A literature review of evidence on physical activity for older people and a review of existing physical activity guidelines for older people

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New Zealand GUIDELINES GROUP
Te Rōpū Rarangi Tohutohu
Promoting Effective Health and Disability Services

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1 Executive summary

Consistent with worldwide trends, the population of New Zealand is ageing. Based on the 2006 Census data, the New Zealand population aged over 65 years at the end of 2006 was 519,940 (12% of the total population) (Ministry of Social Development 2007). It has been estimated that the older adult cohort is projected to increase to 25% of the total population by 2051 (Dunstan et al 2006).

Along with the ageing population come challenges in maintaining health and wellbeing. An important key to healthy ageing is the maintenance of a physically active lifestyle. Physical inactivity has both direct and indirect costs to the health of a population, with evidence showing graded health benefits of physical activity for reducing of a range of non-communicable diseases (US Surgeon General 1996).

The phrase ‘older people’, as used in this report, refers to people over the age of 65 years.

This report examines the evidence since 2004 on the benefits and risks of physical activity, as well as the risks of inactivity. It draws conclusions from the evidence as to what the most effective types of physical activity are for older people and does this from the perspective of both preventing the onset of chronic conditions and also the management of those conditions.

The report addresses the enablers and barriers to participation in physical activity for older people; and examines specific issues (especially with regard to safety) and cultural considerations for New Zealand older people. It also examines the existing evidence from international guidelines and policies on physical activity for older people.

Key messages

The key messages identified below are grouped by area of focus and highlight the main findings of the report. Each chapter of the report outlines the details and evidence supporting each of the key messages.

Benefits associated with physical activity participation for older people

The strongest evidence for the benefits of physical activity for older people in preventing negative health and disability relates to all-cause mortality, cardiovascular mortality, cancer mortality, falls, stroke, heart disease, breast cancer, and colon cancer.

The strongest evidence for the benefits of physical activity for older people in the management of health and disability relates to vascular disease, heart disease, stroke, osteoarthritis, obesity, type 2 diabetes, and depression.

Strong evidence exists for the benefits of physical activity for older people in enhancing physical fitness (including strength and aerobic endurance), quality of life and wellbeing, cognitive function, and physical function.

Risks associated with physical inactivity and sedentary behaviour for older people

Having a less active and more sedentary lifestyle increases the risk of premature mortality relative to leading an active lifestyle.

The lack of moderate to vigorous physical activity and large amounts of time spent sitting (sedentary behaviour) are independent risk factors for negative health outcomes.

Incremental increases in physical activity or decreases in sedentary behaviour are both independently associated with reductions in mortality and morbidity risk.

Effectiveness of various types of physical activity in improving health outcomes for older people

Ample evidence exists that physical activity intervention programmes are effective in preventing disease, injury, and other undesirable health conditions:

- moderate to vigorous intensity aerobic endurance interventions can be effective in preventing osteoporosis, hypertension, type 2 diabetes, disability, and hospitalisation
- resistance training, done at a moderate to high intensity, has effectiveness in preventing osteoporosis and disability
- mobility and balance interventions are effective in preventing falls
- interventions combining mixed types of moderate to vigorous intensity physical activity can be effective in preventing falls, physical disability, osteoporosis, hospitalisation, hypertension, and type 2 diabetes.

Evidence exists that physical activity interventions are effective in the management of health-related conditions in older people:

- moderate to vigorous intensity aerobic endurance interventions are effective in vascular disease, heart disease, stroke, cancer, osteoarthritis, neurological disorders, hip injury, and depression
- resistance training interventions, across a range of intensities, have been shown to be effective in managing vascular disease, stroke, osteoarthritis, frailty, obesity and overweight, hip injury, sleep problems, and depression
- mobility and balance interventions are effective in managing stroke, osteoarthritis, frailty, and sleep problems
- interventions combining mixed types of physical activity, across a range of intensities, have shown effectiveness in managing vascular disease, heart disease, stroke, cancer, osteoarthritis, frailty, obesity and overweight, type 2 diabetes, pulmonary disease, neurological disorders, depression, and sleep problems.

There is evidence that demonstrates that physical activity interventions are effective in enhancing a range of functions in older adults:

- moderate to vigorous intensity aerobic endurance interventions have been shown to enhance cognitive function, physical function and mobility, balance, aerobic capacity, and strength
- resistance training, across a range of intensities, is effective in enhancing cognitive function, physical function and mobility, activities of daily living, balance, aerobic capacity, and strength
- moderate intensity mobility and balance interventions are effective in enhancing cognitive function, physical function and mobility, and balance
- interventions combining mixed types of moderate to high intensity physical activity have shown effectiveness in enhancing physical function and mobility, activities of daily living, balance, aerobic capacity, strength, and quality of life.

Enablers and barriers to physical activity participation in older people

Differences were not generally evident between enablers and barriers to physical activity in New Zealand-specific literature and that from international studies. The New Zealand specific literature identified enablers for physical activity to include guidance/encouragement from health professionals, institutional (including religious) encouragement, and access to community-based programmes, For Māori, it was highlighted that programmes be based on the principles underpinning the Treaty of Waitangi, are culturally appropriate, include facilitators trained on marae, and demonstrate an understanding of tikanga. Identified barriers to physical activity in New Zealand specific literature included health problems and concerns, lack of support and encouragement, and cultural and social norms/expectations.

In looking at the broader international literature, the most frequently cited enablers were positive experiences and outcome expectations, promotion of health and feeling healthy, social support for physical activity, easy access to parks/facilities, and low-cost or no-cost programmes. The most frequently cited barriers were problems with health, functional ability, and fear of falling and sustaining injury.

Safety issues and risks for physical activity participation for older people

While most studies of the role of physical activity in older people have focused on benefits as opposed to harm, it appears there is minimal risk in participating in physical activity for the older adult. Evidence suggests that the adverse events associated with physical activity in older people are generally innocuous.

The risk of adverse events occurring from physical activity, however, does appear to be increase as intensity of physical activity increases.

For those with coronary artery disease, there is an increased risk of cardiac event, and as such, medical advice or supervision should probably be recommended for this sub-population prior to engaging in physical activity. Similarly, the risk of sudden cardiac events is associated with periods of vigorous physical activity, and those at high risk of coronary artery disease should probably seek medical advice or supervision.

The risk of falling does not appear to be increased whilst participating in physical activity.

The risk of sustaining an injury through physical activity can be reduced through incremental increases in the amount of physical activity, the provision of appropriate advice, and through the provision of safe physical activity environments.

Evidence exists that suggests that the benefits of regular physical activity participation outweigh the inherent risk of adverse events.

New Zealand specific issues and cultural considerations

Of older people in New Zealand, those over 80 years are the least active, and women are more likely to be less active than men.

New Zealand developed interventions such as the Green Prescription are effective in increasing the amount of physical activity in community-dwelling older people.

Primary care settings appear to be important in terms of promoting physical activity advice in older people in New Zealand.

Māori are no less active than the overall population, and as such, the focus should be on continuing the uptake of physical activity through the provision of culturally acceptable options.

Some ethnic groups such as Asian groups and Pacific people require specific targeting based on risk factors for physical inactivity or culturally-specific targets to promote physical activity.

Key barriers for older New Zealanders include education, financial constraints, physical/built environment, lack of cultural appropriateness, and medical/physical limitations.

International guidelines and policy documents

Evidence suggests that older people should participate in a minimum of 30 minutes of moderate intensity physical activity on most if not all days of the week. This should be supplemented with strength, balance, and co-ordination activities at least two to three days per week.

Additional moderate and vigorous physical activity is seen to confer additional health benefits.

The duration or physical activity can be accumulated in 10-minute bouts.

Key areas identified as important for the implementation of physical activity recommendations for older people include the development of public health policy, safe community and physical built environments, supportive social environments, public and professional education, inter-agency collaboration and formation of coalitions and partnerships, financial support, evidence based research, evaluation, and monitoring.

Overall conclusion

Given the evidence that forms the basis for the present review of literature on health benefits from physical activity in the prevention and management of disease, and the risks of being physically inactive, it appears that the current burden for health care systems could be eased by developing a more physically active population. Although all people can achieve a variety of benefits from participating in regular physical activity, considerable improvements in population health can occur by focusing health promotion efforts on those sub-populations least likely to achieve sufficient physical activity, such as older people.

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2 Introduction

Purpose

This chapter provides the context for the report in the following areas:

- epidemiological and demographic context
- how older people participate in physical activity
- the Australian national policy response
- the New Zealand national policy response.

The content of each chapter is also described.

Definitions

The operational definitions used in this report are contained in the Glossary. The definitions repeated below for easy reference while reading this chapter.

Older people are people over the age of 65 years. However, not all of the reviewed literature dealt solely with this age group. The average age of people reported on in the reviewed literature is likely to be 65 years or older and the conclusions that are drawn apply to this age group. However, many research articles refer to populations that include younger adults. Where the literature is clear about this, the age range is included in the text. Where it is not clear (especially applies to systematic reviews covering many studies) we note this in the text. Where no age is provided, the population is over the age of 65 years.

A note about **frail** populations: frailty is related to instability and risk of loss of function, a set of linked deteriorations including, but not limited to, the musculoskeletal, cardiovascular, metabolic, and immunologic systems (Faber et al 2006). Within the summary of findings, a statement is made about whether or not the literature separated out this population, and the specific studies are referenced.

Physical activity is categorised as being of either light, moderate, or vigorous intensity, and most health benefits have been associated with moderate to vigorous intensity physical activity (National Advisory Committee on Health and Disability 1998; US Surgeon General 1996). Light intensity physical activity does not cause noticeable increases to breathing, and results in small increases to energy expenditure, while moderate intensity physical activity (eg, brisk walking), and vigorous physical activity (eg, jogging) both create noticeable increases in breathing and energy expenditure (see glossary for further information).

Sedentary indicates getting less than 30 minutes of moderate-intensity physical activity per week, and describes the least active portion of a population.

Epidemiological and demographic context

Many older people in New Zealand do not maintain physically active lifestyles (Gerritsen et al 2008; Mummery et al 2007; SPARC 2008). Recent evidence from the Active New Zealand Survey (SPARC 2008) indicated that nearly a quarter of men and women aged 65 and up were sedentary, accumulating a total less than 30 minutes of moderate intensity physical activity over a seven-day period of study. About one-third of older men and women reported levels of moderate physical activity over the seven-day study period that were sufficient to meet current New Zealand guidelines for physical activity (at least 30 minutes of moderate intensity physical activity on five or more days of the week). The remaining 42% of older men and women in the Active New Zealand Survey accumulated 30 minutes on fewer than five out of seven days, an amount of physical activity less than current New Zealand guidelines (SPARC 2008).

Data from the 2006/2007 New Zealand Health Surveys also indicate that older adults are at increased risk of being sedentary (Gerritsen et al 2008). Among those in the 65 to 74 years age group, 16% of men and 23% of women were categorised as sedentary. In the 75 and up age group, 33% of men and 46% of women were categorised as sedentary. These data show that older women are generally more likely to be sedentary than older men, and that the 75 and up age group is more sedentary than the 65–74 age group. In contrast, 51% of the men in the 65–74 age group reported regular physical activity, compared to 44% of women of the same age. Among the 75 and up age group, 41% of men were regularly physically active, compared to 26% of women. These data show a complementary pattern to that of the sedentary data, in that New Zealand men tend to be more active than their female counterparts, and that the oldest age group is less active than the 65–74 age group.

Other evidence, employing a range of measures of physical activity in a representative population of New Zealand adults 60 years and older (drawn from the Obstacles to Action Survey), has shown that about 18% of this population were classified as sedentary, and about half (49%) reported regularly performing less than 150 minutes of moderate to vigorous physical activity per week (Mummery et al 2007). Within this study, females and those of lower socioeconomic status were less likely to report being regularly active (Mummery et al 2007). Other data have shown that Māori (McLean et al 2009) Asian, and Pacific peoples (Gerritsen et al 2008) may be more likely to be sedentary than Pakeha (New Zealand European) people, but data are conflicting, and often not presented by ethnicity for older adults (Gerritsen et al 2008). Thus, from current prevalence data, it is not certain whether Māori, Asian, and Pacific New Zealander older adults are more or less active than their Pakeha counterparts.

Higher intensity (moderate and vigorous) physical activities tend to decline in older populations, and the prevalence of physical inactivity increases for older people, particularly women (DiPietro 2001; SPARC 2008). For older men and women across demographic categories, walking is the most prevalent physical activity in Europe, Canada, and the United States (DiPietro 2001). This remains true for New Zealand older adults also, as over 73% of those in a nationally representative sample reported participation in recreational walking in the previous year (SPARC 2008). In this New Zealand study's older adults, walking was followed in participation rate by gardening (66%), swimming (15%), equipment-based exercise (14%), bowls (14%), fishing (11%), golf (11%), dance (8%), callisthenics (6%), and cycling (6%) (SPARC 2008).

Mummery and colleagues (Mummery et al 2007) reported other findings from a representative survey of 1894 New Zealand older people (drawn from the Obstacles to Action Survey) in an effort to describe the population physical activity patterns with multiple activity definitions. Results showed that 18% of older New Zealanders reported no physical activity, and a little more than half (51%) reported participating in regular physical activity. Over two-thirds of the sample (68%) reported participating in any amount of walking, and 31% reported some amount of vigorous physical activity. Participation in physical activity varied by demographic factors such as age, income, fruit and vegetable consumption, sex, and other factors. Foremost among the findings were that females were less active overall than males, and that physical activity decreased with increasing category of age group.

How older people participate in physical activity

Physical activity preferences of older people vary considerably, and older people differ from younger generations in how they participate in physical activity (Keogh et al 2009; SPARC 2008). Physical activity can be obtained through a formal regular exercise regime, but can also come from household, leisure, transport, incidental and occupational activities.

Consistent across New Zealand and international studies and demographics is the finding that walking is the most common form of physical activity for older people (Belza et al 2004; DiPietro 2001; Kolt et al 2004; Mummery et al 2007; Semanik et al 2004; SPARC 2008) and walking can be found in the occupational, recreational, leisure-time, and transportation contexts of physical activity, as well as in planned exercise. Housework, and gardening are also frequently reported among older people (SPARC 2008), although some concern exists as to whether sufficient proportions of these physical activities (including walking) are done at the moderate to vigorous intensity level, rather than light intensity (Semanik et al 2004). A wide range of activities have been successfully implemented for groups of older people in various physical activity programmes that have been evaluated in the research literature. Among physical activity programmes, walking, strength training, and flexibility exercises feature prominently, but other programmes have used jogging, cycling, balance exercises, tai chi, yoga, and dance (Cameron et al 2010; van der Bij et al 2002).

