18-year period	Significant reduction in female aerobic capacity and a non-significant reduction in males. Significant increase in BMI and weight and reduction in stature as age increases
Shephard 2000[9]	Review (**)	Age-related physical change and the need for objective assessment	Predictions of work output based on age-related change
Shephard 1999[8]	Review (**)	Age and physical work capacity	Data on reduction in age-related aerobic capacity with suggested reasons why

Similar results for trunk extension strength were obtained, with men having greater strength at every stage of measurement ($p < 0.009$). It was shown that hand-grip strength reduced significantly, by 4.6 kPa for women and 23.9 kPa for men ($p < 0.001$), to a mean of 77.3 kPa for both groups. [10–12]

Gall and Parkhouse's study of 40 male power line technicians[13] involved a battery of physical tests, including two-handed lifting, one-handed leg lifts, one-handed pull downs, standard handgrips, awkward handgrips, overhead lifts from a pole and overhead lifts at arm's reach. Dividing the participants into three age groups (under 40, 40–49 and 50 and over), the test results indicated that the older age group scored significantly lower in the standard hand grip tests for both left and right hands. Furthermore, the results showed that for the 40–49 group, the results for the standard hand grip for the right hand were significantly ($p < 0.05$) lower than for the under-39s. No significant differences were found between the different age groups in the other measures. These data suggest that there is relatively little muscular decline over time for this occupational group. However, the study was small and compared different age cohorts rather than following subjects longitudinally. The authors also suggest that the small observed decline may be due to a training effect from the heavy workload required of the participants. Although this contradicts other research, this study used tests that were designed on the basis of tasks required in the workplace rather than standardised laboratory tests, which may indicate the importance of using specifically designed and occupationally relevant testing in evaluating strength.

Schibye[14] investigated physical capacity in 19 young and 28 older male waste collectors, compared to two control groups based on age and occupation. The study measured maximal isometric muscle strength for back extension and flexion, shoulder elevation and abduction, and hand grip strength. The results found that the waste collectors had a higher muscular capacity in both participant groups when compared to the control group. The young group of waste collectors showed significantly more back strength than the control group ($p < 0.05$). The older waste collectors showed significantly higher strength for shoulder elevation and shoulder abduction ($p < 0.05$) and a significantly lower hand grip strength of approximately 10 per cent ($p < 0.01$). These data suggest a possible training effect from the type of work being carried out. It also indicates the need for relevant strength testing related to occupation.

De Zwart *et al.*,[15] in a review of physical workload and the ageing worker, suggest that there is a decline in muscular capacity with age, with an average decline of 10–25 per cent at age 65 compared to the highest lifetime value. However, this is not consistent across the population and is subject to interindividual variation. The review suggests that variation may be due to both differences in leisure activities and BMI, where there is assumed to be a training effect through the process of carrying extra body weight.

The need for recovery has been addressed by two studies. Kiss *et al.*[16] surveyed 1,100 public sector workers in Belgium. The study asked participants to complete a mailed questionnaire survey which included the 'Need for Recovery Scale'. The results showed that need for recovery was significantly higher in older workers (those over 45) ($p < 0.005$). After multivariate analysis, the results indicated that the factors which had a significant association with need for recovery were age (OR 1.56, 95% CI 1.15–2.11), being female (OR 1.65, 95% CI 1.20–2.28), work pressure (OR 1.25, 95% CI 1.20–1.30) and monotonous work (OR 1.35, 95% CI 1.13–1.60). Devereux & Rydstedt used the Need for Recovery Scale across nine occupational groups.[17] The participants numbered 3,139 at baseline and 2,091 at follow-up 15 months later. The analysis demonstrated that need for recovery was greater in the oldest age group (50–69) compared to the youngest group (17–29) for working more than 42 hours per week (OR 2.04, 95% CI 1.38–3.02), high psychological demands (OR 4.79, 95% CI 2.98–7.69) and physically demanding work (OR 2.39, 95% CI 1.63–3.51).

Both studies reported that the need for recovery was associated with high physical demands, high psychological demands and monotonous work, although it is currently unclear whether sex is an issue. The results indicate that assessing the work demands and recovery needs of older workers is an important component in keeping people at work.

Cassou *et al.*[18] showed in their longitudinal research study that both the prevalence and incidence of chronic neck and shoulder pain increase with age. When results were analysed using logistic regression analysis, poor working conditions (including repetitive work, time constraints and awkward positions) contributed to the development of chronic neck and shoulder pain, but this was independent of the age of the participants. Similar results were found with regard to musculoskeletal complaints in the Netherlands[19] in a cross-sectional questionnaire study, with prevalence rates of musculoskeletal complaints being related to age. However, the authors suggest a more in-depth study is required as the use of a self-completed questionnaire may have influenced reporting.

Woods and Buckle,[20] in their review of work, inequalities and musculoskeletal health, showed that varied results are obtained when examining any relationship between musculoskeletal disorders and age. As mentioned previously, there are great interindividual differences in age-related change in muscular capacity. Although there is a general increase in the risk of many musculoskeletal disorders with age, the research is often confounded by the way data are collected (eg whether by physical examination or questionnaire) and by the fact that older people have been exposed to risk for a longer time. However, Woods & Buckle suggest that where there is an age-related imbalance between physical workload and capacity, the result is a chronic overload that is likely to increase the risk of developing musculoskeletal symptoms.

The studies reviewed indicate that decline in muscular capacity is specific to the individual but can be mitigated. The research suggests that older workers can experience a training effect from their specific work tasks. This was identified through the use of specific strength assessments relevant to the work tasks being carried out. The use of objective measures designed for specific occupational roles is important in assessing ability to continue working; it is also necessary to ascertain whether enough time is included in the work design for recovery. Study design in this field is also problematic, as results vary depending on whether cross-sectional or longitudinal designs are used. The relationship between ageing and the risk of development of musculoskeletal disorders remains an area where further research is required. The research of Cassou *et al.*[17] on chronic neck and shoulder pain suggests that age is an independent factor in the development of musculoskeletal symptoms. This implies that much more consideration must be given to work activity and overload in the case of older workers.

Industrial changes have led to a reduction in the number of jobs requiring high levels of physical strength, as a result of the trend away from extractive and manufacturing industry towards service and knowledge-based industry. These changes also include the use of powered equipment and the effects of legislation, such as the Manual Handling Operations Regulations, which require risks to be controlled so that all workers can work safely.

3.2.3 Balance

Punakallio[21] measured postural balance on a force plate with normal standing (standing with feet parallel and comfortably apart) and tandem standing (standing with one foot in front of the other with toes touching the heel in front) and functional balance (walking along a plank with error measurement) in a cross-sectional study of four groups of workers, including construction workers, firefighters, home care workers and nurses. There were 238 participants, aged between 23 and 61. The results of the study showed that in the case of postural balance, age was significantly related to increased sway in the normal standing position ($p < 0.001$) and the tandem standing position ($p < 0.0001$). Both age ($p < 0.0001$) and occupation ($p < 0.0001$) were related to a reduction in functional balance. The study also showed that construction workers and firefighters scored better and made fewer errors in the tasks.

These data suggest that there are age-related changes in balance. However, there is also suggestion of a training effect for workers whose balance abilities are regularly used. Therefore, as balance reduces with age, employers must consider job design in situations where good balance is a requirement for safe working.

3.2.4 Mobility

From the searches carried out, limited information was available with regard to changes in mobility and the older worker. Garg[22] reports that joint mobility decreases slightly between the ages of 20 and 60. McMahan[23] reports that age-related changes, including in small motor movements associated with gripping, turning or twisting and large motor movements associated with activities such as walking, bending, climbing or stooping, are likely to affect the ability to work. No evidence is provided in this paper, although it suggests that using ergonomics in the work design process could reduce the impact of these changes.

3.2.5 Dexterity

None of the papers examined offered research relating to manual dexterity and the older worker. McMahan[23] suggests that changes in small motor movements may affect dexterity and the ability to manipulate tools or other objects. However, no evidence was given to support either an age-related link or what impact this has on work. The use of ergonomics and usability testing in tool and equipment design and choice should reduce any possible impact from changes in dexterity.

Table 2
Studies relating to strength and endurance (*continued overleaf*)

Author and date	Study design, research type and quality	Research question	Information provided
Cassou *et al*. 2002[18]	Longitudinal study of chronic neck and shoulder pain in France. Study of 18,695 individuals including interview and physical examination (**)	Work-related factors as predictors of chronic neck and shoulder pain	The prevalence and incidence of chronic neck and shoulder pain increases with age, independently of exposure to work risk factors
Devereux & Rystedt 2009[17]	Longitudinal survey of 3,139 at baseline and 2,091 at follow-up 15 months later (**)	Does the need for recovery increase with age?	The need for recovery was greatest in the oldest age group (50–69) compared to the youngest (17–29). Need for recovery was associated with working more than 42 hours per week, high psychological demands and physically demanding work
de Zwart *et al*. 1997[19]	Cross-sectional questionnaire survey of 44,486 employees in the Netherlands (**)	The effects of ageing and physically demanding work on MSDs	An increase in the prevalence of MSDs with age
de Zwart *et al*. 1996[15]	Review (**)	Physical workload and the ageing worker	Average decline in muscular capacity of 10–25% by the age of 65. This is very variable and not consistent, and depends on BMI and leisure activities
Gall & Parkhouse 2004[13]	Cross-sectional experimental study with three age groups of male power line technicians. *N* = 40 (*)	Changes in physical capacity in heavy manual work	No significant difference in the strength measures, apart from hand grip strength, which was significantly lower in the over-50s
Kiss *et al*. 2008[16]	Cross-sectional questionnaire survey. *N* = 1,100 (**)	The need for recovery from psychosocial and physical work strain	An association between age and a higher score on the need for recovery scale
Savinainen *et al*. 2004[10]	Longitudinal study. *N* = 95 (**)	Changes in physical capacity in middle-aged workers over an 18-year period	Significant reduction in spinal flexibility, decrease in trunk flexion strength and similar results for trunk extension strength as age increases
Savinainen *et al*. 2004[11]	Longitudinal study. *N* = 95 (**)	Changes in physical capacity in middle-aged workers over an 18-year period	Significant reduction in spinal flexibility, decrease in trunk flexion strength and similar results for trunk extension strength as age increases
Savinainen *et al*. 2004[12]	Longitudinal study. *N* = 95 (**)	Changes in physical capacity in middle-aged workers over an 18-year period	Significant reduction in spinal flexibility, decrease in trunk flexion strength and similar results for trunk extension strength as age increases

Table 2
continued

Author and date	Study design, research type and quality	Research question	Information provided
Schibye 2001[14]	Cross-sectional study of younger and older male waste collectors compared to two younger and older control groups. *N* = 47 (*)	Maximal strength measures in waste collectors	Waste collectors have a higher muscular capacity compared with control groups. Older waste collectors have significantly higher strength for shoulder elevation and shoulder abduction, but lower hand grip strength. This suggests a possible training effect
Woods & Buckle 2002[20]	Review (**)	Impact of work, inequalities and musculoskeletal health	Great interindividual differences. Research confounded by data collecton measures and exposure times. Have to identify the balance between physical workload and capacity

3.2.6 Thermal tolerance

Reviews of the scientific literature on ageing and heat tolerance[24,25] concluded that age in itself does not have any effect on heat tolerance, although there are distinct cardiovascular changes. However, paradoxically, the literature does support the notion that older people are more susceptible to heat-related problems (eg Levine 1969 cited by Pandolf[24]). These data are presented in Table 3.