Kolt and colleagues (Kolt et al 2004) conducted a cross-sectional survey in Australia and found that reasons for being active were for health, fitness, joint mobility, and general enjoyment of the activity. Some authors have pointed out that older people often embed physical activity within a broader context, such that physical activity may present an opportunity to socialise with children or grandchildren to strengthen family relationships within the household through intergenerational relationship building (Chadha et al 2004). Others authors have indicated how physical activities such as dance might allow older people to maintain a connection to everyday life because it encourages fun and enjoyment, and promotes social interaction, a sense of community, appreciation of aesthetics and continued health, and mobility (Keogh et al 2009). Thus, along with motivations to take advantage of health benefits, it appears to be important for older people to select or maintain physical activities that fit well with their own unique interests and abilities, so that such physical activities become a regular part of the older person’s lifestyle, and that these activities contribute positively to that overall lifestyle.

Conclusions that can be drawn

Two conclusions that can be drawn from the epidemiology and the research into how older people participate in physical activity are that older people are less likely to be sufficiently physically active and more likely to be sedentary, compared to younger age groups (Gerritsen et al 2008; Mummery et al 2007; SPARC 2008; Taylor et al 2004); and older people present a disproportionate burden for health care systems (Dalziel, 2001).

The Australian national policy response

Australian policy makers published national guidelines on physical activity in 2006 (Sims et al 2006). The National Physical Activity Recommendations for Older Australians: Discussion Document was prepared by the National Ageing Research Institute and Australian Government Department of Health and Ageing. What follows is a brief summary of the recommendations.

> *A broad range of physical activity options can improve health outcomes for older people, both in the short and medium-term. Endurance and strength training activities can be used to prevent and treat congestive heart failure, depression, diabetes, osteoporosis and other conditions affecting older people. Progressive resistance training can slow and even reverse age and disease-related loss of muscle mass and function, and activities involving balance can improve stability and reduce risk of falls.*
>
> *In frail older people, even small gains in physical activity performance might have a significant effect on their functional performance and quality of life. Residential care programs must be feasible, acceptable to staff and residents, and be evaluated using relevant outcomes of function and quality of life. In all settings, those providing physical activity programs for older people should have adequate training and understanding of the specific needs and differences in physical activity for older people. Very little research in physical activity for older people has investigated issues of effectiveness, implementation, or adherence in important population sub-groups such as Aboriginal and Torres Strait Islanders, and older people from Culturally and Linguistically Diverse Backgrounds. There is a need to ensure the recommendations and implementation strategies are culturally appropriate.*
>
> *How much physical activity, how often and for how long? The recommendation of 30 minutes of moderate activity on most, if not all days of the week is relevant for older adults. Activity in any form is beneficial for older people. There is not yet sufficient evidence to allow us to advise on the 'best' intensity or duration of physical activity to adopt to accumulate the recommended amount of daily physical activity. That is, we do not know whether it is preferable to do more intense activity for shorter bouts or less intense activity for longer bouts in order to expend our weekly 'dose' of energy. More research is needed to establish optimal doses of physical activity for older people to achieve comprehensive health benefits, using studies that draw upon a broader range of older people and incorporating close monitoring of compliance rates.*
>
> *Older people are generally aware of the health benefits of physical activity. However, knowledge alone is often not sufficient to motivate a person to adopt and maintain physical activity behaviour. Interventions incorporating the principles of behaviour change are needed, both to maximise the reach of physical activity promotion initiatives and programs across the older community and to minimise attrition once people begin to be physically active. Programs that include some behavioural techniques and have a community extension or connection are more likely to result in sustained increases in activity. Activity that is assisted by social support and woven into daily activities increases*

the likelihood of sustained behaviour and associated health benefits. To support older individuals in making behavioural change, modifications to their social and physical environment are needed. Strategies to address negative micro, meso and macro-cultural attitudes toward the concept of physical activity in older people are required. The physical environment will require adaptation to enable safe and enjoyable physical activity options to be readily accessible to all older Australians.

Conclusion: physical activity provides a range of health benefits for older Australians. Physical activity programs – particularly for the frail old – need to provide not only facilities that are safe, accessible and appropriate, but also a supportive environment to optimise program adherence. The evidence overviewed in this document will assist capacity building for organisations and practitioners to conduct physical activity promotion amongst older people. The focus upon the translation of evidence into practice will engender optimal population health impact (Sims et al 2006, pp. 11–12).

The present report extends the Australian review of evidence on physical activity and health in older adults by focusing on the literature published since 2004, as well as international guidelines from 1990.

New Zealand national policy response

Given the physical activity levels reported in the general population of older people in New Zealand (Mummery et al 2007; SPARC 2008) there is cause for concern regarding both health status and health care costs for this population group. The general response (ie, for all population groups) is manifold across the New Zealand health and disability system, with many physical activity programmes occurring across the country. However, these programmes are not always targeted at, nor tailored for, older New Zealanders. The Ministry of Health, with its responsibility to provide advice on the benefits of physical activity for health, will produce guidance on physical activity for older people. The purpose of this guidance is to address the implications for New Zealand's publicly-funded health and disability system by:

- providing evidence-informed policy advice on physical activity for achieving and maintaining the best possible health for older people, and is based on current evidence considered for the New Zealand context
- providing reliable, consistent information for using as a basis for programmes and education to support older people to be active (for example, technical background for health education resources and/or District Health Board ('DHB') programmes)
- guiding and supporting health practitioners and physical activity professionals (including, doctors nurses, primary health care providers, health providers, physical activity experts and teachers) in the practice of healthy physical activity, and provide them with a detailed information resource
- being a resource for health practitioners and physical activity professionals. Education resources on physical activity are intended as the primary means of communicating the policy advice to the public.

This literature review provides an evidence base for the guidance.

Chapter 4 discusses the evidence that surrounds the benefits of physical activity for older people. The literature suggests that a physically active lifestyle is associated with numerous positive health benefits and outcomes for all ages, including older people (Nelson et al 2007). Chronic diseases (including cardiovascular disease, stroke, and certain types of cancer, among others) and premature all-cause mortality appear to be either preventable or able to be delayed, given sufficient physical activity.

The literature also suggests that for older adults with certain chronic diseases or health conditions, physical activity can be beneficial in the management of those diseases and conditions. Indeed, there appear to be many benefits to be gained through the achievement of sufficient levels of physical activity, and people never grow too old to experience the benefits of regular physical activity (US Surgeon General 1996). Chapter 4 therefore addresses the benefits of physical activity in both the prevention and management of diseases and conditions, along with the enhancement of functioning for older people, who now make up a sizeable and growing percentage (about 13%) of the overall population in New Zealand (Ministry of Social Development 2007).

The receipt of benefits from participation in physical activity does not, by itself, provide information about whether being physically inactive or sedentary is detrimental. The literature suggests, however, that older people who spend more of their time being physically inactive are at higher risk of many chronic diseases and premature mortality, relative to older people who are more physically active. Chapter 5 of this report addresses the risks of physical inactivity, or being sedentary.

Chapter 6 provides information from the reviewed literature about the physical activity interventions that appear to be most effective in providing the health and physical functioning benefits. This chapter also provides detailed information about the nature of the interventions (eg, type, duration, frequency).

Chapter 7 provides information about what older people perceive to be the barriers to their uptake of physical activity and the things that they believe will encourage them to increase their participation.

Chapter 8 discusses the literature on safety issues and risks for older people when they are participating in physical activity.

Chapter 9 describes New Zealand-specific considerations for people who are promoting physical activity for older New Zealanders.

Chapter 10 provides comparative information on international policy approaches to promoting physical activity by older people.

The report starts with a presentation of the methods undertaken in the literature review.

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3 Methods

This review of evidence was on literature since 2004 to build on the evidence provided in 'National physical activity recommendations for older Australians: Discussion Document' prepared by the National Ageing Research Institute and Australian Government Department of Health and Ageing (Egger et al 1999).

The following section provides details on the methods used for study selection, and the sources used to identify potential studies. Details of the search strategies can be referred to in chapter 13 of this report.

Date range of publications

All primary research papers (non-guidelines and policy documents) were searched from 2004 to August 2010. When additional targeted searching or hand searching retrieved relevant older papers capable of making a strong contribution to the literature review, these papers were also included. National and international guidelines and policies were searched from 1990 to the present.

Type of publications

For chapters 4, 5 and 6, articles with level of evidence I or II (NHMRC levels of evidence) were used (systematic reviews, RCT, prospective cohort studies). Where there were gaps in the evidence, lower levels of evidence were sought to provide supplemental information.

For chapter 7, all levels of evidence and evidence without a defined level were used, including cross-sectional studies, narrative reviews, published abstracts, and qualitative research.

For chapters 8 and 10, all levels of the hierarchy of evidence were examined. For chapter 9, the types of publication included international guidelines, systematic reviews, policy documents, and scientific position statements.

Editorials, comments, book chapters, conference proceedings, animal studies, correspondence, or news items were excluded. Single case/subject designs and studies with fewer than five participants in either intervention or comparator arm and non-systematic reviews were also excluded. Documents published in English language only were included.

Due to the large number of policy documents available internationally these documents were limited to countries including, and similar to New Zealand, as defined by the Ministry of Health in the service specification, and included Australia, United Kingdom (UK), United States of America (USA), Canada, and some Scandinavian countries (ie, Sweden, Norway, Finland, etc).

Participants

The eligible populations were people aged 65 years and older. Data were initially sought that stratified outcomes by age groups over 65 years. However, the data generally only reported on those aged 65 years or older and such stratification was not possible. Some studies included people younger than 65 years, they were included in the review if the mean age of participants was 65 years or older.

Physical activity

Studies reporting on physical activity were defined for the purpose of this report as those addressing all movement produced by skeletal muscles that increase energy expenditure, whether it is incidental, occupational, leisure, structured or supervised.

Sedentary behaviour

Studies reporting on sedentary behaviour were defined for the purpose of this report as those addressing time spent sitting or in low levels of energy expenditure. In some instances, measures of television viewing, riding in a car, or other typically sedentary activities are used to provide information about sedentary behaviour.

Types of physical activity intervention

Physical activity interventions included in this report were classified according to four broad types: aerobic endurance, resistance training, mobility and balance, and mixed or various types.

Outcome measures

All outcomes were specific to older people. For the primary research questions the outcomes under investigation were:

- benefits of physical activity participation
- risks of inactivity/sedentary behaviours
- risks of physical activity participation
- effectiveness of interventions
- enablers and barriers to physical activity participation
- duration, intensity, type, and frequency of physical activity to improve health outcomes.

For the guidelines and policies the outcomes were to:

- summarise the recommendations from the guidelines as relates to the outcomes of the primary research
- identify similarities and differences between guidelines and policies.

Search sources

Bibliographies of retrieved publications and recent narrative reviews, were also examined to identify any additional eligible studies. Hand searching of journals and contacting of authors was not undertaken in this review.

Chapters 4–7

The following sources were searched for benefits of participation in physical activity, risks of inactivity and sedentary behaviour, effectiveness of physical activity interventions, enablers and barriers to participation in physical activity for older people:

- PubMed (including MEDLINE)
- Cochrane Database of Systematic Reviews
- CINAHL
- EBSCOhost
- Scopus
- SPORTDiscus
- PsychLIT
- PsychINFO
- Google Scholar
- Ausportmed
- Chronic Disease Prevention Database
- Health Source
- National Transportation Information Service
- PsycARTICLES
- PsycBOOKS
- Transportation Research Information Services
- International Road Research Documents
- TRoPHI.

Chapter 8

The following sources were searched for safety issues and risks for physical activity participation for older people:

- Cochrane Library
- Medline
- Embase
- Cinahl
- PsychInfo
- Web of Science
- SportDiscus.

Chapter 9

The following sources were searched for national and international guidelines and policy documents on physical activity and the older person:

- GIN
- National Guideline Clearing House
- National Library for Health (UK) this included NICE and SIGN
- Medline (see strategy below)
- Embase
- Cinahl
- SportDiscus
- Web of Science
- American Heart Association
- SPARC (NZ)
- Heart Foundation (NZ)
- Australian National Heart Foundation
- CDC
- Ministry of Health (NZ)
- NHMRC (AUST)
- Australian Dept of Health and Ageing
- WHO
- Catalog of United States Government Publications
- Database of Promoting Health Effectiveness Reviews
- HSTAT
- SIGLE
- Libraries: Te Puna (NZ), National Library of Medicine, National Library of Australia, CoPAC (UK).

Chapter 10

The following sources were searched for New Zealand specific issues and cultural considerations which had not been identified in the searches from chapters 3 and 4:

- KRIS
- Australasian Digital Theses
- Digital NZ
- Index New Zealand
- NZ Index (via Knowledge Basket)
- Sport Discus
- Medline
- Embase
- Amed
- Cinahl

- Web of Science
- Pedro.

Appraisal

Chapters 4 to 7 were completed by the University of Western Sydney, with quality assurance conducted by Professor Gregory Kolt, an expert in the field of physical activity. The quality of the literature reviewed was evaluated and critiqued by expert researchers without arriving at a quantitative metric. This evaluation looked at quality of the methods employed (eg, systematic reviews, randomised controlled trials) in drawing conclusions for chapters 4 to 7.

In reviewing the literature for chapters 4 to 7, and in drawing conclusions, a distinction was also made between evidence of the benefits of physical activity and the concept of 'effectiveness'. This distinction is made on the grounds of study design, with evidence of effectiveness coming from randomised controlled trials, and that of benefits coming from randomised controlled trials plus other research designs (eg, prospective cohort studies).

Chapters 8 to 10 were completed by the New Zealand Guidelines Group which applied its appraisal tools in the following ways. Relevant guidelines were assessed using the AGREE II instrument (AGREE Next Steps Consortium, 2009) which recommends guidelines, recommends with modifications, or does not recommend. Adapted checklists from the Graphic Appraisal Tool for Epidemiology (GATE) framework to evaluate the quality of level I–IV studies (systematic reviews, meta-analysis, randomised controlled trials, cohort, case-control and cross-sectional studies). These can be accessed at: http://www.fmhs.auckland.ac.nz/soph/depts/epi/epiq/ebp.aspx.

Case series studies are summarised in evidence tables but were not formally appraised using a critical appraisal checklist.