It appears that tolerance of heat decreases because of age-related changes, such as the degradation of the cardiovascular system (reflected in a reduction in physical fitness)[8] or, possibly of more significance, an increase in incipient cardiovascular disease. Some other relevant influences likely to be encountered in an ageing working population have been documented, such as the reduced thermoregulatory ability of those with Type 2 diabetes.[26] Where such factors are adequately controlled, older workers appear to be no more susceptible to adverse effects from working in the heat than their younger colleagues.

Therefore, any health surveillance or risk assessment relating to work in hot conditions should account for these indirect influences, recognising that older workers may develop conditions which predispose them to heat-related illness. There may be some value in exploring the scale of this issue and evaluating the cumulative risk to ageing workers from these age-related disorders.

3.2.7 Psychological factors

There are numerous studies that have shown that with ageing come slower reactions.[27] However, the application of laboratory-based studies in the workplace is fraught with difficulties, in addition to the problems identified when using cross-sectional rather than longitudinal studies. Morgan,[28] in a review of the psychological aspects of ageing, highlighted the need to understand where in the process of reacting the slowing occurs. Morgan has identified the slowing as being mainly due to a slowing in central processing time.

In addition to an increase in reaction time, Morgan reports that caution also increases with age and that there is a trade-off between speed and accuracy, whereby individuals slow down to increase accuracy when carrying out a task, reducing the number of possible errors. Therefore, if speed of performance is measured, older people will inevitably come off worse. However, in the work context, accuracy of performance – especially relating to product quality or safety issues – may be a more relevant measure.

There are numerous other facets involved in mental processing and reflection in the older worker. Cattell,[29] in his early research on general intelligence, identified two factors, fluid and crystallised intelligence, as components of general intelligence. Fluid intelligence includes abilities such as problem solving, learning and pattern recognition, whereas crystallised intelligence relates to verbal ability, language development, sequential reasoning and assimilation of general information. Thus, although there is a slowing of central processing in older people, this can be compensated for by accumulated knowledge and experience. It has been shown when testing older adults that certain components, including vocabulary, arithmetic, comprehension, knowledge and digit span tests, are resistant to change; on the other hand, picture completion, picture arrangement, object assembly and block

Table 3
Studies relating to the impact of heat exposure

Author and date	Study design, research type and quality	Research question	Information provided
Pandolf 1991[25]	Review (**)	Heat intolerance in older individuals	Data provided on heat intolerance and factors affecting it. Demonstrates that age is not a primary factor, but rather that age-related cardiovascular change and ill health affect individuals' heat tolerance
Pandolf 1997[24]	Review (**)	Heat intolerance in older individuals	Data provided on heat intolerance and factors affecting it. Demonstrates that age is not a primary factor, but rather that age-related cardiovascular change and ill health affect individuals' heat tolerance
Shephard 1999[8]	Review (**)	Age and physical work capacity	Data on reduction in age-related aerobic capacity with suggested reasons why
Wick *et al.* 2006[26]	Case control study of 20 participants measuring vasodilation in Type 2 diabetes	The impact of heat on vasodilation in participants with Type 2 diabetes	Suggests that individuals with Type 2 diabetes may have altered control of vasodilation in the skin

design are affected by age.[27] Morgan suggests that when examining recent research, there appears to be a close relationship between crystallised intelligence and what may loosely be called wisdom.[28]

Benjamin *et al.*[27] identified that cognitive abilities can be affected by genetics, personality, health, experience and culture. In terms of maintaining and improving intellectual functioning Morgan[28] suggests that there is support for the 'use it or lose it' hypothesis, whereby maintenance of intellectual abilities has been associated with high levels of educational attainment, high occupational mental workload, linguistic skills, regular intellectual stimulation and cognitive exercises. This suggests that the long-term maintenance of health should involve not only diet and exercise but also consideration of intellectual stimulation and activity.

With regard to ageing and psychological processing, there are large interindividual differences, although age increases the risk of cognitive impairment. Benjamin *et al.*[27] report that 16 per cent of those aged 60 to 70 showed some signs of impairment. However, Benjamin also reports on a second study, in which interviews demonstrated that 95 per cent of individuals over the age of 65 showed no signs of impairment to cognitive abilities. Where cognitive changes do occur, their onset and impact vary between individuals.

Thus, although there may be slowing of certain cognitive processes, this must be examined in relation to the work being carried out and the compensation effects of increased accuracy. Research has shown that certain aspects of ability are maintained through later life and can be improved through intellectual activity.

3.2.8 Mental wellbeing

Analysis of mental wellbeing in the context of this review will consider information on work stress and psychosocial factors, including social support in the workplace. De Lange *et al.*[30] carried out a longitudinal survey of 686 workers in the Netherlands. The survey was analysed on the basis of three groups: workers over 50, those aged 35–50 and those under 35. Initial results showed that the oldest age group reported a higher importance of work and responsibilities compared to the youngest age group. Furthermore, respondents in the oldest group were positive about their training possibilities and health status in comparison to other research. There were no differences between the groups in reporting emotional exhaustion or satisfaction across time. However, de Lange *et al.* reported that emotional exhaustion could be predicted in older workers by low social support from supervisors or colleagues ($p < 0.05$) and therefore recommend that support from supervisors and co-workers is important in reducing emotional exhaustion in older workers.[30] However, the overall recommendation is to provide a demanding and challenging work environment for all workers without specific intervention for older workers.

Gershon *et al.*[31] examined occupational stress in a convenience sample (ie a sample involving participants who are easier to reach or available to participate at the time of the research) of police officers in the USA. Using a self-administered survey tool, 105 police officers aged 50–67 were studied. The results found that the main risk factors associated with perceived work stress were the occurrence of critical incidents (OR = 3.84, 95% CI 1.71–8.65) and maladaptive coping behaviours (OR = 4.95, 95% CI 1.75–16.35). In addition, high perceived work stress was significantly associated with anxiety, somatisation, burnout, chronic back pain and foot problems. The study does highlight the impact of stress on ageing police officers but the lack of a validated measurement tool and no comparison group reduces its quality. Nevertheless, it emphasises the importance of reducing stressors in the workplace and improving coping strategies for older workers who are at high risk.

There is a lack of research on psychosocial factors in older workers, in terms of both measurement and risk reduction strategies. Current research suggests that social support, risk reduction strategies and improving coping strategies are likely to be important issues.

3.2.9 Learning and training

There are myths surrounding the ability to learn as we age. Benjamin *et al.*[27] summarise the issues with regard to learning but it must be highlighted that it is opportunities for learning that are important, not just the learning process. In summary, it has been shown that training and education programmes need to be tailored to the specific group – for example, self-paced training with time for reflection and rehearsal may be beneficial for older workers. Furthermore, an understanding of how people learn is vital; older people may have different approaches to learning, based on their experiences. As mentioned in section 3.2.7, speed of learning may be slower in older people, but they may have a broader knowledge base to work with. However, Benjamin *et al.*[27] suggest that a continuous learning environment would benefit all workers.

There have been several media reports that training opportunities are routinely not offered to older workers, although equal opportunities legislation requires that all workers have access to the same opportunities. Lundberg & Marshallsay[32] carried out a national survey of 2,026 workers over the age of 45 in the finance, construction and aged care industries in Australia. When evaluating training needs, the survey showed that older workers seek equal access to training programmes to maintain and update their skills. The types of training seen as important include computing skills, specific skills for specific industries, and communication skills. Furthermore, qualitative responses in this survey identified the most effective training methods as likely to be in service, in house, one to one and practical, preferably using older workers as mentors.[32]

It can be concluded that older workers are keen to maintain up-to-date skills, but that it is important to ensure that training opportunities are available and that the types and methods of training are relevant to this group.

3.2.10 Sensory abilities

Vision

Changes in vision associated with ageing include a reduction in visual acuity, a loss of accommodation (the speed of refocusing the lens from distant to close vision and *vice versa*), a reduction in depth perception and loss of colour discrimination.[22,27,33] Some of these changes can be mitigated at both an individual level (by using glasses or contact lenses) and workplace level (by improving the general lighting or providing task lighting).[22,27,33]

Hearing

Age-related decline in hearing ability is estimated to affect 7–15 per cent of the population.[34] The effects can be minimised by preventing occupational noise exposure, preferably using a risk management approach to reduce the problem at source before using other protective measures such as ear defenders. Older workers with more severe age-related hearing loss can be kept in work by using hearing aids.[27] They must also continue to be protected from occupational noise exposure throughout their career.

Touch

Seifert[33] reports that ageing is related to a reduction in touch receptors and reduced blood flow, which affect the ability to feel touch, pressure and vibration. Although this may not have a noticeable effect in general working environments, there are some circumstances where it may be a problem. However, Seifert suggests that technology can compensate for this, citing the example of surgeons making

greater use of surgical robots and endoscopes. There is currently no further research available on changes in touch in older workers.