Table 3.1: NHMRC evidence hierarchy: designations of 'levels of evidence' according to type of research question

Level	Intervention	Diagnostic accuracy	Prognosis	Aetiology	Screening intervention
I	A systematic review of level II studies	A systematic review of level II studies	A systematic review of level II studies	A systematic review of level II studies	A systematic review of level II studies
II	A randomised controlled trial	A study of test accuracy with: an independent, blinded comparison with a valid reference standard, among consecutive persons with a defined clinical presentation	A prospective cohort study	A prospective cohort study	A randomised controlled trial
III–1	A pseudo-randomised controlled trial (ie, alternate allocation or some other method)	A study of test accuracy with: an independent, blinded comparison with a valid reference standard, among non-consecutive persons with a defined clinical presentation	All or none	All or none	A pseudo-randomised controlled trial (ie, alternate allocation or some other method)
III–2	A comparative study with concurrent controls: • non-randomised, experimental trial • cohort study • case-control study • interrupted time series with a control group	A comparison with reference standard that does not meet the criteria required for Level II and III–1 evidence	Analysis of prognostic factors amongst persons in a single arm of a randomised controlled trial	A retrospective cohort study	A comparative study with concurrent controls: • non-randomised, experimental trial • cohort study • case-control study
III–3	A comparative study without concurrent controls: • historical control study • two or more single arm study • interrupted time series without a parallel control group	Diagnostic case-control study	A retrospective cohort study	A case-control study	A comparative study without concurrent controls: • historical control study • two or more single arm study

Level	Intervention	Diagnostic accuracy	Prognosis	Aetiology	Screening intervention
IV	Case series with either post-test or pre-test/post-test outcomes	Study of diagnostic yield (no reference standard)	Case series, or cohort study of persons at different stages of disease	A cross-sectional study or case series	Case series

Note: Explanatory notes for this table are outlined in the source (accessed 29 October 2009).

Source: National Health and Medical Research Council additional levels of evidence and grades for recommendations for developers of guidelines, Consultation draft, early 2008 – end June 2009, accessed from http://www.nhmrc.gov.au/_files_nhmrc/file/guidelines/Stage%202%20Consultation%20Levels%20and%20Grades.pdf

The quality scores from the critical appraisal process indicate whether each quality criterion has been met, is unmet or whether there is insufficient information to make a judgment or minor flaws. Each checklist evaluates three domains (internal validity, precision, and applicability) and an overall assessment of the study quality (based on a synthesis of the scores for the three domains). This overall assessment includes the reporting of any major flaws that could affect the validity of the findings and the relevance to clinical practice. The overall quality ratings assigned to each study, for this review are:

- ‘good quality’: with low risk of bias or measurement error (+)
- ‘mixed quality’: not well reported, missing data or minor flaws (?)
- ‘poor quality’: significant methodological flaws (X).

References

AGREE Next Steps Consortium. 2009. Appraisal of guidelines for research and evaluation II: Instrument. Retrieved from http://fhswedge.csu.mcmaster.ca/pebc/agreetrust.

Egger G, Donovan R, Swinburn B, et al. 1999. *Physical activity guidelines for Australians: Scientific background report. A report by the University of Western Australia and the Centre for Health Promotion and Research Sydney for the Commonwealth Department of Health and Aged Care*. Perth, Australia: University of Western Australia.

4 What are the benefits associated with physical activity participation for older people?

Background

This chapter focuses on the benefits associated with participating in physical activity for older people ...

... in the prevention of health conditions:

... in the management or treatment of disease:

... in the enhancement of physical and cognitive functioning, physical fitness, and quality of life:

Definitions

Benefits are defined here as desirable or advantageous outcomes that come directly or indirectly from participation in physical activity, and may be physiological, psychological, or functional in nature. Although many of the reviewed studies focus on the effectiveness of interventions to impact health-related outcomes, or the longitudinal association of physical activity and health, our focus is on the beneficial health-related outcomes that stem from physical activity. The chapter is organised to present the literature in these three areas and each section is organised by single health outcome (eg, disease or condition, quality of life, psychosocial functioning). Given that many of the reviewed articles explored multiple outcomes, some articles are referenced multiple times, but each is discussed in relation to the finding's specific outcome of focus.

A note about the conclusions: all conclusions are about the benefits of physical activity for older people as they arise from the reviewed literature. For detailed information about the studies, refer to appendix 1. Many of the studies in this chapter are relevant to chapter 5 which reviews the literature on effective physical activity interventions, and so are repeated in that chapter, but with greater detail about what the interventions actually were.

Physical activity and the prevention of health-related conditions

Background

A physically active lifestyle has been shown to be beneficial in preventing certain diseases and health conditions. In the prevention literature, researchers have frequently used prospective cohort designs to examine factors such as physical activity that are associated with the risk of a number of morbidities and types of mortality. Many studies reviewed here have examined prevention-related benefits associated with leisure time physical activity, which can be defined as moderate to vigorous physical activity that is done outside of an occupational setting. Others examine prevention-related benefits associated with occupational physical activity, or combined occupational and leisure time physical activity. Topics addressed in this section are prevention of mortality and morbidity, particularly the prevention of falls, as well as stroke, types of cancer, heart disease, hospitalisation; neurological disorders, sarcopenia, kidney dysfunction, osteoporosis, type 2 diabetes, depression, and physical disability.

Body of evidence

Seventy-two articles met the inclusion criteria for physical activity and the prevention of health-related conditions and were appraised or reviewed. All of the included articles were considered to be of good or mixed quality. None of the included articles were considered to be poor quality. There were:

- 25 systematic reviews (Arnold et al 2008; Baker et al 2007; Bonaiuti et al 2002; Cameron et al 2010; Chang et al 2004; Daniels et al 2008; Davies 2010; Gillespie et al 2009; Harling et al 2008; Kelley 1998; Kelley et al 2001; Lee et al 2003; Lee et al 2010; Löllgen et al 2009; McClure et al 2005; Monninkhof et al 2007; Nocon et al 2008; Paterson et al 2010; Shekelle et al 2003; Sherrington et al 2008; Taylor et al 2004; van Uffelen et al 2008; Warburton et al 2010; Wendel-Vos et al 2004; Zijlstra et al 2007)

- 36 prospective cohort studies (Abbott et al 2004; Bardia et al 2006; Byberg et al 2009; Calton et al 2006; Chao et al 2004; Dallal et al 2007; Demakakos et al 2010; Etgen et al 2010; Faber et al 2006; Garg et al 2006; Giovannucci et al 2005; Haines et al 2009; Haydon et al 2006; Hughes et al 2004; Knoops et al 2004; Kritchevsky et al 2005; Ku et al 2009; Lampinen et al 2000; Lan et al 2006; Larson et al 2006; Lautenschlager et al 2008; Leitzmann et al 2007; Li et al 2005; Logghe et al 2009; Manini et al 2006; Middleton et al 2008; Mozaffarian et al 2008; Myint et al 2009; Niti et al 2008; Robinson-Cohen et al 2009; Scarmeas et al 2009; Schooling et al 2006; Strawbridge et al 2002; Voukelatos et al 2007; Weuve et al 2004; Whang et al 2006)
- 11 randomised controlled trials (Baker et al 2010; Binder et al 2002; Courtney et al 2009; Davidson et al 2009; DiPietro et al 2006; Huang et al 2006; Jessup et al 1996; Kerse et al 2005; Villareal et al 2006a; Walker et al 2010; Wisloff et al 2007).

Summary of findings

The findings of the review in relation to the beneficial role of physical activity in the prevention of health conditions are summarised below by condition type, starting with the prevention of premature mortality.

Prevention of all-cause mortality

Thirteen papers were reviewed. Some studies within systematic reviews, eg, Warburton et al 2010, may be based on or include younger people. The findings from these studies are described in the following paragraphs.

Nocon reported on a systematic review and meta-analysis evaluating the primary prevention from physical activity on all-cause and cardiovascular mortality, which included 33 studies with a total of 883,372 participants (Nocon et al 2008). For both all-cause and cardiovascular mortality, a large majority of included studies showed significantly lower relative risks among physically active versus physically inactive participants. Overall findings indicated a risk reduction from physical activity (after adjusting for other relevant risk factors) in both men and women of about 35% in cardiovascular mortality, and a similar risk reduction of 33% in all-cause mortality. This systematic review is likely to include participants under the age of 65.

Löllgen and colleagues conducted a systematic review of 38 prospective cohort studies (Löllgen et al 2009). These authors reported that compared to sedentary persons, regular physical activity over longer time was strongly associated with a reduction in all-cause mortality. These authors also reported a dose–response relationship between level of moderate to vigorous physical activity and mortality. This systematic review is likely to include participants under the age of 65.

Warburton reported a recent systematic review which critically examined the evidence base for the Canadian Physical Activity Guide for Healthy Active Living, including 70 articles on all-cause mortality (Warburton et al 2010). Among articles reviewed, a majority were prospective cohort studies with an average of about 11 years follow-up, and total study participant numbers of 1,525,377 men and women from regions across the world. Of these studies, 90% supported the health benefits of physical activity as a significant risk reduction for all-cause mortality. Further, there was a significant dose–response relationship, such that relatively small incremental increases in physical activity were associated with marked reduction in

mortality risk. A level of physical activity equivalent to 4.2 MJ/week or 1000 Kcal/week was associated with about 20–30% reduced risk of premature mortality, and higher levels of activity were associated with greater risk reduction (Warburton et al 2010). This systematic review is likely to include participants under the age of 65.

Knoops describes a prospective cohort study of older men and women in Europe, in which researchers assessed the impact of four health behaviours on all-cause mortality and mortality linked to coronary heart disease, cardiovascular diseases, and cancer (Knoops et al 2004). The four health behaviours included physical activity, diet, alcohol consumption and smoking This study's findings showed that physical activity was associated with a 37% risk reduction in all-cause mortality, nearly identical to that of non-smoking status.

In the prospective cohort of 47,620 older male health professionals aged 40–75 years at baseline, Giovannucci found that for men over the age of 65, there was a lower risk in those men doing the greatest amounts of vigorous activity for fatal prostate cancer, compared to men who did no vigorous physical activity (Giovannucci et al 2005). No association was observed in this study for total or non-vigorous physical activity, which suggests that regular vigorous physical activity could be influential in reducing prostate cancer mortality. Giovannucci also reported on cancer morbidity (see below).

In a prospective cohort study with a sample of 41,528 Australian men and women aged 27–75 at baseline, Haydon and colleagues found that a lack of regular vigorous physical activity (exercising vigorously for at least 20 minutes, at least once per week) prior to the diagnosis of colorectal cancer was associated with poorer overall survival and disease-specific survival (Haydon et al 2006). After adjusting for age, sex, and tumour stage, vigorous exercisers had a significantly better disease-specific survival compared to non-exercisers.

Garg and colleagues studied 460 men and women with peripheral arterial disease, average age around 72 years, using a prospective cohort design (Garg et al 2006). Compared to participants in the highest quartile of objectively-measured physical activity, those in the lowest quartile had more than three times higher total mortality (hazard ratio = 3.48; 95% confidence interval = 1.23 to 9.87). Also, the researchers found that lower weekly numbers of stair flights climbed were associated with higher total mortality. Garg also reported findings from this study on cardiovascular disease morbidity (see below).

Manini and colleagues conducted a prospective cohort study with 302 men and women aged 70–82 years (Manini et al 2006). These researchers determined that older people in the lowest tertile of free-living activity energy expenditure were at a significantly higher mortality risk, compared to the most active older people.

Lan and colleagues conducted a prospective cohort study with 2113 older men and women (mean age 73 years) in Taiwan to examine the association between physical activity and mortality (Lan et al 2006). In this study, regular exercisers showed a 35% reduced risk of death, compared with sedentary individuals after adjustment for covariates. Older people with a weekly physical activity amount of energy exceeding 1000 kcal had significant benefit of mortality risk reduction, and there was also a significant dose–response relationship between number of activities and the reduction in total mortality. The benefit on mortality reduction among the three components of total energy amount (frequency, intensity, and duration) was only observed for intensity. This suggests that intensity of physical activity is a

stronger determinant of energy expenditure than frequency and duration, and thus more influential for mortality reduction. Protection of exercise against death also increased with the number of activities.

Whang and colleagues reported results from a large cohort of 69,693 women aged 40 to 65 at baseline, followed over about 18 years (Whang et al 2006). In the cohort analyses, women with higher levels of moderate to vigorous physical activity were had lower long-term risk of sudden cardiac death in age-adjusted and multivariable models, compared to less active women.

In a large prospective cohort study in China with 54,088 men and women aged 65 and up, Schooling and colleagues found higher risks of premature mortality among the least active participants (Schooling et al 2006). In the full sample, there were significant reductions in all-cause mortality, cardiovascular mortality, respiratory mortality, and other mortality for more active individuals. In analyses stratified by health status, compared with participants who reported no physical activity, those who reported some level of daily physical activity had lower mortality in the group with poor baseline health status, but not in the group with good baseline health status.

Leitzmann describes a prospective cohort study of 252,925 men and women in the USA aged 50–71 years examined whether individuals who met national physical activity guidelines (30 minutes of moderate activity on most days of the week or 20 minutes of vigorous activity three times per week) had lower risk of death over approximately five years of follow-up (Leitzmann et al 2007). Participants were aged 50 to 71 years at baseline, with a sample average of about 63 years at baseline, and about 68 years at study end. This study found that significant mortality benefits were obtained for those who met the recommendations, and there was a further decrease in mortality risk (approximately 50%) for those achieving both 30 minutes of moderate activity on most days of the week and 20 minutes of vigorous activity three times per week. This reduction in risk remained for subgroup analyses of smokers, overweight or obese individuals, and those watching two or more hours of television per day. Further, the study found a dose–response relationship, such that engaging in less than the recommended level of physical activity was also related to a decreased mortality risk, relative to the inactive.

Although many studies examine the link between baseline measures of physical activity and subsequent mortality risk, Byberg reported on a prospective cohort study of 2205 Swedish men which examined the association between change in leisure-time physical activity from age 50 to 60 and subsequent mortality risk over 35 years of follow-up (Byberg et al 2009). This study found that an increased level of physical activity in middle age was followed by a reduction in mortality, comparable to that of men with unchanged high physical activity levels. The reduction in mortality risk from physical activity was comparable to that achieved by smoking cessation. This study suggests that a reduced mortality risk from participation in physical activity can be attained relatively late in life, even for those not previously physically active.

Conclusions and implications: prevention of all-cause mortality

Three systematic reviews and 10 prospective cohort studies are presented. Given this collection of evidence, findings can be interpreted with confidence. In particular, the three systematic reviews provide strong foundations of this evidence base (Löllgen et al 2009; Nocon et al 2008; Warburton et al 2010).

Physical activity levels of participants in the studies reviewed are typically grouped into three or four categories from the lowest group that reports little or no moderate to vigorous physical activity during occupation or leisure time on most days to the highest group that typically reports 30 minutes or more of moderate to vigorous physical activity on most days.

- Older people who report the least physical activity, relative to more active older people in the population are usually shown to have higher risk of all-cause mortality, even when adjusting for likely confounding variables (Byberg et al 2009; Garg et al 2006; Knoops et al 2004; Lan et al 2006; Leitzmann et al 2007; Löllgen et al 2009; Manini et al 2006; Nocon et al 2008; Schooling et al 2006; Warburton et al 2010; Whang et al 2006), and there is a small minority of studies that do not report this relationship. This suggests that physical activity is a modifiable risk factor for all-cause mortality, and that increasing physical activity level can decrease mortality risk.
- A level of physical activity equivalent to 4.2 MJ/week or 1000 Kcal/week has been associated with reduced risk of premature mortality, and higher levels of physical activity are associated with greater risk reduction (Lan et al 2006; Warburton et al 2010).
- The benefit from physical activity regarding mortality reduction has been identified for both men and women (Löllgen et al 2009; Nocon et al 2008; Warburton et al 2010).
- The benefit from physical activity has been identified for cardiovascular mortality (Nocon et al 2008; Whang et al 2006), including sudden cardiac death (Whang et al 2006), as well as prostate cancer mortality (Giovannucci et al 2005) and colorectal cancer mortality (Haydon et al 2006).
- There is a consistently identified dose–response relationship between physical activity and mortality risk, exemplified in a very large prospective cohort study (Leitzmann et al 2007). This study found that significant mortality benefits were obtained for those who met the American recommendations for moderate or vigorous intensity physical activity, and there was a further decrease in mortality risk (approximately 50%) for those achieving both 30 minutes of moderate activity on most days of the week and 20 minutes of vigorous activity three times per week.

Prevention of injury from falls

Fourteen papers were reviewed. One of the papers separated the ‘frail’ older adult within the study population (Faber et al 2006). This study identified favourable outcomes from physical activity amongst the pre-frail, but not frail older people, suggesting that physical activity intervention programmes may need to target older people before they succumb to unintentional weight loss, weakness, exhaustion, slowness, and low physical activity, if falls are to be prevented (Faber et al 2006).

Some studies within systematic reviews, eg Gillespie et al 2009, may be based on or include younger people, though falls are typically more likely to affect older people.

The findings from these studies are described in the following paragraphs.

Chang reported a systematic review and meta-analysis of 40 randomised clinical trials, which found that interventions to prevent falls in older people have been beneficial in reducing both the risk of falling and the monthly rate of falling. Further, although physical activity intervention programmes had a beneficial effect on older people's risk of falling and monthly fall rate, the most beneficial intervention was a multi-factorial fall risk assessment and management programme (Chang et al 2004). This systematic review is likely to include participants under the age of 65.

McClure assessed the impact of population-based fall countermeasure interventions through a systematic review of six evaluation studies in Australia, Denmark, Norway, Taiwan, and Sweden (McClure et al 2005). Those studies with a physical activity component showed relative reductions in fall-related injuries. None of the studies was a randomised controlled trial, but the consistency of findings across studies bodes well for population-based efforts to prevent falls, including through the promotion of physical activity.

In a systematic review by Baker and colleagues, researchers examined 15 randomised controlled trials, with a total sample of 2149 participants generally ranging from 67 to 84 years of age (Baker et al 2007). Although the available evidence was limited, this study found a beneficial effect on falls prevention from multi-modal physical activity programmes.

Sherrington and colleagues reported on a systematic review of 44 trials, most of which were based on men and women above the age of 75 years (Sherrington et al 2008). This systematic review found that physical activity programmes can prevent falls in older people. Greater benefits were seen in programmes that included physical activities that challenge balance, use a higher dose of physical activity, and do not include a walking programme.

Arnold and colleagues reported on a systematic review of randomised controlled trials, concluding that individualised and group exercise programmes were both beneficial in reducing fall risk (Arnold et al 2008). The participants were aged 50 years and older. Seventeen of 19 studies that measured fall risk and eight of 14 studies that measured falls had positive outcomes associated with physical activity. Of the 14 studies with some positive outcome, four reported no change in actual falls, and two reported inconsistent results. Both short-term and long-term interventions manifested favourable results for decreased fall risk, but for interventions indicating actual prevention of falls or lower fall rates, nearly all were longer than six months in duration. The authors could not define the best physical activity design for fall prevention in community-dwelling older people (with regard to type, frequency, and amount of physical activity).

Gillespie reported a systematic review of interventions for preventing falls among older people living in the community, which included 111 randomised controlled trials with a participant total of 55,303 (Gillespie et al 2009). The review found that physical activity programmes had targeted various physical functioning components: 1) strength; 2) balance; 3) flexibility; and 4) endurance for the prevention of falls amongst study participants. Results showed that intervention programmes containing two or more of the above components were

more likely to reduce the rate of falls, or number of people falling, relative to single-component interventions. Furthermore, physical activity interventions based on group tai chi exercise, individual home-based exercise, or supervised multiple-component group exercise were found to be beneficial. This systematic review is likely to include participants under the age of 65.

Cameron reported on systematic review of intervention programmes for older people which included 41 studies that represented 25,422 participants from nursing-care facilities or hospitals (Cameron et al 2010). A key finding was that supervised physical activity interventions resulted in significant reductions of fall risk such that physically active participants had less than half the fall risk of controls. There was no evidence, however, that interventions targeting single risk factors could reduce falls, but the review found evidence for the benefits of multi-factorial interventions (those including physical activity in combination with other intervention components) as a means to reduce falls and the risk of falling in hospitals.

Faber reported on a randomised controlled trial evaluating group physical activity intervention programme for older men and women, who were classified as either frail, or pre-frail (Faber et al 2006). Frailty is related to instability and risk of loss of function, a set of linked deteriorations including, but not limited to, the musculoskeletal, cardiovascular, metabolic, and immunologic systems (Faber et al 2006). The results of this randomised controlled trial showed favourable outcomes from physical activity amongst the pre-frail, but not frail older people. This suggests that physical activity intervention programmes may need to target older people before older people succumb to unintentional weight loss, weakness, exhaustion, slowness, and low physical activity, if falls are to be prevented.

Haines reported on a randomised controlled trial that evaluated a home-based physical activity video with regard to falls and fear of falling (Haines et al 2009). This trial found a significant reduction in fear of falling among the physical activity participants, but a non-significant reduction in falls, compared to the control condition.

The benefits of tai chi regarding fall prevention was discussed in six studies (Gillespie et al 2009; Harling et al 2008; Li et al 2005; Logghe et al 2009; Voukelatos et al 2007; Zijlstra et al 2007). Gillespie's study is reported above. The other five are:

- Zijlstra and colleagues conducted a systematic review of 19 randomised controlled trials that were conducted with samples of older men and women, aged 60 years and up (Zijlstra et al 2007). This study found that home-based exercise, fall-related multi-factorial programmes, and community-based tai chi delivered in group format all led to reduced fear of falling in community-living older people.
- Harling conducted a systematic review that summarised the findings of seven randomised controlled trials evaluating tai chi interventions for fall reduction in people over the age of 60 (Harling et al 2008). This study found weak evidence to support tai chi for reducing falls, but strong evidence to support tai chi for reducing the fear of falling in older people.
- Li reported on a randomised trial that showed lower fall rates relative to controls for previously inactive people attending a thrice-weekly tai chi exercise group (Li et al 2005). Furthermore, improvements were seen in fear of falling, functional balance, and physical performance.

- Voukelatos reported a randomised controlled trial studying community-dwelling older people over the age of 60, in which researchers showed that participation in a once-a-week tai chi class for 16 weeks resulted in less frequent falls and better balance relative to controls (Voukelatos et al 2007).
- Logghe and colleagues conducted a randomised controlled trial to investigate the benefits from a home-based tai chi programme for fall prevention for people with an average age of 77 years (Logghe et al 2009). Results showed that after 12 months, there was no lower fall risk in the tai chi group than in the control group. Also, there were no significant impact on balance, fear of falling, blood pressure, heart rate at rest, forced expiratory volume during the first second, peak expiratory flow, physical activity, and functional status. The authors concluded that tai chi may not prevent falls in older people at a high risk of falling who live at home.

Conclusions and implications: prevention of injury from falls

Nine systematic reviews and five randomised controlled trials are presented. Given this collection of evidence, findings can be interpreted with confidence. In particular, Gillespie and colleagues' systematic review makes a strong contribution, due to its large number of included studies and participants, and recent review of literature (Gillespie et al 2009).

Physical activity programmes within the reviewed literature are heterogeneous, and have targeted various physical functioning components, including strength, balance, flexibility, and endurance for the prevention of falls amongst study participants.

- Physical activity intervention programmes have often been shown to provide benefits such as reduced fall risk (Arnold et al 2008; Baker et al 2007; Cameron et al 2010; Chang et al 2004; Gillespie et al 2009; McClure et al 2005; Sherrington et al 2008) but some have found no fall reduction benefit (Arnold et al 2008; Haines et al 2009; Logghe et al 2009).
- Those physical activity interventions targeting at least two components (of strength, balance, flexibility, or endurance) were more likely to reduce the rate of falls, or number of people falling, relative to single-component interventions (Gillespie et al 2009). Systematic reviews have also suggested a need for multi-component interventions that include other components beyond a single type of physical activity (Baker et al 2007; Cameron et al 2010; Chang et al 2004; Sherrington et al 2008).
- Physical activity interventions based on group tai chi exercise, individual home-based exercise, or supervised multiple-component group exercise have often been found to be beneficial (Gillespie et al 2009). Two systematic reviews found that there was good evidence for reduction in fear of falling among participants who participated in tai chi physical activity intervention programmes (Harling et al 2008; Zijlstra et al 2007).
- One randomised controlled trial evaluated a home-based physical activity video on falls and fear of falling (Haines et al 2009). This trial found a significant reduction in fear of falling among the physical activity participants, but a non-significant reduction in falls.
- Within nursing homes or hospitals, supervised physical activity interventions have frequently resulted in significant reductions of fall risk (Cameron et al 2010).

- Both short-term and long-term physical activity-based interventions have manifested favourable results for decreased fall risk, but for interventions indicating actual prevention of falls or lower fall rates, nearly all were longer than six months in duration (Arnold et al 2008).

Prevention of hospitalisation

Four papers were reviewed. Some studies within systematic reviews, eg, Davies (2010), may be based on or include younger people. The findings from these studies are described in the following paragraphs.

Chien described a systematic review of randomised controlled trials in older people with chronic heart failure which included 10 studies with a total of 648 older participants (Chien et al 2008). Results showed that home-based exercise increased exercise capacity safely but did not improve quality of life in patients with chronic heart failure. In the meta-analysis of these trials, home-based exercise increased walking performance and peak oxygen consumption more than usual activity, but did not improve heart failure scores or odds of hospitalisation.

Davies and colleagues analysed physical activity training interventions from 19 randomised controlled trials that included 3647 participants with heart failure (Davies 2010). This systematic review may include participants under the age of 65. The kinds of physical activity programmes in this review were mostly aerobic endurance. This review found that aerobic endurance physical activity reduced hospital admission rates over both short term and long-term assessments.

Kerse reported on a group-randomised controlled trial with 270 New Zealand men and women which studied the outcomes of individualised goal setting and physical activity plans in residential care facilities (Kerse et al 2005). Leisure-time moderate physical activity and energy expenditure increased to a greater degree in the individualised intervention group and hospitalisations decreased, compared to the control group.

Courtney reported on a randomised controlled trial in Australia which evaluated an individualised programme of physical activity strategies and nurse-conducted home visits and telephone follow-ups, compared to a control group (Courtney et al 2009). This study found that along with fewer emergency visits and lower hospital readmission rates, the intervention group reported more improvement in quality of life, relative to controls. Thus, this study showed that a physical activity programme with home visits and telephone follow-up may reduce emergency health services for older people with health problems.

Conclusions and implications: prevention of hospitalisation

Two systematic reviews and two randomised controlled trials are presented. Given this collection of evidence, findings can be interpreted with confidence.

Physical activity programmes within the reviewed literature are heterogeneous, and have targeted various components, primarily aerobic endurance, but also strength, balance, and flexibility.

- One systematic review and two randomised controlled trials showed that physical activity intervention programmes led to reduced hospitalisation rates in older people: with chronic heart failure (Davies 2010) who had been recently admitted to the hospital (Courtney et al 2009); and who were primary care patients (Kerse et al 2005).
- Another systematic review found no benefit from physical activity intervention for older people with chronic heart failure (Chien et al 2008).
- The reviewed studies suggest that physical activity may confer some benefit in reduced risk of hospitalisation (Courtney et al 2009; Davies 2010; Kerse et al 2005). This risk, however, is likely related to the characteristics of study population, particularly the type and severity of disease or disability. Thus, the current evidence is insufficient to make conclusions across types and severities of disability, and more high quality studies are needed in this topic area.

Prevention of stroke

Four papers were reviewed. Some studies within systematic reviews, eg, Warburton et al 2010, may be based on or include younger people, though the chronic disease under review is typically more likely to affect older people. The findings from these studies are described in the following paragraphs.

Lee reported on a systematic review and meta-analysis of 23 studies which found that moderate and high levels of physical activity were associated with reduced risk of ischemic strokes, haemorrhagic strokes, and total strokes (Lee et al 2003). In this study, highly active individuals had a 27% lower risk of stroke incidence or mortality, relative to low-active persons. This systematic review is likely to include adults under the age of 65.

Wendel-Vos reported on a systematic review and meta-analysis of 31 studies which examined the influence of both occupational physical activity and leisure-time physical activity on total stroke risk (Wendel-Vos et al 2004). In this study, pooled relative risks of total, haemorrhagic, and ischemic stroke were consistently lower among the more physically active study participants, compared to less active participants. Results showed a 36% lower risk for occupational, and 15% lower risk for leisure-time physical activity protective factor for stroke, and that moderate intensity physical activity is sufficient to reduce stroke risk. This systematic review is likely to include adults under the age of 65.

In their large systematic review, which included 25 studies related to physical activity and stroke, Warburton and colleagues found those with higher levels of physical activity had lower risk for stroke, compared to those with lower physical activity levels (Warburton et al 2010). Warburton and colleagues also reported on all-cause mortality, breast cancer, colon cancer, cardiovascular disease, hypertension, osteoporosis, and type 2 diabetes, and identified a dose–response curve between physical activity levels and chronic diseases (see below). This systematic review is likely to include adults under the age of 65.

Myint published the results of a prospective cohort study which examined lifestyle behaviours in relation to stroke risk, including physical activity, smoking, alcohol consumption and fruit and vegetable intake (Myint et al 2009). In this study of 20,040 men and women from the UK, participants were measured at baseline (ages between 40 and 79) on the four lifestyle behaviours, and followed for an average of 11.5 years. This study found that, after

adjustment for age, sex, social class, body mass index, blood pressure, cholesterol, and history of diabetes and aspirin use, there was a significant relationship between the collection of health behaviours and risk of stroke. Unfortunately, analyses were not conducted in a way that the individual contribution of each of the health behaviours (eg, physical activity) for stroke risk could be determined. Healthy lifestyle behaviours, in general, were associated with beneficial reductions in stroke risk.

Conclusions and implications: prevention of stroke

Three systematic reviews, representing 79 studies and one prospective cohort study are presented. Given this collection of evidence, consistent findings are likely to be robust and can be interpreted with confidence. In particular, Warburton and colleagues' systematic review makes a strong contribution to the evidence base, due to its large number of included studies and participants, and recent review of literature (Warburton et al 2010).