3.2.11 Work organisation

This section briefly examines the two research papers identified that covered aspects of work organisation, including overtime and shift working. Allen *et al.*[35] examined the impact of overtime on health, safety and productivity and compared older and younger workers in a group of 2,746 workers in US heavy manufacturing. The study used nine outcome measures, including physical health, mental health, productivity and safety. The results showed that adverse outcomes were associated with age but only in hourly paid employees working more than 60 hours per week. For employees on salaries there were no differences in adverse outcomes from working overtime. Workers on hourly pay are more likely to be employed in heavy industry, whereas salaried workers are more likely to be employed in office environments. This suggests that physical workload has a greater impact than mental workload on the outcome measures used in the study and that employers' requirement for excessive overtime has the greatest impact on older workers in physically demanding jobs. This may be partially addressed in the EU by the Working Time Directive, unless the workers in question are covered by an exemption.

Costa & Sartori[36] report on a study of 1,449 workers in healthcare, the chemical industry and construction. The participants were examined during periodic health checks by an occupational physician and completed the Work Ability Index (WAI). The age range of the participants was 21 to 67 years. The results showed that the WAI scores reduced with age, as is seen in most working populations. However, WAI reduction was also associated with job activity, including heavy manual work. In comparison, participants with jobs that are less physically active but involve higher mental involvement and autonomy maintained their WAI scores. In relation to shift working, Costa & Sartori showed that women working shifts had a reduction in WAI from the age of 35; for men the reduction is not apparent until after 45. The authors hypothesise that this is due to the conflicts inherent in mothers' dual roles at work and at home. For men, they suggest that there is a 'healthy worker effect', in that only those who can cope with shift work are likely to continue to do such work. With demographic change, there may be a requirement to extend current recommendations on working shifts, including night work. Shift work schedules should be designed around ergonomic criteria, giving additional consideration to:

- limiting night work for 45–50-year-olds
- giving these workers priority transfer to day shifts
- giving them a choice of preferred shifts
- shortening their working hours
- reducing their workload
- arranging more frequent health checks
- giving training and counselling on sleep management, diet, exercise and stress.[36]

3.3 Accidents in older workers

The results from the HSE self-reported workplace injuries survey[37] are broken down into age cohorts, including ages 45–54 and 55 and over. The results from the 2008 report show that with regard to reportable non-fatal injuries, men aged over 55 had the lowest estimated incidence of injuries. In contrast, women aged over 55 had the highest estimated incidence rate. This cohort of both men and women was significantly different from the other age cohorts. However, the HSE[37] points out that the differences in reporting for different age groups is related to the occupational groups involved, rather than to the age of the cohort. This appears to be supported by the research of Laflamme,[38] in which women over 45 were concentrated in blue-collar roles while those under 25 are mainly employed in white-collar occupations. In general, younger workers have been found to be a higher accident risk.[27,38]

Personick & Windau[39] showed that the risk of serious non-fatal accidents was lower for those over 55 in the general population in the United States. The study examined the injury and illness patterns for 8.8 million workers aged 55 and over, and the data included 2 million workers aged over 65. The most frequently encountered type of injury was sprains and strains (approximately one third of all injuries), with fractures, bruises and cuts accounting for 10 per cent each. Overexertion was cited as the most common event leading to injury – in nearly 25 per cent of cases – but falls on the same level accounted for 20 per cent of events. When the source of injury was examined, the commonest was found to be the floor or ground surface (in 25 per cent of cases).

Layne & Landen[40] examined nonfatal occupational injuries where treatment was received in a sample of hospital departments in the United States. The results showed that the service industries had the greatest absolute number of injuries (31.9 per cent of the total) but that the highest injury rate was in agriculture, forestry and fishing (at 1.5 per 100 workers). The analysis showed that for over-65s, the commonest injuries were fractures or dislocations resulting from falls on the same level. Layne[41] also showed that while older workers were more likely to be hospitalised after a fall, they were not at any greater risk of injury.

Data from the UK suggest that the estimated number of days taken off work by men due to self-reported workplace injury was found to be highest in the 16–24 age group.[37] For women, the highest level was among those aged over 55. Rogers & Wiatrowski[42] report that the injuries sustained by older workers are more severe and require more time away from work, with a median of eight days for the whole working population, compared to 12 days for those aged 55–64 and 18 days for over-65s. This is supported by the review of ageing and occupational accidents by Laflamme.[43] When examining outcomes after injury, Pransky[44] showed that although work absence following injury tends to be longer in older workers, for those who return to work there is no significant age-related difference in their ability to do their job. Pranksy suggested that although older workers had more pre-existing illnesses and more severe injuries, workplace factors were key in their positive return to work. These included a longer time with the employer, a higher level of job satisfaction and positive employer–employee interaction after the injury.

Rogers & Wiatrowski[42] report on fatalities in the workplace in the United States. in 2003 there were 5,575 fatalities, with a fatality rate for those over 65 of 11.3 per 100,000 workers. This level is three times that of younger workers. An increased risk of fatalities was also found by Grandjean.[45] In the UK, the number of fatalities has reduced in 2006/07 but the rate is highest for those aged 55 to 59 years, at 1.6 per 100,000.[37] Personick & Windau,[39] in a study of 1,315 fatalities in workers over 55, found that 25 per cent were in agriculture, 11 per cent in sales and 10 per cent in truck driving. The principal causes of the events were highway incidents (18 per cent), homicides (13 per cent), on farm or industrial premises (10 per cent), struck by an object (10 per cent) and falls to a lower level (10 per cent). When the industry breakdown is examined, 26 per cent of fatalities were in agriculture, forestry or fishing, 11 per cent in construction, 11 per cent in manufacturing, 11 per cent in transportation and 12 per cent in retail.

The research on occupational injuries suggests that although younger workers are more at risk of an injury at work, older workers are more at risk of death. These data are presented in Table 4. For serious non-fatal injuries, although time for recovery is longer in older workers, there are no differences in functioning on return to work and engagement by the employer is important in the process of returning to work. Data from the United States also suggest that older workers are more at risk of a fatal accident, with high numbers of accidents occurring in agriculture, construction, manufacturing and transport. Care must be taken with these data, as they have been collected in a number of different formats, including self-report and samples of reasons for admittance to hospital.

3.4 Ill health and ageing

Although people change both physically and mentally throughout life, the ageing process is not the only determinant of whether someone is healthy. When using the term ‘health’, this review uses the World Health Organization’s definition:

> Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.[46]

Benjamin *et al.*[27] identified that there were other equally important determinants of health including lifestyle, education, socioeconomics, physical activity, nutrition, access to healthcare and stress. The Department of Health reported in 2004 that for the over-65s in the general population there had been decreases in deaths from coronary heart disease, stroke, cancer and suicide from 1993 to 2002.[47] Furthermore, there have been increases in life expectancy from 14.6 years to 16.1 years after age 65 for men and from 18.2 years to 19.2 years for women. Although increasing age is associated with increasing ill health, there is a current improvement in over-65s through improved access to healthcare, improved screening, better health advice and uptake and public health initiatives.

For the population below 65 years of age, there are still concerns with regard to health. It is estimated that 17 million people live with chronic health conditions, including diabetes and arthritis.[48] Workers with chronic conditions have been found to suffer higher rates of sickness absence

Table 4
Studies relating to occupational injury

Author and date	Study design, research type and quality	Research question	Information provided
Benjamin & Wilson 2005[27]	Review (**)	Facts and misconceptions about age and employability	Younger workers are at greater risk of accidents
Grandjean *et al*. 2006[45]	Data analysis (**)	A breakdown of severe occupational injuries in older workers	Greater risk of fatalities in older workers
HSE 2008[37]	Survey data (**)	Results of the self-reported work-related illness and workplace injuries survey	Data on self-reported injuries
Laflamme 1997[38]	Retrospective analysis of data (**)	Age-related risk of injury in automotive assembly	Increase in risk of older females is related to type of occupation rather than age
Laflamme & Menckel 1995[43]	Review (**)	A review of ageing and occupational accidents	Older workers take more time off to recover after serious accidents
Layne & Pollack 2004[41]	Retrospective analysis of data (**)	Non-fatal occupational injuries from slips, trips and falls to older workers	Commonest injuries were fractures and older workers were more likely to be hospitalised
Layne & Landen 1997[40]	Retrospective analysis of data (**)	Non-fatal occupational injuries to older workers	Commonest injuries are in service industries but agriculture has the highest injury risk
Personick & Windau 1993[39]	Data analysis (**)	A breakdown of severe occupational injuries in older workers	Risk of injury is lower for older workers, with sprains and strains the most common injury after exposure to overexertion
Pransky *et al.* 2005[44]	Postal survey; *N* = 3,056 (**)	Age-related differences in return to work after injury	No age-related difference in return to work after injury for older workers
Rogers & Wiatrowski 2005[42]	Data (**)	Summary of workplace illnesses and injuries	Older workers are more at risk of fatal injury at work

when compared to other workers. The report by Vaughan-Jones & Barham[48] raises concerns about health in the working age population. Using current data on factors such as increased obesity and drinking levels to predict likely changes to 2030, they forecast that incidence of mental illness, coronary heart disease, stroke, MSDs, breast cancer, bowel cancer, diabetes and prostate cancer is likely to increase. These predictions are based on current knowledge and take no account of the possible impact of health behaviour changes, public health intervention or other health promotion activities, either in the workplace or in the community.

Although there is an increase in the likelihood of developing disease with age, this is not a reason to exclude individuals from the workforce without objective cause. Various diseases can be treated and controlled, including heart disease or diabetes. Making reasonable adjustments to work tasks and the work environment, ensuring good ergonomic work and job design and measuring work task requirements objectively are likely to improve the experience of work for everyone, not just older employees.

The Labour Force Survey[37] examined the demographic characteristics of ill health in the UK's working population and estimated that for men the highest prevalence rates (ie the total rate of ill health in a population) were in the age group 55–64 and for women in the age groups 45–54 and 55–59. When estimated incidence rates (ie the number of new cases of ill health) were examined, they were found to be reduced for males and females over the age of 55. However, both males and females

over the age of 55 take more days off work due to self-reported illness caused or made worse by work (on average, 1.6 days more for men and 1.8 days more for women). Benjamin *et al.*[27] reported that the largest source of absence in the UK is short-term uncertified sickness absence. This has been generally associated with younger workers. However, medically certified absence has been associated with the older working population. Research needs to establish whether prevention of long-term absence is possible through either work redesign, health promotion or further occupational health interventions.