Physical activity levels of participants in the studies included in the systematic reviews are typically grouped into three or four categories. The lowest group reports little or no moderate to vigorous physical activity during occupation or leisure time on most days and the highest group typically reports 30 minutes or more of moderate to vigorous physical activity on most days.

- Older people who report the least physical activity, relative to more active older people in the population have the highest risk of stroke, even when adjusting for likely confounding variables (Lee et al 2003; Warburton et al 2010; Wendel-Vos et al 2004).
- Physical activity, along with such factors as smoking, alcohol consumption and fruit and vegetable intake, is a modifiable risk factor for stroke (Myint et al 2009) and increasing the physical activity level of older people could decrease stroke risk (Lee et al 2003; Warburton et al 2010; Wendel-Vos et al 2004).
- Risk reduction benefits from physical activity have been identified for both ischemic and hemorrhagic types of stroke (Lee et al 2003; Wendel-Vos et al 2004).
- There appears to be a dose–response relationship (inverse) between amounts of physical activity and risk of stroke (Warburton et al 2010).
- Moderate intensity physical activity is likely sufficient to reduce stroke risk (Wendel-Vos et al 2004).

Prevention of heart disease (including associated cardiovascular risk factors)

Eleven papers of high-level evidence were reviewed. One of these papers separated the 'frail' older adult within the study population, and this study found a weight loss intervention with a physical activity component resulted in reductions in levels of triglycerides, blood pressure, and metabolic syndrome. A twelfth paper of lower-level evidence (a narrative review) is also presented.

Some studies within systematic reviews eg, Warburton et al 2010, may be based on or include younger people.

The findings from these studies are described in the following paragraphs.

Kelley and Kelley conducted a systematic review and meta-analysis of literature that addressed whether physical activity provides benefit to resting blood pressure in older people (Kelley et al 2001). This study included participants younger than age 65 years. Results of the meta-analysis showed that aerobic endurance physical activity intervention programmes led to a drop in systolic blood pressure.

Taylor and colleagues reported on a systematic review of 48 randomised controlled trials representing 8940 participants with heart disease, in which researchers conducted a meta-analysis of the effects of cardiac rehabilitation, which represents a secondary prevention strategy (Taylor et al 2004). Results showed that participants in cardiac rehabilitation programmes had reductions in systolic blood pressure, about 3 mm Hg in size.

Thomas published a systematic review and meta-analysis, which evaluated 14 randomised controlled trials including 377 older participants with type 2 diabetes to investigate health-related benefits derived from physical activity interventions (Thomas et al 2007). The participants included those under the age of 65. The results of this systematic review and meta-analysis showed that physical activity improves control of blood glucose and reduces levels of visceral adiposity and triglycerides, but does not result in beneficial change to plasma cholesterol in this population.

In their large systematic review, Warburton and colleagues found those with higher levels of physical activity had lower risk for cardiovascular disease and hypertension, compared to those with lower physical activity levels (Warburton et al 2010). Warburton and colleagues also reported on all-cause mortality, breast cancer, colon cancer, osteoporosis, and type 2 diabetes, and identified a dose–response curve between physical activity levels and chronic diseases (see above and below). This systematic review is likely to include adults under the age of 65.

A randomised controlled trial by Takeshima and colleagues included 35 older men and women, and examined benefits derived from circuit exercise training (Takeshima et al 2004). This physical activity intervention included both aerobic endurance and resistance training. This combination of physical activity resulted in beneficial improvements in body composition and high-density lipoprotein cholesterol in the participants.

Kerse reported on a group-randomised controlled trial with 270 New Zealand men and women which studied the outcomes of individualised goal setting and physical activity plans in residential care facilities (Kerse et al 2005). Results showed that although hospitalisations decreased and measures of general health improved, there was no benefit from the intervention for blood pressure (Kerse et al 2005).

Villareal and colleagues conducted a randomised controlled trial assessing a lifestyle intervention that included physical activity components versus a control condition in 27 diabetic obese older men and women from the US (Villareal et al 2006a). Results showed greater reductions in plasma glucose, triglycerides, blood pressure, and in proportion of people with metabolic syndrome for the intervention group relative to controls.

Garg and colleagues studied 460 men and women with peripheral arterial disease, average age around 72 years, using a prospective cohort design (Garg et al 2006). Results showed that compared to participants in the lowest baseline quartile of objectively-measured physical activity, those in the highest quartile had more than three times higher risk of cardiovascular events.

Huang and colleagues conducted a randomised controlled trial with a community-based sample of men and women aged 75 and up (Huang et al 2006). In this study, previously inactive participants were randomised to an aerobic endurance physical activity group doing moderate-intensity or high-intensity exercises, or to an inactive control group. Results showed that the high-intensity aerobic endurance physical activity led to reductions in resting systolic and diastolic blood pressure readings, about 8 to 10mm Hg. The moderate-intensity group also achieved a significant drop in diastolic blood pressure of about 8mm Hg.

Mozaffarian reported on a prospective cohort study of 5446 older (> 65 years) participants from the US which examined the risk between various characteristics of usual physical activity and atrial fibrillation (Mozaffarian et al 2008). Participants were an average age of 73 years at baseline, and followed over about nine years. Results showed that leisure-time physical activity was associated with lower atrial fibrillation incidence. Versus no physical activity, incidence was lower with moderate-intensity physical activity, but not with high-intensity physical activity. Walking distance and pace were each associated with lower atrial fibrillation risk in a graded manner. Thus, this prospective cohort study found that the amount of leisure-time physical activity, walking distance, and walking pace were all inversely associated with atrial fibrillation incidence in a dose–response manner. Moderate intensity physical activity showed lowest risk levels for atrial fibrillation.

Logghe and colleagues conducted a randomised controlled trial to investigate the benefits from a home-based tai chi programme for fall prevention for people with an average age of 77 years (Logghe et al 2009). Aside from results related to falls, this study showed that there was no significant impact on blood pressure, or heart rate at rest from participation in tai chi.

A large narrative review by Warburton and colleagues addressed primary and secondary prevention of cardiovascular disease across all ages (Warburton et al 2006). The populations within reviewed studies included people under the age of 65 years. This review indicated that there was strong and compelling evidence for physical activity in the prevention of cardiovascular disease, as well as many other chronic diseases. The review also identified a dose–response relationship between physical activity and preventive health benefits.

Conclusions and implications: prevention of heart disease

Four systematic reviews, five randomised controlled trials, and two prospective cohort studies are presented, along with one supplemental narrative review. Given this collection of evidence, consistent findings are likely to be robust and can be interpreted with confidence. In particular, Warburton and colleagues' systematic review makes a strong contribution to the evidence base, due to its large number of included studies and participants, and recent review of literature. (Warburton et al 2010).

Physical activity types and levels within this body of evidence are heterogeneous, due to diversity within the systematic reviews and different methods among randomised controlled trials and prospective cohort studies.

- Some studies have shown physical activity to benefit general resting blood pressure readings in older people (Huang et al 2006; Villareal et al 2006a) while other studies have shown no benefit (Kerse et al 2005; Logghe et al 2009). Beneficial changes have more frequently been shown for systolic blood pressure (Huang et al 2006; Kelley et al 2001; Taylor et al 2004) than for diastolic blood pressure (Huang et al 2006).
- Physical activity appears to be beneficial in the prevention of hypertension, or high blood pressure, but the evidence pertaining only to older people may not be sufficient. (Warburton et al 2010; Warburton et al 2006).
- There is mixed evidence regarding physical activity and beneficial impact on cholesterol, as a systematic review on diabetes found no benefit (Thomas et al 2007) but a randomised controlled trial found benefit for HDL (Takeshima et al 2004).
- Physical activity has been linked to beneficial changes in blood triglycerides for older people (Mozaffarian et al 2008; Thomas et al 2007; Villareal et al 2006a).
- There appears to be an inverse dose–response relationship between amount of leisure time physical activity and atrial fibrillation, and similar inverse dose–response relationships have been found between risk of atrial fibrillation and walking distance, walking pace, and walking distance by pace (Mozaffarian et al 2008).
- Moderate intensity physical activity showed lowest risk levels for atrial fibrillation, though vigorous intensity was not associated with increased risk (Mozaffarian et al 2008).
- The majority of studies show physical activity to be beneficial for the prevention of cardiovascular disease generally, including heart disease (Garg et al 2006; Warburton et al 2010; Warburton et al 2006).

Prevention of cancer

Among major causes of morbidity and mortality, various types of cancer feature prominently in older populations.

Seven papers were reviewed. Some studies within systematic reviews, eg, Warburton et al 2010, may be based on or include younger people, though the chronic disease under review is typically more likely to affect older people. The findings from these studies are described in the following paragraphs.

Monninkhof reported on a systematic review which included 17 cohort studies and 28 case-control studies that assessed leisure-time activities, of which approximately half (8/17 cohort studies and 14/28 case-control studies) demonstrated risk reduction benefits of physical activity in relation to breast cancer (Monninkhof et al 2007). Menopausal status appeared to be a moderating influence, as risk reductions of 20–80% were observed for physically active post-menopausal women relative to inactive post-menopausal women. Furthermore, there was evidence for a dose–response relationship, as trend analysis showed a 6% decrease in breast cancer risk for each additional hour of physical activity per week. This systematic review is likely to include adults under the age of 65.

Warburton and colleagues large systematic review, including 43 studies on breast cancer and 33 studies on colon cancer, found clear support for a protective dose–response relationship between physical activity and breast cancer and colon cancer (Warburton et al 2010). Results showed that physical activity was inversely related to the risk of colon cancer, with a mean risk reduction of 30% comparing the most active group versus the least active group. For breast cancer, this study found a mean risk reduction of 20% across all studies comparing the most active group versus the least active group. Warburton and colleagues also reported on all-cause mortality, cardiovascular disease, hypertension, osteoporosis, and type 2 diabetes (see above and below). This systematic review is likely to include adults under the age of 65.

Bardia reported on a prospective cohort study of 41,836 US post-menopausal women aged between 55 to 69 years (Bardia et al 2006). This study found that high levels of recreational physical activity were associated with an approximate 14% lower risk of breast cancer. Further, Risk reduction varied by hormonal (estrogen and progesterone) receptor status of the tumour, being most marked for estrogen-positive/progesterone-negative tumours, which, in general, have been associated with a clinically more aggressive tumour phenotype.

Dallal reported on a prospective cohort study of 110,599 US women aged between 20–79 years, which examined the role of long-term strenuous recreational physical activity on the risk of breast cancer (Dallal et al 2007). This study found that strenuous physical activity had a protective role against invasive and in situ breast cancer. Invasive breast cancer risk was inversely associated with long-term strenuous activity, as was in situ breast cancer risk. Strenuous and moderate long-term activities were associated with reduced risk of estrogen receptor-negative but not estrogen receptor-positive invasive breast cancer.

Chao reported on a prospective cohort study of 151,174 men and women from the US, which examined the association between recreational physical activity and risk of colon and rectal cancer (Chao et al 2004). Participants were a median age of 63 at baseline, followed over six years. In this study, colon cancer risk decreased in proportion to increased total hours of physical activities per week, a dose–response relationship. This relationship was not found for rectal cancer, but in older men and women, recreational physical activity was nevertheless related to a decreased rectal cancer risk. The multivariate-adjusted rate ratios (95% confidence intervals) associated with any recreational physical activity compared with none were reduced by 13% for colon cancer and 30% for rectal cancer. Colon cancer risk decreased significantly with increasing total hours and metabolic equivalent hours per week of activities. No clear decrease in rectal cancer risk was seen with increasing hours per week of physical activity. Past exercise, reported more than 10 years prior, was not associated with risk of either colon or rectal cancer.

Carlton and colleagues published a prospective cohort study assessing the long-term association between physical activity and colon cancer in 31,783 US women aged 61 at baseline (Calton et al 2006). This study showed that there was no significant relationship between activity level and colon cancer. Further, the relationship between physical activity and colon cancer risk did not vary by anatomic subsite or across subgroups defined by age, body mass, dietary fibre intake, menopausal status, menopausal hormone use or aspirin use.

In the prospective cohort of 47,620 older male health professionals aged 40–75 years at baseline, Giovannucci found that for men over the age of 65, there was a lower risk in those men doing the greatest amounts of vigorous activity for advanced prostate cancer, compared to men who did no vigorous physical activity. This study also found that relative to older adult men who had consistently low levels of total physical activity, the relative risks for advanced prostate cancer were greater for men who had reduced their physical activity from a high to a low category, much lower for men who had increased their physical activity from a low to a high level, and much lower for men who had consistently remained in a high level of activity (Giovannucci et al 2005). Giovannucci also reported on cancer mortality (see above).

Conclusions and implications: prevention of cancer

Two systematic reviews and five prospective cohort studies are presented. Given this collection of evidence, findings can be interpreted with confidence for cancer generally, but not for various subtypes of cancer. Warburton and colleagues' systematic review makes a strong contribution to the evidence base, due to its large number of included studies and participants, and recent review of literature (Warburton et al 2010).

Physical activity levels of participants in the studies included in the systematic reviews are typically grouped into three or four categories. The lowest group reports little or no moderate to vigorous physical activity during occupation or leisure time on most days and the highest group typically reports 30 minutes or more of moderate to vigorous physical activity on most days.

- Relative to more active older people in the population, those who report the least physical activity are frequently shown to have higher risk of breast cancer, even when adjusting for likely confounding variables (Bardia et al 2006; Dallal et al 2007; Monninkhof et al 2007; Warburton et al 2010), but there is some inconsistency in this relationship. A large systematic review found that about half of the included cohort and case-control studies reported that physical activity was beneficial for reducing breast cancer risk (Monninkhof et al 2007). This suggests that physical activity may be a modifiable risk factor for breast cancer, and that increasing physical activity level can decrease breast cancer risk, but more high-quality studies are needed for confirmation of this finding.
- Older people who report the least physical activity, relative to more active older people in the population are also often shown to have higher risk of colon cancer, even when adjusting for likely confounding variables (Chao et al 2004; Warburton et al 2010), but there are inconsistent findings, and a large prospective cohort found no relationship between physical activity and colon cancer in women (Calton et al 2006).
- There is some evidence for a protective relationship between physical activity and rectal cancer (Chao et al 2004) but this evidence is insufficient and more high-quality studies are needed.
- There is some evidence for a protective relationship between physical activity, particularly vigorous intensity, and prostate cancer (Giovannucci et al 2005). This evidence is insufficient and more high-quality studies are needed.
- Overall, the evidence suggests that physical activity is a modifiable risk factor for cancer, and that increasing physical activity level may decrease cancer risk.

Prevention of neurological disorders/cognitive decline

Twelve papers were reviewed. The findings from these studies are described in the following paragraphs.

Van Uffelen conducted a systematic review of 23 randomised controlled trials that evaluated physical activity interventions in people with and without cognitive decline (van Uffelen et al 2008). Five of the studies reported that for people without cognitive decline, there were significant beneficial intervention outcomes for information processing, executive function or memories. Five of the studies showed benefits from physical activity interventions for general cognition, executive functioning, and memory for those people with cognitive decline.

Paterson reported on a systematic review of 34 studies which found mixed results of beneficial outcomes from physical activity interventions on cognitive function indices (Paterson et al 2010). Results from prospective cohort studies showed that a high level of physical activity was related to better cognitive functioning and lower dementia risk, but the intervention studies were more equivocal. Physical activity interventions in older people were found to result in improvement in physiological measures and physical function, but many did not show benefit for cognitive function.

Lee and colleagues reported on a systematic review of 37 studies which identified nine that pertained to the association between physical activity and dementia or cognitive health (Lee et al 2010). In this systematic review, results showed that eight of the nine selected studies exhibited significant inverse associations between physical activity and dementia or cognitive function. Leisure time physical activity, even of moderate level, appears to provide the benefit of reduced risk of dementia.

Weuve reported a prospective cohort study of 18,766 older women, aged 70–81 years at baseline, in the Nurse's Health Study (Weuve et al 2004). In this study, researchers examined the longitudinal association over two years, between physical activity and cognitive function. Results showed that the most physically active women were 20% less likely to become cognitively impaired, compared to the least active women. Among women performing the equivalent of walking at an easy pace for at least 90 minutes per week, mean global cognitive performance scores were significantly higher compared with those walking less than 40 minutes per week. This study found that energy expenditure through physical activity was associated with significantly better cognitive function and less cognitive decline in older women, especially those in the two highest quintiles of energy expenditure.

Abbott reported a prospective cohort of 2257 physically capable Hawaiian older men, in which researchers sought to determine whether the distance men walked per day was predictive of future risk of dementia (Abbott et al 2004). This study found that a higher amount of walking was associated with reduced risk of dementia, suggesting that promotion of physical activity in older men could help preserve late-life cognitive functioning.

One prospective cohort study, conducted by Larson and colleagues, followed 1740 American men and women without cognitive impairment at study start (Larson et al 2006). Results showed that incidence rate of dementia was 13.0 per 1000 person-years for participants who exercised three or more times per week compared with 19.7 per 1000 person-years for those who exercised fewer than three times per week. The age- and sex-adjusted hazard ratio of

dementia was 0.62 (95% CI = 0.44 to 0.86) in more frequent exercisers, relative to less frequent exercisers. Thus, a regular physical activity regimen was associated with a delay in onset of Alzheimer's disease and dementia.

Lautenschlager reported on a randomised trial conducted in Australia with 170 adults reporting memory problems, but without meeting criteria for dementia (Lautenschlager et al 2008). In this study, participants were randomly allocated to an education plus usual care group (without physical activity), or to a 24-week home based physical activity programme. Results showed a modest improvement in cognition among the exercising group over an 18-month follow-up period relative to controls.

Niti and colleagues conducted a prospective cohort study of 1635 community dwelling Chinese men and women, with a mean age of 66 years (Niti et al 2008). Results showed that over one year of follow-up, cognitive decline was observed in 30% of the respondents. In analyses controlling for age, gender, education and other risk factors, odds ratios were significantly reduced in those with medium (odds ratio = 0.60, 95% CI: 0.45–0.79) and high physical activity levels (odds ratio = 0.62, 95% CI: 0.46–0.84).

Middleton reported a prospective study of 4683 unimpaired men and women taking part in the Canadian Study of Health and Aging (Middleton et al 2008), which assessed the relationship between physical activity and vascular cognitive impairment – no dementia. In this study, results showed that moderate–high physical activity for women was associated with lower odds of cognitive impairment relative to low physical activity for women. This study found a lack of similar association in men and no relationship between physical activity and mild cognitive impairment.

Scarmeas reported that in a prospective cohort study of 1880 older people without dementia in the US, physical activity was associated with a reduced risk of Alzheimer's disease (Scarmeas et al 2009). In that study, participants reporting much physical activity (weekly amounts of 1.3 hours of vigorous, 2.3 hours of moderate, or 3.8 hours of light physical activity, or a combination thereof) had a 33% reduction in Alzheimer's disease risk (hazard ratio = 0.67, 95%CI 0.47–0.95).

Baker reported on a small randomised controlled trial conducted with 33 men and women who had amnestic mild cognitive impairment (Baker et al 2010). Participants were randomized to either to six months of supervised vigorous aerobic physical activity or a flexibility-focused control group. Both groups met four days per week for 45 to 60 minutes. Results showed that besides improvements to fitness and body composition, aerobic physical activity improved multiple tests of cognitive function in women, while only one cognitive test improved for men.

Etgen and colleagues reported on a prospective cohort study of a sample of 3903 older German men and women, in which researchers examined the longitudinal association between physical activity level and incident cognitive impairment over a two-year follow-up period (Etgen et al 2010). Participants were categorised into three levels of physical activity, based on the number of days per week they performed 'strenuous' physical activity (0 days = no activity, 1–2 days = moderately active, 3–7 days = highly active). In models adjusted for potential confounders, results showed that both moderately active and highly active individuals had more than 30% reduced risk of cognitive impairment.

Conclusions and implications: prevention of neurological disorders/cognitive decline

Three systematic reviews, seven prospective cohort studies, and two randomised controlled trials are presented. Given this collection of evidence, findings can be interpreted with confidence. In particular, Paterson and Warburton's systematic review makes a strong contribution, due to its large number of included studies and participants, and recent review of literature (Paterson et al 2010).

Physical activity levels of participants in the studies included in the systematic reviews are typically grouped into three or four categories. The lowest group reports little or no moderate to vigorous physical activity during occupation or leisure time on most days and the highest group typically reports 30 minutes or more of moderate to vigorous physical activity on most days.

- There is abundant heterogeneity in physical activity programmes, measures of cognitive function, and measures of physical activity within the reviewed literature, making comparisons and conclusions difficult.
- Physical activity has been often been shown to be associated with cognitive ability, including general cognition, executive function, and memory (Lee et al 2010; Paterson et al 2010; van Uffelen et al 2008) but many studies have found mixed results or no benefit to cognitive ability from physical activity (Lee et al 2010; Paterson et al 2010; van Uffelen et al 2008).
- Some studies have found positive relationships between physical activity and cognitive function in a single-sex study of either males (Abbott et al 2004) or females (Weuve et al 2004), as well as in studies with both sexes (Etgen et al 2010; Larson et al 2006; Lautenschlager et al 2008; Niti et al 2008; Scarmeas et al 2009). Two studies have shown a positive relationship between physical activity and cognitive function more favourable for women (Baker et al 2010; Middleton et al 2008).
- Although benefits have been found by some studies in both observational and intervention studies, the evidence from prospective cohort studies provides more evidence of benefit from physical activity than does the evidence from randomised controlled trials (Paterson et al 2010). This suggests either that other variables may be influential in the relationship between physical activity and cognitive function, or that the apparent benefits in cognition are the result of more long-term exposure to physical activity, such that the reviewed randomised controlled trials may be too short in duration to show cognitive benefits consistently arising from the interventions that were evaluated.
- Despite the number of high quality studies identified for this review, the results within this evidence are equivocal and inconclusive, and additional high-quality studies using standardised measures of cognition and physical activity could help to elucidate potential relationships.

Prevention of sarcopenia

Two papers of high-level evidence were reviewed, supplemented by two additional lower-level evidence papers. The findings from these studies are described in the following paragraphs.

Hughes and colleagues conducted a small prospective cohort study over 10 years, with 54 men and 75 women with a mean baseline age of 60 years (Hughes et al 2004). This study found that increased physical activity amongst men and women was associated with less of a decline in lean tissue (measured at the thigh) over the 10-year follow-up period. Thus, physical activity appears to attenuate the decline in lean tissue expected with ageing.

Goodpaster and colleagues conducted a randomised controlled trial with 42 older men and women with moderate functional limitations to evaluate whether a physical activity intervention that included aerobic endurance, resistance training, balance, and flexibility exercises could attenuate the loss of strength and muscle mass and the gain muscle fat infiltration over time (Goodpaster et al 2008). Results showed that the loss of strength and the gain in muscle fat infiltration were nearly completely prevented through physical activity. Total weight and muscle mass, however, decreased despite the physical activity regimen. Based on this study's findings, it appears that physical activity prevents the age-associated loss of muscle strength, but not sarcopenia, in older people with moderate functional limitations.

Park and colleagues published a cross-sectional study that addressed the prevention of sarcopenia via physical activity (Park et al 2010). In this study, older Japanese men and women (aged 65 to 84 years) wore pedometers continuously for a whole year to capture physical activity levels, and were measured for skeletal muscle mass via dual X-ray at the end of the year. This study found that after statistically controlling for age and sex, muscle mass was associated with physical activity, more closely for the legs than the arms, and more closely for moderate physical activity than for total steps. Researchers concluded that those who walked at least 7000 to 8000 steps per day, and/or accumulated 15 to 20 minutes per day in moderate intensity physical activity were likely to have a muscle mass level above the threshold for sarcopenia.

A large narrative review by Paterson and colleagues addressed the prevention of sarcopenia, in the greater context of literature around ageing and physical activity (Paterson et al 2007). This review found that physical activity interventions that provide sufficient neuromuscular stress can counter sarcopenia in healthy individuals, even those over 90 years of age. This review indicated that such physical activity is also beneficial for strength and power to enhance quality of life and maintain independence.

Conclusions and implications: prevention of sarcopenia

No systematic reviews were available. One randomised controlled trial and one prospective cohort study are presented, supplemented with lower-level evidence from a narrative review and cross-sectional study. Given this rather limited evidence, findings should be interpreted with caution.

The physical activity levels under investigation in the reviewed studies were heterogeneous. In the prospective cohort study, physical activity levels of participants were measured by questionnaire, and converted into estimates of energy expenditure (Hughes et al 2004). In the randomised controlled trial, participants took part in physical activity programme of three sessions of 40 to 60 minutes in duration, mostly walking. In the cross-sectional study, ambulatory physical activity was measured via pedometer.

- In the prospective cohort study, more physically active older people had better body composition and lower levels of sarcopenia across 10 years of follow-up, compared to less physically active older people (Hughes et al 2004).
- In the randomised controlled trial, muscular fat infiltration was reduced and gains were made in strength, but sarcopenia was not prevented (Goodpaster et al 2008).
- Supplemental evidence suggests that physical activity may be beneficial for the prevention, delay, or slowing of sarcopenia (Park et al 2010; Paterson et al 2007).
- With regard to sarcopenia, physical activity appears to be protective factor, but the current collection of evidence is insufficient, and more high quality studies are needed in this topic area.

Prevention of kidney dysfunction

Three papers of high-level evidence were reviewed, and this was supplemented with one lower-level cross-sectional study. One of the high-level evidence papers separated the 'frail' older adult within the study population, and this study found no apparent benefit to kidney functioning in this population (Villareal et al 2006a).

The findings from these studies are described in the following paragraphs.

Jessup and colleagues conducted a randomised controlled trial to assess whether aerobic endurance training resulted in beneficial changes to renal function in a group of 23 older men and women (Jessup et al 1996). Results showed that older adults who were randomly assigned to 16 weeks of thrice weekly treadmill and stair-climber physical activity experienced no significant changes to effective renal plasma flow or glomerular filtration rate. Thus, there was no apparent benefit in kidney function from the aerobic endurance training undergone by the older participants in this study.

Villareal and colleagues conducted a randomised controlled trial assessing a lifestyle intervention that included resistance training, aerobic endurance training, and balance training, versus an inactive control condition in 27 obese older frail men and women from the US (Villareal et al 2006a). Results showed benefits from the intervention for body weight, fat mass, waist circumference, physical performance, aerobic capacity, functional status, strength, walking speed, and physical health scores. There was no apparent benefit, however, to measures of kidney functioning in this population.

In a study of 4011 American older men and women, Robinson-Cohen and colleagues investigated the association between physical activity and rapid decline in kidney function (Robinson-Cohen et al 2009). Results showed that the estimated risk of rapid decline in kidney function was 16% in the highest physical activity group and 30% in the lowest physical activity group. After multivariate adjustment, results showed that the two highest physical activity groups were associated with a 28% lower risk of rapid decline in kidney function than the two lowest physical activity groups (score of 2–3). Greater kilocalories of leisure-time physical activity and faster walking pace were also each associated with a lower incidence of rapid decline in kidney function.

A cross-sectional study by Finkelstein and colleagues investigated the association between various self-report measures of physical activity and the kidney function measures of glomerular filtration rate and urine microalbuminuria (Finkelstein et al 2006), Participants were US adults, aged 18 and older, from the NHANES III study, but Finkelstein and colleagues analysed data and reported findings for separate age groups, including 4549 men and women aged 56 years and older. Results showed that in statistical models adjusting for potential confounding factors, there was no significant relationship between physical activity variety, frequency, or energy expenditure and the two kidney function measures for older people.

Conclusions and implications: prevention of kidney dysfunction

No systematic reviews were available. Two randomised controlled trials and one prospective cohort study are presented, supplemented by lower-level evidence (a cross-sectional study). Given this very limited evidence, findings should be interpreted with caution.

Physical activity levels under investigation in the reviewed studies were heterogeneous. In the prospective cohort study, physical activity levels of participants were measured via questionnaire at baseline to estimate each participant's self-reported walking pace, exercise intensity, number of blocks walked per week, and leisure-time activity levels. These variables were combined to rank participant physical activity into seven ordinal groups. In the two randomised controlled trials, participants were assigned to thrice weekly aerobic endurance (Jessup et al 1996) or combined aerobic endurance and resistance training (Villareal et al 2006a) physical activity at moderate to vigorous intensity.

Kidney function was assessed with multiple markers, including blood urea nitrogen (Villareal et al 2006a), microalbuminuria (Finkelstein et al 2006) effective renal plasma flow, or glomerular filtration rate (Finkelstein et al 2006, 2006; Jessup et al 1996). Rapid decline in kidney function was defined by loss of more than 3.0 mL/min/1.73m^2 per year in glomerular filtration rate (Robinson-Cohen et al 2009).

- In the randomised controlled trials, no benefit to kidney function or prevention of kidney dysfunction was apparent from physical activity interventions of 16 to 26 weeks (Jessup et al 1996; Villareal et al 2006a).
- In the prospective cohort study, more physically active older people had 28% lower risk of rapid decline in kidney function over seven years of follow-up, compared to less physically active older people. A similar reduction in risk was seen for older people with a faster walking pace (Robinson-Cohen et al 2009).
- In the cross-sectional study, there was not a significant relationship between physical activity and kidney function (Finkelstein et al 2006).
- Randomised controlled trials may be too short in duration to reveal possible benefit to prevention of kidney dysfunction in older people. The current evidence is insufficient, and more high quality studies are needed in this topic area.