For the working population, the Labour Force Survey identified that MSDs and stress, depression or anxiety were the most common sources of new cases of work-related illness in the year preceding the survey.[37] A breakdown of these figures by age cohort shows that for MSDs, those over 55 have the highest estimated prevalence in the working population, at 4,220 per 100,000. However, these high prevalence rates are likely to be due to cumulative exposure to workplace risk factors over the whole working life. As mentioned in section 3.2.2, it is difficult to determine whether the increase in MSDs is a result of age or of cumulative exposure, and as such the research is often confounded.

For stress, anxiety and depression, the 45–54 age group has the highest estimated prevalence rate, of 1,940 per 100,000. The reasons for the increase in prevalence in this age group can only be hypothesised; however, this highlights areas where intervention can be prioritised.

Only one paper was found which identified predictors of an early exit from working life. The paper, by Hopsu *et al.*,[49] investigated predictors of early retirement in professional cleaners with 97 participants between 1991 and 2003. At the follow-up stage in 2003, 75 participants were involved, with 45 still working and 28 retired. The study used the WAI and measured BMI, balance, oxygen uptake, repeated situps, dynamic trunk flexion and side bending. The analysis showed that those who had retired had a poor or moderate WAI score ($p < 0.0001$), reduced maximal situp score ($p < 0.04$), and reduced trunk side bending ($p < 0.01$). Hopsu *et al.* also reported that a large organisational change had occurred in 1995 which resulted in 70 per cent of the retirees taking retirement. The authors suggest that for cleaners, reduction in WAI scores, increasing BMI, reduction in fitness and organisational change are good predictors of early retirement. Although the study is small, it does suggest the importance of supporting fitness and managing change in this working group.

3.5 Where do older workers need support or risk reduction?

3.5.1 Physical work

The research on age-related change has identified a number of areas where changes occur in the healthy working population. Reductions in aerobic capacity, changes in anthropometry and reduction in muscle strength do occur with age. However, workplace requirements do not generally expect individuals to be working at maximal output or maximal strength throughout the working day. Furthermore, certain aspects of physical fitness can be maintained through physical activity. Three of the papers reviewed identified a possible training effect from work affecting the strength of specific muscle groups and balance. Future research should examine whether strength and balance are maintained through physical work.

Ilmarinen[50] makes recommendations with regard to changes in physical capacity. These include making assessments of functional capacity in older workers, such as oxygen uptake, heart rate and strength, including hand grip, knee extension, elbow flexion, trunk extension and trunk flexion. This should be complemented by measurement of the work demands, including physical activities and workload. From this, the level of strain on the individual can be calculated using either measures of oxygen uptake or, less accurately but more feasibly, heart rate. Any imbalance between work capacity and job demands can thus be identified. Ilmarinen makes a number of recommendations, including that relative aerobic strain should not exceed 50 per cent for an eight-hour shift where rest breaks are available and 35 per cent where rest breaks are not available. For example, if an individual has a maximal aerobic capacity of 3.0 L min^{-1}, working at a level of 1.0 L min^{-1} equates to a relative aerobic strain of 33 per cent.

Measuring aerobic capacity in the workplace is not always possible, but using heart rate measures is, although heart rate can be influenced by other external factors. Ilmarinen[48] reports on data previously collected examining aerobic capacity and suggests that the level of heart rate reached when carrying out physical work will vary depending on the fitness of the individual. For example, assuming a decline in VO_2 max with age, a fit individual working at a level of 1.0 L of oxygen per minute will have a heart rate of 100 beats per minute, whereas a less fit person will reach a heart rate of 120

beats per minute. Thus, although physical work can be limited to below 1.5 L of oxygen per minute for the male working population, the impact of individual aerobic fitness levels is extremely variable. The authors note that more research is required in this area, especially with regard to women in the workforce, as the current data cover only men.[48] These data presume healthy workers and Ilmarinen also points out that 50 per cent of the over-50s have at least one chronic disease (most commonly musculoskeletal or cardiovascular), where different criteria are likely to be required.

Two papers[16,17] reported that age was linked to an increase in the need for recovery after work. Although this cross-sectional study found an association, it did not give any further data. Thus more research is required to examine the need for recovery between work tasks and between work shifts. Current research on thermal tolerance suggests that age itself does not have an impact on heat tolerance but other factors, including cardiovascular changes or having diabetes mellitus, which are themselves more prevalent in older workers, result in lower thermoregulatory control. This would suggest that further risk assessment is important for older workers undertaking hot work to ensure that they are able to work without risk from either cardiovascular or endocrine health problems.

Research on age-related changes in sensory abilities shows that both vision and hearing change with age. As these changes occur, it is clear that personal aids can be used to maintain ability. Furthermore, with regard to visual environments, workplace lighting can be changed and improved. For hearing, continued prevention of occupational hearing loss is essential throughout the working life.

3.5.2 Mental and psychosocial factors

The research reviewed in this study shows that there are psychological changes in mental processing as we age, namely a reduction in reaction time but an increase in accuracy. These changes are accompanied by increases in levels of accumulated knowledge and experience. This is within the background of large interindividual differences and the fact that the majority of people show no signs of mental impairment before the age of 65. There is also evidence for the 'use it or lose it' hypothesis, which suggests that maintaining intellectual stimulation is vital. Policies for promoting health should therefore consider physical interventions, dietary interventions and intellectual stimulation.

However, much of the research on psychological change is based on laboratory research which is difficult to translate into the workplace, where a slight slowing down of reaction time may or may not be critical. Future research needs to address this, particularly for safety-critical workers.

With regard to mental wellbeing, two papers reviewed identified the importance of social support from colleagues and co-workers, reducing stress in the workplace and improving coping strategies when dealing with stress. It is hypothesised that making these changes is likely to improve work for workers of all ages, not just older ones.

Learning and training were also examined in the review. The research showed that for older workers it is essential to consider the learning media, make sure that there is time for reflection and ensure that opportunities for learning are available. One paper showed that older workers are keen to update their skills, including computing skills, and that their preferred learning modes are in-service training, in-house training, on-the-job training and one-on-one training, using more experienced workers as mentors.

3.5.3 Work organisation

Two papers were identified that evaluated the effect of working overtime or working shifts on older workers. The first showed that excessive overtime (a total of over 60 hours per week) was associated with adverse outcomes in physically demanding jobs. The second showed that individuals working shifts had a reduction in WAI from the age of 35 for women and 45 for men. These two papers identify the importance of regulation, including the Working Time Regulations, in combating these problems. As well as ensuring overtime in physical work is restricted, it is also important to ensure that shift schedules are based on ergonomic criteria, and health evaluation of older shift workers may need to be increased.

3.6 Workplace interventions for safety

Section 3.3 showed that although younger workers are more at risk of an injury at work, older workers are more at risk of a fatal injury and take longer to recover from serious non-fatal injuries. The data identify particularly high-risk industries, including agriculture, construction and transport. However, at the time of writing no intervention studies have been reported that evaluate strategies to reduce the risks for older workers with regard to either fatal injuries or serious non-fatal injuries.

Although there are reports of older workers changing the way they work through experience to try to reduce physical strain,[51] there is currently only anecdotal evidence of this. However, from the view of participatory ergonomics, feedback from employees on how to improve job design is often vital. Thus further research on the impact of experience on safe working is likely to be an important research avenue.

The review also showed that a large number of non-fatal accidents are falls at work. It is unclear whether these are due to housekeeping issues in the workplace or as a result of changes in balance or bone structure with ageing. It is clear that there is a need to develop strategies to reduce the number of falls in the workplace and to evaluate the impact of this as part of research on slips, trips and falls at work.

3.7 Workplace interventions for occupational health

Occupational health provision for older workers is seen as positive in contributing to their continued health.[52–55] As part of this, it is essential to consider the fact that older workers have already had a longer duration of exposure to any potential risks.

Eight intervention studies were identified in this section, but as can be seen from Table 5 (see pages 30–31), most of them are of questionable quality. There are very few quantitative data provided in several of the papers and most report a change without any evidence.[56–60]

Aday & Kehoe[61] report on an intervention which involved participation in an employment programme. The intervention, involving 113 participants, was the Senior Community Service Employment Programme, which is funded through the US Department of Labor, Employment and Training. The paper is unclear on the nature of the intervention itself but implied that it included on-the-job training and some classroom experience. The aim of the paper was to evaluate the health impact of remaining employed. The study established that the participants were generally healthy and that 68.3 per cent of them believed their mental health had improved by taking part in the programme. Correlations showed that those who reported improved mental health were more positive about themselves as older workers ($p < 0.05$). The participants also reported improved social networks as a result of the programme. The study is rated as poor quality for the purposes of the present research mainly because of the poor descriptions of methods and analysis. Nevertheless, it does give some evidence as to the positive impact of employment programmes on older workers.

Dale[62] reports on a small intervention study to reduce musculoskeletal symptoms in older academics. This case study involved four academic staff members at a US university. The interventions included interviews with and observations of participants followed by workplace changes. The academics were visited one week later. It was reported that there were reductions in MSDs the following week, although there is no formal measurement mentioned or data presented. This paper was rated as being of poor quality because of the small numbers, lack of data and the short follow-up period.

De Boer *et al.*[63] report on a randomised controlled trial of an occupational health intervention for those at risk of taking early retirement on health grounds. There were 116 participants, who were randomly assigned either to an occupational health intervention or to care as usual. The intervention involved at least three consultations with specially trained occupational physicians, the development of an action plan for each participant and consultation with supervisors. Outcome measures used the WAI, the Utrechtse Burnout Scale (UBOS), the Nottingham Health Profile (NHP) and sick leave. Measurements were made at baseline, six months and two years. The results showed that the commonest reasons for not being able to continue working until normal retirement age were work related (87 per cent) rather than health related (10 per cent) or for social reasons (3 per cent). The main problems identified with working were work demands or work stress (57 per cent), conflicts with supervisors (11 per cent), too little or dull work (8 per cent) and musculoskeletal complaints (6 per cent). For the intervention group, the physicians contacted supervisors and/or personnel managers in 72 per cent of cases. In 52 per cent of cases, this involved contacting personnel to request a change in work conditions.

The comparison between the intervention and control groups identified a significant reduction in early retirement in the intervention group ($p = 0.04$). No significant differences were found between the intervention group and control group at baseline for the WAI, UBOS or NHP. At six months, the intervention group scored significantly higher for work ability ($p < 0.001$), exhaustion ($p < 0.05$) and mental distance (ie distancing oneself from one's work) ($p < 0.01$) on the UBOS scale and significantly better for energy ($p < 0.01$), emotion ($p < 0.001$) and sleep ($p < 0.05$) on the NHP. At the two-year follow-up, only mental distance on the UBOS scale was significantly better ($p < 0.05$).

The sickness absence analysis showed that before the intervention, there were no differences in sick leave taken. At two years after the intervention, the average number of days taken as sick leave were 107.8 in the control group versus 82.3 in the intervention group, but this was not significantly different.

The work situation of participants at the two-year mark showed that there was a significant difference in the numbers taking early retirement, with six in the intervention group and 13 in the control group ($p = 0.04$).

This paper shows that a planned occupational health intervention can reduce the number of people taking early retirement. It is interesting to note that the majority of participants stated that not being able to continue working was work-related rather than health-related, with work demands being the main reason for this. The study also identifies improvements in work ability, burnout and quality of life at six months, although these are not present at two years. Thus an occupational health intervention involving medical personnel who can discuss work and health issues with supervisors and personnel managers is effective.

Overall, there is a dearth of research with regard to occupational health interventions and older workers. One randomised controlled trial has shown that an occupational intervention can reduce the risk of early retirement in conjunction with co-operation from supervisors and managers. However, further research is clearly needed in this area.

3.8 Workplace interventions for health promotion

For the purposes of this review, health promotion is defined as:

> the process of enabling people to increase control over the determinants of their health thus to improve their health.[64]

With regard to older workers the review identified limited research on health promotion, but three papers, covering one intervention study, are of interest.

With regard to health promotion and older workers, Shephard[65] carried out a review of worksite health promotions and their impact on physical and mental health. For physical health interventions, there is evidence that such promotions can improve oxygen uptake and muscle strength, and reduce body fat, blood pressure and blood cholesterol levels. However, the studies did not always show a long-term positive change. For mental health, worksite fitness breaks were found to increase alertness and improve reaction times but no studies have identified an increase in job satisfaction.[65] Although the author states that wellness programmes have the potential to enhance health in the older worker, there are a number of difficulties. These include ensuring broader participation in the workplace, not only of those who are interested; maintaining participation across all the modules if a modular approach is used; and maintaining compliance with the desired behaviours after the programmes have finished.

Naumanen[54,55] evaluated the opinions of older workers on health promotion in Finland. A qualitative evaluation was carried out in a survey of 93 older workers. The survey showed that individual workers can have an impact on their own health (95 per cent of respondents) through good habits, a balanced lifestyle and good professional and personal relationships. With regard to the workplace, occupational health promotion factors identified as important included:

- health checks (99 per cent)
- counselling and education (92 per cent)
- nursing care (91 per cent)
- health condition tests (94 per cent)
- rehabilitation (94 per cent)
- mental support (95 per cent)
- listening (95 per cent).

From the workplace perspective, factors identified as important included:

- personnel leadership (91 per cent)
- a good atmosphere (100 per cent)
- professional skills (99 per cent)
- being appreciated (100 per cent).

Table 5
Overview of interventions for occupational health (*continued opposite*)

Author and date	Study design, research type and quality	Research question	Study population, setting, country and size
Aday & Kehoe 2008[61]	Cross-sectional (*)	The impact of the senior community service employment programmes on quality of life	113 older workers in two US states
Cirla *et al.* 2005[56]	Cross-sectional (-)	The impact of exercise and ergomotricity on sedentary workers	56 Italian office workers, of whom 19 were aged 50–60
Dale 2004[62]	Case study (*)	Describe the risks and implement risk reduction strategies for MSDs in older academics	Four staff members at a US university. Participants recruited on the basis of having problems at work
Doppler 1998[57]	Case studies (-)	The impact of workplace changes in two case studies on older workers	Not reported
De Boer *et al*. 2004[63]	Randomised controlled trial (**)	Evaluation of an occupational health intervention programme for workers at risk of early retirement on health grounds	Participants recruited from a Dutch electronics manufacturing workforce if they felt they were unable to work until normal retirement age. $N = 61$ in intervention group and $N = 55$ in the control group; at two years after intervention, $N = 42$ in intervention group and $N = 34$ in the control group still employed in some capacity
Knauth *et al*. 2005[58]	Case studies (-)	How to improve the work ability of older workers	EU RESPECT project. Development of laboratory and field pilots of new work models, including corporate culture, leadership, professional competence, health, work organisation, shift organisation and breaks
Ward *et al.* 2002[60]	Five qualitative studies (-)	How to recognise, value and use job competence in older workers	27 SMEs in Finland
Walker & Taylor 1998[59]	Case studies (-)	How to combat age barriers in employment and practise age management, including ergonomic and organisational interventions	Seven case studies from different companies

Table 5
continued

Description of interventions	Outcome variables	Outcomes
Three SESEP programmes on disadvantaged older workers	Questionnaire survey of social support, self-esteem, life satisfaction, job satisfaction and older worker empowerment. Data summarised and correlations made	Increased sense of satisfaction with life and work. Improved mental health and social networks
Ergomotricity – selected muscular movements as exercises. Initial training course of three hours including anatomy, physiology, postural arrangement and practical exercising. Some exercises to be carried out at work (four times a day) and some at home (twice a day)	Measured musculoskeletal symptoms before and after intervention – not stated how. Intervention was assessed at three months with 21 participants reporting an improvement. No age distinction made in the paper	Study reports an improvement in one third of participants but provides no data to back this up
Data collected using interviews and observation with each participant. Workplace changes implemented at individual level and informal review of interventions made	Unclear	Reduction in reported MSD complaints within a week – no further follow-up
Narrative reporting	Unclear	Maintenance of workforce
Six-month intervention programme including three consultations with an occupational physician and referral to other specialists if necessary. At initial consultation, assessment made and action plan developed from identified reasons for not being able to continue working	Work Ability Index, Utrechtse Burnout Scale, Nottingham Health Profile, retirement age and sick leave data. Measurements were made at 6, 12 and 24 months after intervention	At baseline the intervention group had significantly less emotional wellbeing and more social isolation than the control group. At the six-month follow-up the intervention group had significantly better work ability, less burnout and a better quality of life. At the two-year follow-up, only one significant difference was found: less emotional distance on the burnout scale for the intervention group. Significantly less sick leave was seen at six months and two years in the intervention group. Significantly less early retirement in the intervention group
Training management on age, developing healthy teams, manual handling, age-related workplace design and improvement, forward rotating shift systems, flexible working hours, more micropauses and more breaks throughout the day	Various measures not clearly presented	Improvements in measures but no quantitative data
Questionnaires and interviews with managers and employees. Development of case studies using a range of learning interventions. The main thrust was towards 'non-traditional' learners, with older workers as a subset	Unclear	The survey itself was seen as the intervention and resulted in increased awareness of the learning needs of older workers
Narrative description	No data reported	Improvements in design, reduced sickness absence

Table 6
Interventions for health promotion (*continued opposite*)

Author and date	Study design, research type and quality	Research question	Study population, setting, country and size
Karazman *et al.* 1999[67]	Before and after (**)	The impact of a health promotion intervention on urban transport drivers	122 urban transport drivers in Germany
Karazman *et al.* 2000[66]	Before and after (**)	The impact of a health promotion intervention on urban transport drivers	122 urban transport drivers in Germany

Although this study was small, it highlights the issues that older workers have identified as important, namely positive attitudes and the support of others in the workplace, including from the occupational health provider.

One intervention study was identified and is summarised in Table 6. The two studies by Karazman *et al.*[66,67] of urban transport drivers in Germany were carried out over a period of one year. The study of 122 drivers evaluated the impact of participation in 20 health days. The health days included physical training, stress management, self-experience groups, social skills training and advice on diet. All participants had taken part in a minimum of 18 sessions. The measures used were the Work Ability Index and a measure of Effect Typology. Effect Typology is a questionnaire tool that aims to examine the impact of health promotion interventions on how individuals find work in terms of interest and challenge, finding meaning and taking responsibility. The Effect Typology questionnaire identifies whether participants are in recovery (able to regenerate and recover psychological and health resources when away from work), relaxation (relief from stress by increasing resources and psychosocial skills through interventions) and evolution (generation of improved health potentials through development of meaningful work, improved decision making, taking responsibility and improving one's own health). The results identified no significant differences in WAI scores before and after the study. However, further analysis showed that when the WAI scores were analysed in relation to the effect typology scores, a large number of participants moved into the category of 'high evolution' and 'evolution'. This suggests that, through the health promotion programme, individuals moved into evolution. This is described as where health potentials are induced, improvements in work relationships, decision making and an understanding of how the individual can help themselves. When the results for the WAI were analysed within the effect typology groups, the WAI scores for the participants in the evolution group were significantly higher ($p < 0.0001$) and thoughts about early retirement were significantly reduced ($p < 0.0001$). The paper suggests that health promotion programmes are vital in maintaining older people at work.

In summary, there is limited research on the impact of health promotion in maintaining older people in the workplace. A number of factors have been identified as important, including:

- ensuring participation by older workers in health promotion programmes
- the involvement of occupational health in this process
- having positive working environments and good relationships with colleagues and supervisors
- maintaining individual health and skills.

3.9 Do safety initiatives affect health or *vice versa*?

From the research currently available, there are no data to support or refute the impact of safety initiatives on health or *vice versa*.

3.10 Is the research reviewed relevant to the UK situation?

The research reviewed in this document was from a variety of European and American sources. Although different methods are used in data collection and healthcare structures in these regions, these have been highlighted within the text. The authors feel that the research included in the review is relevant to the UK.