Prevention of osteoporosis

Four papers of high-level evidence were reviewed, supplemented by an additional cross-sectional study and a narrative review, both representing lower-level evidence. Some studies within systematic reviews (Bonaiuti et al 2002; Kelley 1998; Warburton et al 2010) are based on, or include younger people, though osteoporosis progressively worsens with age. The findings from these studies are described in the following paragraphs.

Kelly and colleagues reported on a systematic review of six intervention studies that evaluated the effectiveness of physical activity for promoting bone density (Kelley 1998). The population included people under the age of 65 years. Five of the six interventions reviewed had an aerobic endurance component. Some specified that physical activity was weight-bearing, and at least one intervention included resistance training. This study's meta-analysis found an overall benefit to bone density from physical activity that was equivalent to a preferential change of over 2%.

Bonaiuti reported a systematic review of 18 randomised controlled trials, including 1423 participants between the ages of 45 and 70 years, which showed that weight bearing physical activity, resistance training, and aerobic endurance exercises all were beneficial in increasing bone mineral density of the spine (Bonaiuti et al 2002). In this study, walking was also beneficial in increasing bone mineral density of the hip.

In their recent systematic review, which included two observational studies related to physical activity and osteoporosis, Warburton and colleagues found those with higher levels of physical activity had lower risk for osteoporosis, compared to those with lower physical activity levels (Warburton et al 2010). Warburton and colleagues also reported on all-cause mortality, breast cancer, colon cancer, cardiovascular disease, hypertension, and type 2 diabetes, and identified a dose–response curve between physical activity levels and chronic diseases (see above and below).

Pang reported on a randomised controlled trial evaluating a physical activity intervention in a sample of 63 community-dwelling Canadian men and women over the age of 50 with chronic stroke (Pang et al 2005). The physical activity programme was designed to improve hip bone mineral density, as well as cardio-respiratory fitness, mobility, leg muscle strength, and balance. Results showed that there were significantly greater benefits in bone density for the physically active group, compared to controls.

Park and colleagues reported a cross-sectional study that addressed the prevention of osteoporosis via physical activity (Park et al 2007). In this study, older Japanese men and women (aged 65 to 83 years) wore pedometers continuously for a whole year to capture physical activity levels, and were measured for heel bone density via quantitative ultrasound technique at the end of the year. This study found that for both sexes, bone density was associated with physical activity in a dose–response manner. Nearly all men and women who achieved more than 6800 steps and 16 minutes of moderate-intensity physical activity per day had bone densities above the threshold for osteoporosis. Similarly, those who walked less than 6800 steps per day, and accumulated less than 16 minutes per day of moderate intensity physical activity were two to eight times more likely to sustain fractures, relative to the most active older people.

A large narrative review by Warburton and colleagues addressed primary and secondary prevention of osteoporosis across all ages (Warburton et al 2006). The populations within reviewed studies included people under the age of 65 years. This review indicated that weight-bearing and impact types of physical activity prevent bone loss associated with ageing. This review indicated that physical activity interventions were found to prevent or reverse about 1% of bone loss per year in postmenopausal women. Warburton and colleagues concluded that regular physical activity was beneficial for maintaining bone health and preventing of osteoporosis.

Conclusions and implications: prevention of osteoporosis

Three systematic reviews and one randomised controlled trial that represent high-level evidence are presented. Two supplemental papers, a review paper and cross-sectional study representing lower-level evidence, are also presented. Given this somewhat limited collection of evidence specific to older people, findings should be interpreted with caution.

The physical activity, as measured or randomly assigned to participants within the reviewed studies, showed great heterogeneity, including aerobic endurance, resistance training, weight-bearing physical activity, and more.

- Randomised controlled trials have demonstrated that aerobic endurance exercise or resistance training has been beneficial in increasing bone mineral density of the spine and/or hip, which should be protective against osteoporosis (Bonaiuti et al 2002; Kelley 1998; Pang et al 2005).
- Physical activity, particularly of weight-bearing type, appears to be protective for osteoporosis, and physical activities that involve significant loading/impact are often advocated for the prevention of osteoporosis(Bonaiuti et al 2002; Kelley 1998; Pang et al 2005; Warburton et al 2010; Warburton et al 2006).
- Based on the high-level evidence, it is presently difficult to define clearly the precise characteristics of physical activity programmes required to cause a reduction in the incidence of osteoporosis, and further research is needed, in particular research that examines the relationship between physical activity and the incidence of osteoporosis in both sexes from varied ethnic backgrounds (Warburton et al 2010).
- The current evidence for osteoporosis prevention in older people is insufficient, and more high quality studies are needed in this topic area.

Prevention of insulin resistance and type 2 diabetes

Five papers of higher-level evidence were reviewed, and two supplemental papers provided lower-level supplemental evidence. Most literature addressing the relationship between physical activity and type 2 diabetes is based on populations of adults younger than age 65, and there is ample evidence in general adult literature to suggest a strong preventive role for physical activity (Warburton et al 2010). The findings from these studies are described in the following paragraphs.

Thomas published a systematic review and meta-analysis, which evaluated 14 randomised controlled trials including 377 older participants with type 2 diabetes to investigate health-related benefits derived from physical activity interventions (Thomas et al 2007). The participants included those under the age of 65. The results of this systematic review and meta-analysis showed that physical activity improves control of blood glucose and reduces levels of visceral adiposity and triglycerides, but does not result in beneficial change to plasma cholesterol in this population.

DiPietro and colleagues randomly assigned older women to one of three conditions in their trial: moderate-intensity or high-intensity aerobic endurance training, or a low-intensity placebo control group (DiPietro et al 2006). Results showed that there were significant improvements in glucose utilisation and insulin-stimulated suppression for the high-intensity aerobic endurance training group. Findings suggest that long-term higher intensity exercise training provides more enduring benefits to insulin action compared with moderate- or low-intensity exercise, likely due to greater transient effects.

Davidson and colleagues studied older sedentary people with excess abdominal adiposity (Davidson et al 2009). In this trial, participants were randomised to resistance training, aerobic endurance training, resistance and aerobic endurance training (combined), or a no-intervention control group. The researchers found that insulin resistance improved in both the aerobic endurance and combined groups.

A randomised controlled trial was conducted by Baker and colleagues with 33 men and women who had mild cognitive impairment (Baker et al 2010). Participants were randomised to either to six months of supervised vigorous (high intensity) aerobic endurance physical activity, or a low-intensity flexibility-focused control group. Results showed that for women, aerobic endurance improved glucose disposal during the metabolic clamp, and reduced fasting plasma levels of insulin.

Demakakos and colleagues conducted a prospective cohort study with 7466 men and women, with a mean age of 64, who were free of type 2 diabetes at baseline and were followed over 10 years (Demakakos et al 2010). Results showed that moderate-to-vigorous intensity physical activity at least once a week was associated with 36% reduced risk of type 2 diabetes after adjustment for all covariates. Age-stratified analysis showed that low-intensity physical activity at least once a week was associated with 47% reduced risk of type 2 diabetes for those aged 70 years and over, after adjustment for all covariates. Compared with physical inactivity, any type of physical activity was associated with reduced risk of type 2 diabetes in adults aged 70 years and over.

Park and colleagues published a cross-sectional study that addressed the prevention of osteoporosis via physical activity (Park et al 2008). In this study, older Japanese men and women (aged 65 to 84 years) wore pedometers continuously for a whole year to capture physical activity levels, and were screened for metabolic syndrome at the end of the year. This study found that the risk of metabolic syndrome was about four times greater in the least physically active participants, compared to the most active. Older people who took 8000 to 10,000 steps, or achieved 20 to 30 minutes of moderate to vigorous intensity physical activity per day were unlikely to have metabolic syndrome.

Warburton and colleagues reported a large narrative literature review that addressed primary and secondary prevention of diabetes across all ages (Warburton et al 2006). The populations within reviewed studies included people under the age of 65 years. This review indicated that both aerobic and resistance types of exercise have been shown to be associated with a decreased risk of type 2 diabetes. Accumulating evidence supports the importance of physical activity for prevention of type 2 diabetes, but additional research is required to determine the most beneficial type and dose of physical activity for diabetes prevention.

Conclusions and implications: prevention of type 2 diabetes

One systematic review, three randomised controlled trials and one prospective cohort study are presented, supplemented by lower-level evidence. Given that there is little high-level evidence that strictly pertains to older people, findings should be interpreted with caution.

The physical activity, as measured or randomly assigned to participants within the reviewed studies, showed great heterogeneity, including aerobic endurance, resistance training, and other types of physical activity. In the prospective cohort study, baseline physical activity was categorised as physical inactivity or low-intensity physical activity or moderate-to-vigorous-intensity physical activity at least once a week (Demakakos et al 2010).

- Physical activity appears to improves control of blood glucose and reduce levels of insulin, visceral adiposity and triglycerides (Baker et al 2010; Davidson et al 2009; Thomas et al 2007), but does not result in beneficial change to plasma cholesterol in the adult population (Thomas et al 2007).
- In randomised controlled trials, beneficial reductions in diabetes risk have been found for aerobic endurance (Baker et al 2010; Davidson et al 2009; DiPietro et al 2006; Warburton et al 2006) and resistance training (Warburton et al 2006) or resistance training combined with aerobic endurance training (DiPietro et al 2006).
- In the prospective cohort study, for those aged 70 and over, low-intensity physical activity, done at least once a week, was associated with reduced risk of type 2 diabetes (Demakakos et al 2010). Based on this study, any intensity of physical activity may reduce the risk of type 2 diabetes in adults aged 70 years and over, in comparison with physical inactivity.
- In the prospective cohort study, across all ages, moderate-to-vigorous intensity physical activity performed at least once a week was associated with reduced risk of type 2 diabetes (Demakakos et al 2010).
- Supplemental data from the cross-sectional study suggests that older people who take 8000 to 10,000 steps, or achieve 20 to 30 minutes of moderate to vigorous intensity physical activity per day may be less likely to have metabolic syndrome (Park et al 2008).
- Higher intensity, or vigorous physical activity appears to provide more enduring benefits to insulin action, compared with moderate- or low-intensity physical activity, but more research is needed to confirm this finding (DiPietro et al 2006).
- The current evidence for physical activity's role in prevention of insulin resistance and type 2 diabetes in older people is insufficient, and more high quality studies are needed in this subject area.

Prevention of depression

Four papers were reviewed. The findings from these studies are described in the following paragraphs.

Lampinen and colleagues conducted a prospective cohort study in Finland, with 663 older men and women (Lampinen et al 2000). In this study, participants who were the least physically active at baseline assessment had greater risk for increased depression at follow-up. Those who reduced the intensity of their physical activity over the eight-year follow-up period reported more depressive symptoms than those who remained steadily physically active, or those who increased their level of activity. Thus, this study suggests that older people who are inactive or who reduce their physical activity level are at greater risk for depression, compared to more physically active older people.

Strawbridge and colleagues conducted a prospective cohort study with nearly 2000 participants aged 50 to 94 at baseline, and followed over five years of study (Strawbridge et al 2002). This study sought to determine whether physical activity was associated with depression incidence and prevalence. Results showed that after statistically controlling for age, sex, financial stress, chronic conditions, disability, alcohol, smoking, and social support, there was a significant protective relationship between physical activity level and depression incidence and prevalence. Thus, physical activity appears to be influential in the prevention of depression for older people.

Ku and colleagues conducted a prospective cohort study in Taiwan, with 3778 men and women, aged 50 years and older, who were followed for seven years (Ku et al 2009). Participants were assessed on their frequency of physical activity sessions per week at the study beginning, and three years later, and were categorised as high or low, depending on whether the frequency of physical activity was three or more times per week. In this study, multivariate models for predicting incident cases of depression were used, both including and excluding participants with physical limitation at baseline and depressive symptoms. Participants who were low in leisure-time activity at both time points were at 43% greater risk of developing depressive symptoms in 2003. Thus, this study showed that leisure-time physical activity was associated with reduced risk of significant depressive symptoms in older Taiwanese adults.

Walker and colleagues conducted a randomised controlled trial with 909 men and women aged 60–74 years in Australia (Walker et al 2010). This trial compared various intervention arms, including dietary supplementation, mental health literacy and physical activity promotion. Results showed that participants in the physical activity promotion arm did not decrease in depressive symptoms at any time point. This lack of demonstrated benefit, however, may have stemmed from poor compliance with the physical activity programme among participants.

Conclusions and implications: prevention of depression

No systematic reviews were identified. Three prospective cohort studies and one randomised controlled trial are presented. Given this somewhat limited evidence, findings should be interpreted with caution.

Physical activity levels of participants in the prospective cohort studies reviewed are grouped into ordinal categories from the lowest group that reports little or no moderate to vigorous physical activity during occupation or leisure time on most days to the highest group that typically reports 30 minutes or more of moderate to vigorous physical activity on most days.

- The prospective cohort studies show clear protective relationships between physical activity level and depression in older study participants (Ku et al 2009; Lampinen et al 2000; Strawbridge et al 2002).
- In one prospective cohort study, those who did not achieve three physical activity sessions per week were at greatest risk of depression at the study conclusion, relative to more active older people (Ku et al 2009). Another cohort study showed that older people who are inactive or who reduce their physical activity level over time may be at greater risk for depression, compared to more physically active older people (Lampinen et al 2000).
- However, observational evidence from prospective cohort studies is not supported by the randomised controlled trial, which found no protective effect for older people who participated in physical activity (Walker et al 2010). This difference may be due to a longer time of study for prospective cohort studies, potential bias from self-selection or confounding variables, poor intervention compliance, or other possibilities, and further high-quality research is needed in this subject area.
- Although there is substantial literature on physical activity interventions for the treatment or management of depression and depressive symptoms in older people (see below section on management), the current evidence on primary prevention is insufficient, and more high quality studies are needed in this subject area.

Prevention of physical disability

Five papers were reviewed and three papers separated the ‘frail’ older adult within the study population (Binder et al 2002; Daniels et al 2008; Faber et al 2006). These studies on frailty showed that physical activity may reduce disability in frail older people (Binder et al 2002; Daniels et al 2008), but one study found that physical activity may be more beneficial in pre-frail older people, as opposed to the frail (Faber et al 2006).

Some studies within systematic reviews (eg, Paterson et al 2010) may be based on or include younger people.

The findings from these studies are described in the following paragraphs.

A systematic review by Daniels and colleagues looked at eight clinical trials to evaluate the effects of physical activity on disability and activities of daily living among older people (Daniels et al 2008). Results of the review showed that of the eight interventions, three reported that physical activity reduced measures of disability in the older frail men and women studied.