Table 6
continued

Description of interventions	Outcome variables	Outcomes
The drivers took part in 20 health days over one year, including physical exercise, physical skills training, diet counselling and group self-experience	Work Ability Index and Effect Typology	No significant changes in Work Ability Index. When results were broken down into Effect Typology, the Work Ability Index score increased in those individuals in the 'high evolution' and 'evolution' groups – those that were inducing health potentials
The drivers took part in 20 health days over one year, including physical exercise, physical skills training, diet counselling and group self-experience	Work Ability Index and Effect Typology	No significant changes in Work Ability Index. When results were broken down into Effect Typology, the Work Ability Index score increased in those individuals in the 'high evolution' and 'evolution' groups – those that were inducing health potentials

3.11 Data gaps from the review

A number of data gaps have been identified in the review:

- a lack of longitudinal research, resulting in the use of cross-sectional methodologies which do not give an accurate description of age-related change
- a lack of good quality intervention studies to inform good practice in managing older workers
- no further analysis on the reasons for fatal injuries, despite a higher rate of such injuries among older workers
- a lack of further research on rehabilitation after serious injuries and the need for longer recovery times
- no further research on the reasons behind the high incidence of fall injuries where analysis of this would be vital to prevention
- no explanation of the high levels of reporting of musculoskeletal injuries and mental health problems in the UK workforce or of how these can be reduced
- no exploration of what factors in health promotion are going to be effective in ensuring attendance of older workers, maintenance of behaviours after intervention, methods of education and impact
- a need for occupationally relevant objective measurement to identify capacity for physical and mental work.

4 Guidance from available evidence

4.1 Introduction

In the UK, as in most other comparable countries, the population structure is changing and in particular it is ageing. For the first time, in 2007 there were more people aged over 65 than under 16. The working population (16–64 years) is also changing, with the proportion of the total population in employment due to decrease from 65 per cent now to 60 per cent by 2032. Within the current working population, the employment rate of those aged between 50 and 64 years reduces with age, such that only 50 per cent are still working one year before state retirement age. Among those who are no longer working, large numbers are receiving benefits or have retired involuntarily. Retaining the over-50s at work is becoming increasingly important. The guidance below is based on current available evidence for maintaining the health and wellbeing of the over-50s in the workplace.

4.2 Physical change with age

Available research shows that there are physical and mental changes associated with ageing, including a reduction in aerobic capacity and oxygen uptake, an increase in BMI (caused by both an increase in weight and a loss of stature) and a reduction in muscle strength (in some studies). Although there is a reduction in certain physical capacities, this does not necessarily have an effect in the workplace. Some maintenance of aerobic and muscular capacity is possible but no individual, regardless of age, can work to 100 per cent of capacity all the time.

4.2.1 Physical capacity

For physically demanding jobs, maintenance of fitness levels is essential. However, for all workers, job demands must meet the aerobic and muscular capacity of the individual. Where it has been identified that individuals are no longer able to carry out the demands of the job, it is important to establish whether this is because the job itself is too demanding and requires redesign or whether it is down to the abilities of the individual. Thus objective assessment of job requirements is necessary in order to tell whether the job demands are too great.

Consideration of the whole workforce is important, as jobs cannot be designed for only the strongest and fittest within it; ergonomic designs need to be developed that allow the majority to continue working. Changes which may alleviate some of the work demands include:

- examining the work–rest schedule to ensure recovery time between tasks is adequate
- ensuring that a risk assessment has been carried out for any handling tasks with a risk of injury and that risk reduction measures have been taken
- ensuring that there is a good reporting route for individuals who have identified problems.

4.2.2 Shift work

Working time has also been identified as a possible risk factor for older workers. Working long hours (over 60 per week) in physically demanding environments has been found to increase the risk of adverse outcomes in older workers. Furthermore, there is currently limited evidence to show that night work may affect women at an earlier age than men. It is recommended that if shift work is necessary, shifts are designed using good ergonomic criteria, as well as the following recommendations from Costa & Sartori:[34]

- consider possible limitation or cessation of night work for workers aged over 45–50
- give older workers priority to transfer to day work
- where possible give older workers a choice of preferred shift
- reduce workload
- shorten working hours and/or increase rest periods
- arrange more frequent health checks
- give proper counselling and training on coping strategies concerning sleep, diet, stress management and exercise.

As there are large differences in how well individuals cope with shift work, proper support and health surveillance are vital in maintaining all shift workers at work.

4.2.3 Heat tolerance

Although heat tolerance is not directly related to age, individual health and fitness affect continued heat tolerance in older workers. Regular health assessments are therefore recommended for people

carrying out hot work to check that their fitness is being maintained and their health status has not changed.

4.2.4 Working environment

Although hearing and vision change with age, the effects of these changes can be minimised by risk management. For example, with regard to noise exposure, noise reduction measures, including using hearing protection throughout one's working life, can reduce the likelihood of serious hearing loss. Again, problems associated with age-related change in vision can be corrected with improvements in lighting and visual screening, as well as the use of glasses or contact lenses. These measures are required in any case in the UK by the Health and Safety (Display Screen Equipment) Regulations 1992 for work tasks involving computers and similar equipment.

4.2.5 High-risk industries

In certain high-risk industries it may be necessary to consider more frequent health assessment of staff to ensure that they are able to continue to do their work safely. However, these assessments must be objective and relevant to the work involved. For example, strength measurements should be made in the context of the power and specific muscle groups needed to perform the task in question safely.

4.3 Psychological and psychosocial factors

The research literature shows that ageing tends to cause several changes in this area, including a slowing of reaction times but an increase in knowledge and accuracy. Much of the research in this area is based on laboratory measures, which can often be difficult to translate into the working environment. There is no evidence to support the suggestion that mental impairment is a problem for workers aged over 50; rather, most people show no mental impairment before the age of 65 and one study demonstrated that 95 per cent of those aged over 65 showed no impairment in intellectual functioning. Although changes do occur, they are offset by the greater knowledge base and greater levels of experience that older workers typically have.

There is also evidence to support the 'use it or lose it' hypothesis, which suggests that long-term maintenance of health involves not only consideration of diet and physical activity but also mental activity. Thus, continued training and intellectual stimulation is important for all workers. Despite the many myths associated with people's ability to learn as they get older, maintenance and updating of skills is equally important for older workers. However, the style of training may need consideration, as older workers tend to prefer on-the-job training, one-to-one training and practical training using older workers as mentors.

There is currently very little research available regarding older workers and mental wellbeing. There is limited evidence that lack of social support is linked to emotional exhaustion and that coping strategies for stress in high-risk environments need further development. However, the lack of research does not mean that there are no problems for this particular group; rather, any measures or interventions made in the workplace with regard to mental wellbeing for workers in general should include workers over 50 as well.

4.4 Safety

Although younger workers are more at risk of accidents, accident reporting data show that older workers are more at risk of fatal injury and take longer to recover from non-fatal injuries. Employer engagement is also vital in ensuring a successful return to work for older workers after an injury. The types of accident more commonly suffered by older workers include sprains, strains, fractures and dislocations caused by overexertion, followed by falls on the same level resulting in fractures or dislocations.

No intervention studies are currently available in relation to accident prevention in older workers. However, it is clear that accident prevention in this age group and accident analysis are essential tools in reducing accidents. However, risk reduction measures, including strategies or training, must be made accessible to the whole working population.

4.5 Occupational health interventions

Ill health is not an inevitable outcome of the ageing process. Although there is an increased likelihood of developing disease with age, this is not a reason to exclude individuals from the workplace without objective cause. The onset of cardiovascular disease or diabetes can be treated and controlled; relevant workplace adjustments can be made; and health assessments can be carried out more often if appropriate or required for specific work tasks, such as driving.

Examination of data on ill health suggests that medically certified leave is more commonly associated with older workers, whereas uncertified leave is more commonly associated with younger workers. In addition, self-reported illness data show that the highest prevalence rates for MSDs occur in people aged over 55 in the UK population. This may be associated with cumulative exposure over time for this age group, rather than the direct effects of age. Self-reported illness data also show that reporting of stress, anxiety and depression is higher in the 45–54 age group than in the rest of the population. Again, it is unclear whether this is an effect of age or due to cumulative exposure over time. However, the data do suggest that workplace intervention action should be prioritised for the over-50s.

There is evidence for the positive impact of occupational health interventions in the workplace in maintaining the health of older workers, but it is limited by the lack of good quality research in this area. However, one good quality study identified that the risk of early retirement could be reduced by using a planned occupational health intervention involving occupational physicians. The intervention involved three consultations, the development of an action plan for each employee and, where difficulties were identified for the worker, allowing contact, discussion and job change through health professionals, human resources and line managers. The study identified a significant reduction in the number of people taking early retirement as well as a statistically non-significant reduction in sickness absence.

Currently there is no further evidence to show the positive impact of occupational health interventions in older workers. However, the importance of the role of occupational health in general in improving and maintaining health at work must not be overlooked. One study in Finland showed that health checks, health condition tests, rehabilitation, mental support and healthcare were regarded as important by over 90 per cent of older workers.

4.6 Health promotion opportunities

Health promotion initiatives in relation to ageing workers were limited in number in the available research. As mentioned above, occupational health is seen as an important factor by older workers. However, this study also showed that personnel leadership, professional skills, being appreciated and having a good atmosphere at work are also important.

With regard to health promotion, in this case defined as 'the process of enabling people to increase control over the determinants of their health thus to improve their health',[64] there is limited research available. One study evaluated the impact of attending 20 health days during work time over the period of a year. The results of the study were unclear in that work ability was not significantly improved overall. However, where individuals had improved working relationships, decision making and self-help, their work ability scores significantly increased. Further reviews of health promotion have also identified the importance of increasing physical activity to reduce health risks and increase aerobic and muscular capacity, as well as improvements in mental health from worksite fitness breaks.

There is therefore the potential to improve and maintain health in older workers but a number of difficulties have been identified. These include:

- ensuring that participation in health promotion activities is encouraged for workers of all ages, and is not seen as applying only to younger workers
- surveying older employees to find out whether age-specific groups for some kinds of intervention would be more beneficial and encourage attendance
- in a multicomponent intervention, trying to maintain attendance at all components, not just specific areas
- as with other health promotion activities, allowing time during the working day for attendance.

Although there is a lack of interventional evidence available, making positive changes in health behaviours will have an impact at any age and, for older workers, also have a positive effect into retirement.

4.7 Conclusion

Although there is a lack of high quality research on health, safety and health promotion for older workers, any interventions or changes made are likely to have a positive impact on all workers, not just those aged over 50.

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Appendix: References excluded from the review

Paper	Reason for exclusion
Anon. Ageing worker. *The Medical Press* 1951; 226: 469–470	Outside dates for review
Annis J F, Case H W, Clauser C E and Bradtmiller B. Anthropometry of an aging work force. *Experimental Aging Research* 1991; 17: 157–176	Data but no intervention
Armstrong-Stassen M. Reactions of older employees to organizational downsizing: the role of gender, job level, and time. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences* 01 July 2001; 56 (4): 234–243	No intervention and no further data given
Bangali L. *Are older workers genuine assets for the economy? Strategies and possibilities for the effective use of their human resource potential* (working paper). Tübingen: Eberhard-Karls-Universität, 2004	Policy and position paper – no intervention or data
Bellusci S M and Fischer F M. Aging and work conditions in forensic workers. *Revista de Saúde Pública* 1999; 33: 602–609	No intervention
Bennington L and Tharenou P. Older workers: myths, evidence and implications for Australian managers. *Asia Pacific Journal of Human Resources* 1996; 34: 63–76	No intervention – review
Bowling A. Enhancing later life: how older people perceive active ageing. *Aging and Mental Health* 2008; 12: 293–301	No intervention but references reviewed
Brooke L and Taylor P. Older workers and employment: managing age relations. *Ageing and Society* 2005; 25 (3): 415–429	Position and advice paper – no data
Campanelli L. The aging workforce: implications for organizations. *Occupational Medicine* Oct–Dec 1990; 5 (4): 817–826	No intervention but references reviewed
Chaffin D B and Ashton-Miller J A. Biomechanical aspects of low-back pain in the older worker. *Experimental Aging Research* 1991; 17: 177–187	No intervention but references reviewed
Chan G, Tan V and Koh D. Ageing and fitness to work. *Occupational Medicine (Oxford, England)* 2000; 50: 483–491	No intervention but references reviewed
Chan G C and Koh D S. The ageing worker. *Annals of the Academy of Medicine, Singapore* 1997; 26: 781–786	No intervention but references reviewed
Chaparro A, Bohan M, Fernandez J, Kattel B and Choi S D. Is the trackball a better input device for the older computer user? *Journal of Occupational Rehabilitation* 1999; 9: 33–43	Experimental laboratory-based study but no intervention
Charness N. Ergonomics and ageing: the role of interactions. In: Graafmans J, Taipale V and Charness N. *Gerontechnology: a sustainable investment in the future*. Amsterdam: IOS Press, 1998	No intervention or descriptions of technology and not work-related

Paper	Reason for exclusion
Charness N. Work, older workers and technology. *Generations* 2006; 30: 25–30	No intervention but references reviewed
Charness N, Czaja S and Sharit J. *Age and technology for work*. Mahwah, New Jersey: Lawrence Erlbaum Associates, 2007	No intervention but guidance suggested with no evidence – references reviewed
Choo T E. The aging workforce: some implications, strategies and policy considerations for human resource managers. *Asia Pacific Journal of Human Resources* 1999; 37: 60–75	Position paper; no intervention but references reviewed
Costa G. Aging and shift work: a complex problem to face. *Chronobiology International* 2008; 25 (2): 165–181	Position paper – references reviewed
Costa G (ed.). Some considerations about aging, shift work and work ability. *International Congress Series* 2005; 1280: 67–72	No intervention but references reviewed
Desmette D and Gaillard M. When a 'worker' becomes an 'older worker': the effects of age-related social identity on attitudes towards retirement and work. *Career Development International* 2008; 13 (2): 168–185	Cross-sectional study but does not inform review
De Zwart B C H and Meijman T F. The aging shiftworker: adjustment or selection? A review of the combined effects of aging and shiftwork. In: Taylor and Francis (ed.). *Work and aging*. London: Taylor and Francis, 1996	No intervention but references reviewed
Diggle S B. Work and aging: a European perspective – book review. *Occupational and Environmental Medicine*, 1995; 52: 495.	Book review – no intervention studies reported
Doeringer P, Sum A and Terkla D. Devolution of employment and training policy: the case of older workers. *Journal of Aging and Social Policy* 2002; 14 (3–4): 37–60	No interventions or data – references reviewed
Fletcher W L, Hansson R O and Bailey L. Assessing occupational self-efficacy among middle-aged and older adults. *Journal of Applied Gerontology* 1992; 11: 489–501	No intervention but references reviewed
Ford R and Orel N. Older adult learners in the workforce: new dimensions to workforce training needs. *Journal of Career Development* 1 Dec 2005; 32 (2): 139–152	Position and guidance paper but no evidence
Francis M, Good G, Johnson J, Lathrop J, Ryan L, Propst S, Shaw M, Moyers P and Beebe R. The effects of a typing task on the hand volume of the older worker. *Work* 2004; 22: 111–115	Experimental laboratory-based study but no intervention
Freeman J H. *Evaluating the effects of age on the variability in lifting technique*. Master's thesis, North Carolina State University, 2005	No intervention but references reviewed
Frohner K D. Work situation evaluation as a prerequisite for productive aging of engineers and innovators. In: Kumashiro M (ed.). *Aging and work*. London: Taylor and Francis, 2002	No intervention but references reviewed

Paper	Reason for exclusion
Furunes T and Mykletun R J. Age management in Norwegian hospitality businesses. *Scandinavian Journal of Hospitality and Tourism* 2005; 5: 116–134	No intervention but references reviewed
Gander P and Signal L. Who is too old for shift work? Developing better criteria. *Chronobiology International* 2008; 25: 199–213	No intervention but references reviewed
Ghosheh N, Lee S and McCann D. *Conditions of work and employment for older workers in industrialized countries: understanding the issues*. Conditions of Work and Employment Series No. 15. Geneva: International Labour Office, 2006	No intervention but references reviewed
Griffiths A. Work design and management – the older worker. *Experimental Aging Research* 1999; 25: 411–420	No intervention but references reviewed
Griffiths A. Ageing, health and productivity: a challenge for the new millennium. *Work and Stress* 1997; 11: 197–214	No intervention but references reviewed
Griffiths A. Healthy work for older workers: work design and management factors. In: Loretto W, Vickerstaff S and White P. *The future for older workers: new perspectives*. Bristol: Policy Press, 2007	No intervention, book chapter and references reviewed
Hadler N M. The bane of the aging worker. *Spine* 2001; 26: 1309–1312	No intervention but references reviewed
Haigh R. *The contribution of ergonomics to the design of technology for older people*. Amsterdam: IOS Press, 1992	Position paper; no intervention but references reviewed
Haigh R, Haslegrave C M, House S and Street F. The older worker in industry. In: *Contemporary ergonomics: Proceedings of the Ergonomics Society's Annual Conference*. London: Taylor and Francis, 1992	Position paper; no intervention but references reviewed
Haight J M and Miles T P. Experience offsets and accommodations for an aging workforce. In: Miles T P and Furino A (eds). *Annual review of gerontology and geriatrics: aging health care workforce issues*. New York: Springer Publishing Company, 2006	No intervention but references reviewed
Hansson R O, Robson S M and Limas M J. Stress and coping among older workers. *Work* 2001; 17: 247–256	No intervention but references reviewed
Hansson R O, Dekoekkoek P D, Neece W M and Patterson D W. Successful aging at work. Annual review 1992–1996: the older worker and transitions to retirement. *Journal of Vocational Behavior* 1997; 51 (2): 202–233	Selective review; no intervention but references reviewed
Hansson R O, Killian J H and Lynch B C. The older worker. In: Sanders M J (ed.). *Ergonomics and the management of musculoskeletal disorders*. St Louis, Missouri: Butterworth Heinemann, 2004	Book chapter: gives guidance but no evidence of effectiveness
Hartley D, Biddle E, Grosch J and Marsh S. The burden of occupational fatal injury for older workers in the United States. *Injury Insights* Jun–Jul 2002; special issue: *Our aging population*	No intervention or data but references reviewed

Paper	Reason for exclusion
Hartley D and Biddle E A. Will risks to older workers change in the 21st century? *Human and Ecological Risk Assessment* 2001; 7: 1885–1894	No intervention but references reviewed
Health and Safety Commission and Executive. *An ageing agricultural industry*. Agriculture Industry Advisory Committee paper 080701. London: Health and Safety Commission, 2001	No intervention but references reviewed
Healy M L. Management strategies for an aging work force. *Official Journal of the American Association of Occupational Health Nurses* 2001; 49: 523–531	Position paper; no intervention but references reviewed
Hilsen A I and Ennals R. An action research approach to work ability, health and well-being of ageing workers. *International Congress Series* 2005; 1280: 365–370	Description of intervention but no follow-up
Huppert F. Designing for older users. In: Clarkson J, Coleman R, Keates S and Lebbon C. *Inclusive design: design for the whole population*. London: Springer, 2003	No intervention but references reviewed
Hwalek M, Essenmacher V and Kosniewski K. *Older workers in direct care: a labor force expansion study*. Detroit, Michigan: SPEC Associates, 2005	No intervention but references reviewed
Hwalek M, Straub V and Kosniewski K. Older workers: an opportunity to expand the long-term care/direct care labor force. *The Gerontologist* 2008; 48: 90–103	No intervention but references reviewed
Iellatchitch A. *New careers: towards a new image of an ageing work force?* Vienna: Wirtschaftsuniversität Wien, 2001 (unpublished working paper)	Position paper; no intervention but references reviewed
Ilmarinen J. The ageing workforce – challenges for occupational health. *Occupational Medicine* 2006; 56 (6): 362–364	Editorial – no intervention
Ilmarinen J. Physical requirements associated with the work of aging workers in the European Union. *Experimental Aging Research* 2002; 28: 7–23	No intervention but references reviewed
Ilmarinen J, Tuomi K and Seitsamo J. New dimensions of work ability. *International Congress Series* 2005; 1280: 3–7	No intervention but references reviewed
Ilmarinen J E. Aging workers. *Occupational and Environmental Medicine* 2001; 58 (8): 546–552	No intervention but references reviewed
Ilmarinen J and Rantanen J. Promotion of work ability during ageing. *American Journal of Industrial Medicine* 1999; 36 (s1): 21–23	Description paper; no intervention or data
Ilmarinen J. Aging, work and health. In: Snel J and Cremer R. *Work and aging: a European perspective*. London: Taylor and Francis, 1994	Book chapter on demographic change and Work Ability Index – references reviewed
Janicak C A. Occupational fatalities to workers age 65 and older involving tractors in the crops production agriculture industry. *Journal of Safety Research* 2000; 31 (3): 143–148	No intervention but references reviewed

Paper	Reason for exclusion
Jiang Z, Shu Y, Drum J, Reid S and Mirka G A. Effects of age on muscle activity and upper body kinematics during a repetitive forearm supination task. *International Journal of Industrial Ergonomics* 2006; 36: 951–957	No intervention; small laboratory-based study, not relevant
Kemmlert K and Lundholm L. Slips, trips and falls in different work groups – with reference to age and from a preventive perspective. *Applied Ergonomics* 2001; 32: 149–153	No intervention but references reviewed
Kiss P and De Meester M. Need for recovery in ageing workers. *International Congress Series* 2005; 1280: 202–207	No intervention but references reviewed
Kiss P, Walgraeve M, Vanhoorne M. Assessment of work ability in aging fire fighters by means of the Work Ability Index. Preliminary results. *Archives of Public Health* 2002; 60: 233–243	No intervention but references reviewed
Koopman-Boyden P G and MacDonald L. Ageing, work performance and managing ageing academics. *Journal of Higher Education Policy and Management* 2003; 25 (1): 29–40	Review paper but no interventions or evidence – references reviewed
Koh G C and Koh D. Occupational health for an ageing workforce: do we need a geriatric perspective? *Journal of Occupational Medicine and Toxicology (London)* 2006; 1: 8	Position paper; no intervention but references reviewed
Kovner C T and Brewer C S. Work attitudes of older RNs. *Policy, Politics and Nursing Practice* 2007; 8: 107–119	No intervention and data limited
Kowalski-Trakofler K M, Steiner L J and Schwerha D J. Safety considerations for the aging workforce. *Safety Science* 2005; 43: 779–793	Position paper; no intervention but references reviewed
Kumar R and Kumar S. Musculoskeletal risk factors in cleaning occupations – a literature review. *International Journal of Industrial Ergonomics* 2008; 38 (2): 158–170	A review of risk factors in cleaners – no age data
Kumashiro M. Ergonomics strategies and actions for achieving productive use of an ageing work-force. *Ergonomics* 2000; 43: 1007–1018	Position paper; no intervention but references reviewed
Lahti S and Moilanen R (eds). *Sharing of the tacit knowledge – a challenge of managing young and aging employees*. Paper presented at the 19th Workshop on Strategic Human Resource Management, HEC-Paris, 22–23 April 2004	No intervention but references reviewed
Leaviss J, Gibb A and Bust P. *Understanding the older worker in construction*. Reading: SPARC, 2007	No intervention but references reviewed
Letvak S. Health and safety of older nurses. *Nursing Outlook* 2005; 53: 66–72	No intervention but references reviewed
Lusa S, Saarinen K and Louhevaara V. Method to evaluate the quality of work place health promotion in security organisations. *International Congress Series* 2005; 1280: 382–385	Methodology paper; no intervention but references reviewed

Paper	Reason for exclusion
Mackey M, Maher C G, Wong T and Collins K. Study protocol: the effects of work-site exercise on the physical fitness and work-ability of older workers. *BMC Musculoskeletal Disorders* 2007; 8: 9	Methodology paper – no further publications yet on intervention
Mangino M. The aging employee. Impact on occupational health. *Official Journal of the American Association of Occupational Health Nurses* 2000; 48: 349–359	Position paper; no intervention but references reviewed
Marquié J C, Jansou P, Baracat B, Martinaud C, Gonon O, Niezborala M, Ruidavets J B, Fonds H and Esquirol Y. Aging, health, work: overview and methodology of the VISAT prospective study. *Le Travail Humain* 2002; 3: 243–260	Methodology paper; no intervention but references reviewed
Marshall N L. Health and illness issues facing an aging workforce in the new millennium. *Sociological Spectrum* 2001; 21 (3): 431–439	Review paper; no intervention but references reviewed
Marshall V. *Canadian research on older workers*. Chapel Hill, North Carolina: University of North Carolina, 2001.	Review of Canadian research – no interventions or data
Merletti R, Pozzo M and Zennaro D. Neuromuscular assessment of the elderly worker: the European NEW project. *Giornale Italiano di Medicina del Lavoro ed Ergonomia* 2005; 27: 88–95	No intervention but references reviewed
Mital A. The need to accommodate older workers in the workplace. *Journal of Occupational Rehabilitation* 1999; 9: 1–2	Position paper; no intervention but references reviewed
Morrow L A, Needleman H, Kirisci L and Sandstrom D. *Occupational lead exposure: risk to the aging worker* (OH03891-03). Alexandria, Virginia: US Department of Commerce, 2004	Study of the impact of lead exposure in later years, suggesting vulnerability of older workers with high past lead exposures – references reviewed
Moyers P A. Adaptation of the older worker to occupational challenges. *Work* 2004; 22: 71–78	No intervention but references reviewed
Munzberger E. The securing of adequate working possibilities for the older worker as a specific work-hygienic task. *Zeitschrift für die gesamte innere Medizin und ihre Grenzgebiete* 1976; 31: 127–130	No intervention but references reviewed
Naumanen P. The health promotion of aging workers from the perspective of occupational health professionals. *Public Health Nursing* 2006; 23 (1): 37–45	No intervention but references reviewed
Nygård C H, Luopajarvit T and Ilmarinen J. Musculoskeletal capacity and its changes among aging municipal employees in different work categories. *Scandinavian Journal of Work, Environment and Health* 1991; 17: 110–117	Longitudinal study but followed up for longer by the Savinainen papers[10–12]
Ogińska H, Pokorski J and Ogiński A. Gender, ageing, and shiftwork intolerance. *Ergonomics* 1993; 36: 161–168	No intervention but references reviewed
Peek-Asa C, McArthur D L and Kraus J F. Incidence of acute low-back injury among older workers in a cohort of material handlers. *Journal of Occupational and Environmental Hygiene* 2004; 1: 551–557	No intervention but references reviewed – data possibly useful for evaluation of impact of ageing

Paper	Reason for exclusion
Peeters M C W and van Emmerik H. An introduction to the work and well-being of older workers: from managing threats to creating opportunities. *Journal of Managerial Psychology* 2008; 23 (4): 353–363	Introduction to a special journal issue
Piekkola H. *Active ageing and the European labour market. Synthesis report*. Helsinki: Elinkeinoelämän Tutkimuslaitos, 2004	Position paper; no intervention but references reviewed
Pohjonen T. Age-related physical fitness and the predictive values of fitness tests for work ability in home care work. *Journal of Occupational and Environmental Medicine* 2001; 43 (8): 723–730	Assessment of fitness tests but no intervention
Punakallio A, Hirvonen M and Grönqvist R. Slip and fall risk among firefighters in relation to balance, muscular capacities and age. *Safety Science* 2005; 43: 455–468	No intervention but references reviewed
Richardson B. Promoting healthy work activities in an ageing population – are you involved? *Advances in Physiotherapy* 2001; 3: 137–139	No intervention but references reviewed
Rix S E. The ageing workforce: will we ever be ready for it? *Gerontologist* 2006; 46 (3): 404–409	Book review
Roper K O and Yeh D C. Ergonomic solutions for an aging workforce. *Journal of Facilities Management* 2007; 5: 172–178	Position paper; no intervention but references reviewed
Samorodov A. *Ageing and labour markets for older workers*. Geneva: Employment and Training Department, International Labour Office, 1999	Summary of conference with advice – no further data
Savinainen M, Nygård C H, Korhonen O and Ilmarinen J. Changes in physical capacity among middle-aged municipal employees over 16 years. *Experimental Aging Research* 2004; 30: 1–22	No intervention but references reviewed – data possibly useful for evaluation of impact of ageing
Schwerha D J and McMullin D L. Prioritizing ergonomic research in aging for the 21st century American workforce. *Experimental Aging Research* 2002; 28: 99–110	Position paper; no intervention but references reviewed
Schwoerer C E and May D R. Age and work outcomes: the moderating effects of self-efficacy and tool design effectiveness. *Journal of Organizational Behavior* 1996; 17: 469–487	No intervention but references reviewed
Sharit J and Czaja S J. Ageing, computer-based task performance, and stress: issues and challenges. *Ergonomics* 1994; 37: 559–577	No intervention but references reviewed
Shephard R J. Human rights and the older worker: changes in work capacity with age. *Medicine and Science in Sports and Exercise* 1987; 19 (2): 168–173	No intervention but references reviewed
Shephard R J. Review essay. A personal perspective on aging and productivity, with particular reference to physically demanding work. *Ergonomics* 1995; 38 (4): 617–636	No intervention or new data – references reviewed

Paper	Reason for exclusion
Sluiter J, de Croon E, Meijman T and Frings-Dresen M. Need for recovery from work related fatigue and its role in the development and prediction of subjective health complaints. *Occupational and Environmental Medicine* 2003; 60: i62–i70	No intervention and not age-related but references reviewed
Sluiter J K. What do we know about ageing at work? Evidence-based fitness for duty and health in fire fighters. *Ergonomics* 2007; 50: 1897–1913	Not an intervention and no new data
Smentek D. *Managing an ageing workforce: the impact of an ageing population on the German labour market and how employers can deal with related challenges* (Diploma thesis). Perth and Sydney: Curtin University of Technology, 2006	Position paper; no intervention but references reviewed
Stalnaker C K. Safety of older workers in the 21st century. *Professional Safety* 1998; 43: 28–31	Position paper; no intervention but references reviewed
Streb C K, Voelpel S C and Leibold M. Managing the aging workforce: status quo and implications for advancement of theory and practice. *European Management Journal* 2008; 26: 1–10	Position paper; no intervention but references reviewed
Teiger C. We are all aging workers: for an interdisciplinary approach to aging at work. In: Snel J and Cremer R. *Work and aging: a European perspective*. London: Taylor and Francis, 1994	Position and guidance paper – no evidence of effectiveness of advice
Tepas D I, Duchon J C and Gersten A H. Shiftwork and the older worker. *Experimental Aging Research* 1993; 19: 295–320	No intervention but references reviewed
Torgén M, Nygård C H and Kilbom Å. Physical work load, physical capacity and strain among elderly female aides in home-care service. *European Journal of Applied Physiology* 1995; 71 (5): 444–452	Survey of 20 older workers – no intervention but references reviewed
Vickerstaff S. Managing the older workforce. *Equal Opportunities Review* 2005; 137: 6–10	No intervention but references reviewed
Waddell G and Burton A K. *Is work good for your health and well-being?* London: The Stationery Office, 2006	No intervention but references reviewed
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