In a systematic review by Paterson and colleagues, 66 studies were used to assess the relationship between physical activity and physical function (Paterson et al 2010). Given the size of the systematic review, it is likely that it includes younger adults. In this study, both aerobic endurance and resistance training physical activity interventions for older adults led to physiological and functional improvements, reduced risk of functional limitations, and a likely reduction in long term disability. Furthermore, the review showed consistent findings across varying types of studies with a broad range of functional independence measures. From the review, researchers concluded that moderate to vigorous physical activity confers protection in physical function.

Binder and colleagues randomly assigned 115 older people American frail men and women to one of two physical activity conditions over nine months of study (Binder et al 2002). One condition involved supervised resistance training, flexibility exercises, and balance training, while the other condition consisted of low-intensity flexibility exercise at home. This study demonstrated that physical activity can improve measures of physical function and preclinical disability in older people who have impairments in physical performance and oxygen uptake.

Kritchevsky and colleagues followed 3075 well-functioning community-dwelling older women and men who were in their 70s at baseline in a four-year prospective cohort study (Kritchevsky et al 2005). Results showed that the physically active participants (those who reported more than 1000 kilocalories per week of physical activity- exercising, walking, and stair climbing) were less likely to develop mobility limitation.

In a randomised controlled trial evaluating group physical activity for 278 men and women, Faber and colleagues randomly assigned participants to a no-intervention control group, a functional walking group, or to a balance group (Faber et al 2006). Results showed small improvements in mobility assessment and physical performance for participants in both physical activity groups, and those in the walking group showed small improvement in disability rating. This study identified favourable outcomes from physical activity amongst the pre-frail, but not frail older people, suggesting that physical activity intervention programmes may need to target older people before older people succumb to unintentional weight loss, weakness, exhaustion, slowness, and low physical activity, if falls are to be prevented.

Conclusions and implications: prevention of physical disability

Two systematic reviews, two randomised controlled trials, and one prospective cohort study are presented. Given this collection of evidence, findings may be interpreted with confidence. In particular, Paterson and colleagues' systematic review makes a strong contribution, due to its number of included studies and participants (Paterson et al 2010).

Physical activity levels under investigation in the reviewed studies were heterogeneous. Types of physical activities in the reviewed studies have included aerobic endurance, resistance training, functional walking, flexibility, balance, and combinations of these.

- Physical activity may reduce disability in frail older people (Binder et al 2002; Daniels et al 2008), but not all studies show beneficial effects (Faber et al 2006).
- From the evidence available, moderate to vigorous physical activity appears to confer protection in physical function (Paterson et al 2010).

- There may be a dose–response relationship between physical activity and physical functioning, but more high-quality studies are needed to confirm these findings (Kritchevsky et al 2005; Paterson et al 2010).

Physical activity and the management of health conditions

Background

Given the numerous ways in which physical activity has been linked to positive health outcomes, researchers have evaluated the potential of many physical activity interventions for improving health or preventing disease for various populations. For older people, various physical activity interventions have been designed to manage or treat specific diseases or conditions, and the benefits of physical activity identified in these studies are described in this chapter. The benefits from physical activity for the management of vascular diseases, heart disease, stroke, various types of cancer, arthritis, obesity, type 2 diabetes, pulmonary diseases, depression, neurological disorders, insomnia and disability are discussed further in this section.

Body of evidence

Fifty-nine articles that met the inclusion criteria were identified in relation to physical activity and the benefits it provides relevant to the management of specific diseases and conditions. All of the included articles were considered to be of good or mixed quality. None of the included articles were considered to be poor quality. There were:

- 29 systematic reviews (Ashworth et al 2005; Bartels et al 2007; Bendermacher et al 2006; Blake et al 2009; Brosseau et al 2003; Chien et al 2008; Daniels et al 2008; Davies 2010; Forster et al 2009; Fransen et al 2008; Fransen et al 2009; Frazer et al 2005; Goodwin et al 2008; Heyn et al 2004; Holland et al 2008; Kay et al 2006; Latham et al 2004; Luctkar-Flude et al 2007; Mehrholz et al 2010; Montgomery et al 2002; Morris et al 2004; Rolland et al 2007; Saunders et al 2009; Sjösten et al 2006; Taylor 2010; Taylor et al 2004; Thomas et al 2007; van de Port et al 2007; Watson et al 2008) and
- 28 randomised controlled trials (Blumenthal et al 2005; Callahan et al 2008; Davidson et al 2009; Fatouros et al 2005; Forbes et al 2008; Fransen et al 2007; Guell et al 2006; Hung et al 2004; Irwin et al 2008; Kerse et al 2010; LeMaster et al 2008; Mador 2004; Marigold et al 2005; McDermott et al 2009; Messier et al 2004; Mikesky et al 2006; Morey et al 2009b; Motl et al 2005; Nicklas et al 2004; Pang et al 2005; Singh et al 2005; Suetta et al 2004; Villareal et al 2006a; Villareal et al 2006b; von Bonsdorff et al 2008; Walker et al 2010; Windsor et al 2004; Wisloff et al 2007).

Summary of findings

The findings of the review in relation to the beneficial role of physical activity in the management of health conditions are summarised below by condition type, starting with the management of vascular disease.

Management of vascular disease (peripheral arterial disease, intermittent claudication)

Four papers were reviewed. The findings from these studies are described in the following paragraphs.

Ashworth and colleagues conducted a systematic review, wherein six controlled trials were reviewed to evaluate the impact of physical activity programmes in a total sample of 392 people over the age of 50 with peripheral vascular disease or chronic obstructive pulmonary disease (Ashworth et al 2005). This systematic review found that for patients with peripheral vascular disease, centre-based programmes were superior to home-based programmes. Despite this finding, the authors of this systematic review suggested that across diseases, home-based programmes were more promising than centre-based programmes for long-term adherence to a physical activity routine. Aside from differences and comparisons between where physical activity programmes are based, the relevant message from these reviews is that exercising, wherever it takes place, can improve health and physical function in older people with peripheral vascular disease (Ashworth et al 2005).

Bendermacher's systematic review of eight randomised trials representing 319 older males and females aged between 40 and 86 years addressed the impact of physical activity interventions on those with intermittent claudication, which is a main symptom of peripheral arterial disease (Bendermacher et al 2006). This systematic review assessed whether supervised treadmill training was superior to an unsupervised walking programme in reduction of intermittent claudication. Results showed that supervised treadmill physical activity was superior to the unsupervised routine, but both interventions proved beneficial in the reduction of intermittent claudication.

Watson and colleagues published a systematic review of literature on physical activity programmes for intermittent claudication (Watson et al 2008). This review included 22 randomised controlled trials that collectively studied 1200 participants. The population included adults under the age of 65 years. Findings indicated that physical activity significantly improved walking performance measures, including pain-free walking distance, and that these improvements were seen up to two years later. However, physical activity did not affect ankle brachial pressure index, and outcomes were inconclusive for mortality, amputation, and peak exercise calf blood flow.

McDermott's randomised controlled trial evaluated two physical activity programmes amongst 156 US men and women aged over 60 years with peripheral arterial disease (McDermott et al 2009). The researchers found that both treadmill exercise and resistance training provided positive health-related benefits. A treadmill walking programme was beneficial for improving walking performance, blood flow, and quality of life, but not the short physical performance battery score. Resistance training was demonstrated to provide benefits in improved walking performance, quality of life, and stair climbing ability. This suggests that other forms of physical activity, besides the typically recommended walking programme, may be beneficial for older people with these vascular conditions.

Conclusions and implications: management of vascular disease

Three systematic reviews and one randomised controlled trial were reviewed in relation to vascular disease. Given this collection of evidence, findings can be interpreted with confidence. In particular, Watson and colleagues' systematic review makes a strong contribution, due to its number of included studies and participants (Watson et al 2008).

The types of physical activities in the reviewed studies included mostly centre-based or home-based walking.

- Physical activity programmes appear to be beneficial as improvements have been seen in walking performance measures, including pain-free walking distance, and that these improvements were seen up to two years later (Watson et al 2008).
- Physical activity interventions have demonstrated health benefits in improving functional capacity of people with vascular diseases, but the underlying physiological disease responsible for physical limitations likely remains unaffected (Ashworth et al 2005).
- Physical activity programmes provide benefits such as improvement to walking leg pain and related quality of life (Watson et al 2008).
- There was variation in the physical activity regimens studied, but many are based on walking. Walking programmes clearly improve walking time and distance for people considered fit for exercise regimens, which likely results in enhanced quality of life (Watson et al 2008).
- Health benefits have also been demonstrated from participation in resistance training for walking performance, quality of life, and stair climbing ability (McDermott et al 2009).
- Treadmill exercise was shown to be beneficial for improving walking performance, blood flow, and quality of life, but not other measures of physical performance (Watson et al 2008).
- Being physically active, wherever the physical activity takes place, can provide benefits in health and physical function for older people with peripheral vascular disease (Ashworth et al 2005).

Management of heart disease (chronic heart failure, ischemic heart disease)

Cardiac rehabilitation programmes are designed to restore the health of people with heart disease using physical activity, education, and psychological support (Taylor 2010).

Seven papers were reviewed. The findings from these studies are described in the following paragraphs.

In a systematic review of 48 randomised controlled trials representing 8940 participants, Taylor and colleagues conducted a meta-analysis of cardiac rehabilitation, relative to usual care (Taylor et al 2004). The population included adults under the age of 65 years. Physical activity, or 'exercise therapy', is a central component of cardiac rehabilitation (Taylor et al 2004). Participants in the usual care condition did not receive any form of structured exercise training or advice, but that received standard medical care, such as drug therapy. This study found that cardiac rehabilitation led to a reduction in all-cause mortality of about 20%, and a

reduction in cardiac mortality of about 25%. Cardiac rehabilitation programmes also resulted in greater reductions in total cholesterol and triglyceride levels.

Chien's systematic review of randomised controlled trials in older people with chronic heart failure included 10 studies with a total of 648 participants (Chien et al 2008). In the meta-analysis of these trials, home-based physical activity increased walking performance and peak oxygen consumption more than usual activity, but did not improve heart failure scores or odds of hospitalisation. The population included adults under the age of 65 years.

In another systematic review, Taylor and colleagues sought to compare home-based to centre-based cardiac rehabilitation (Taylor 2010). Physical activity, or 'exercise therapy', is a central component of cardiac rehabilitation (Taylor et al 2004). The systematic review included 12 randomised controlled trials with a total of 1938 participants, and found that cardiac rehabilitation appeared to be equally beneficial, regardless of setting, for improving health-related outcomes. The population included adults under the age of 65 years.

A systematic review by Davies analysed physical activity interventions from 19 randomised controlled trials that included 3647 adults over the age of 18 with heart failure (Davies 2010). This review of literature found that physical activity programmes, mostly consisting of brisk walking, reduced hospital admission rates and health-related quality of life, both in the short term, and for long-term assessments. This review, however, found no evidence suggesting physical activity to be either beneficial for all-cause mortality, or harmful for people with heart failure.

In a randomised controlled trial with 21 older women (aged 60–80 years) diagnosed with coronary artery disease, Hung sought to compare a programme of aerobic endurance training to a combined resistance training and aerobic endurance training programme (Hung et al 2004). Results showed that both programmes resulted in similar improvements to aerobic capacity, distance walked over six minutes, lower-body strength, and emotional and global quality of life. The combined programme, however, also resulted in improvements to upper-body strength and physical and social quality of life.

Blumenthal's randomised controlled trial of patients with ischemic heart disease in the US evaluated aerobic endurance training and stress management in relation to psychosocial functioning and markers of cardiovascular risk (Blumenthal et al 2005). Participants were aged 40 to 84 years. This study found that both the exercise and the stress management groups experienced greater benefits in reduced depression, psychological distress, and improved cardiovascular risk, relative to those receiving usual medical care alone (without physical activity).

A randomised controlled trial by Wisloff and colleagues evaluated an aerobic endurance training programme in a sample of 27 older Norwegian men and women with heart failure (Wisloff et al 2007). This study found that higher intensity physical activity was beneficial in reversing left ventricular remodelling and improving aerobic capacity, endothelial function, and quality of life in patients with post-infarction heart failure.

Conclusions and implications: management of heart disease

Four systematic reviews and three randomised controlled trials were reviewed in relation to heart disease. Given this collection of evidence, findings can be interpreted with confidence. In particular, Taylor and colleagues' systematic review and meta-analysis makes a strong contribution, due to its number of included studies and participants (Taylor et al 2004).

The types of physical activities in the reviewed studies included mostly centre-based or home-based aerobic endurance and resistance training exercises.

- Cardiac rehabilitation programmes, of which physical activity is a key component, appear to reduce all-cause mortality and cardiac mortality, and appear to improve certain risk factors, such as total cholesterol and triglyceride levels (Taylor et al 2004).
- No differences between cardiac rehabilitation and usual care (without physical activity) are apparent for myocardial infarction, revascularisation, high- and low-density lipoproteins, diastolic blood pressure, or quality of life (Taylor et al 2004).
- One small randomised controlled trial suggests that higher intensity physical activity may reverse left ventricular remodelling and improve aerobic capacity, endothelial function, and quality of life in patients with post-infarction heart failure (Wisloff et al 2007) but more studies are needed.
- For those older people with heart failure, physical activity is beneficial for improving walking performance, functional capacity, and health-related quality of life, but not for heart failure scores (Chien et al 2008; Davies 2010; Wisloff et al 2007). Also, there are equivocal findings for odds of hospitalisation (Chien et al 2008; Davies 2010) and no evidence suggesting physical activity programmes to be either harmful or beneficial for all-cause mortality in those with heart failure (Davies 2010).
- For those with ischemic heart disease, one randomised controlled trial suggests that a physical activity programme can result in reduced depression, psychological distress, and improved cardiovascular risk (Blumenthal et al 2005), but the evidence is insufficient at this time, and more studies are needed.
- Physical activity programmes, in either supervised settings or home settings can provide health benefits. Home-based rehabilitation programmes may result in better adherence over the long term (Chien et al 2008; Taylor 2010).
- Studies have frequently used aerobic walking programmes (Davies 2010), and more studies of resistance training or other forms of physical activity are needed. One randomised controlled trial evaluated aerobic training plus resistance training in a sample of older women, and found better fitness and quality of life outcomes, compared to aerobic training alone (Hung et al 2004).
- Many interventions include components beyond physical activity, such as stress management, so the individual contribution of physical activity on management of heart disease warrants further study (Blumenthal et al 2005; Taylor 2010; Taylor et al 2004).

Management of stroke

Five papers were reviewed. The findings from these studies are described in the following paragraphs.

Morris's systematic review of eight studies sought to determine whether progressive resistance training improves functional status in older people recovering from stroke (Morris et al 2004). The population included adults under the age of 65 years. Among the studies, three were randomised controlled trials, and the rest were uncontrolled pre-post trials. The authors concluded that progressive resistance training programmes reduced musculoskeletal impairment after stroke, but uncertainty remained with regard to the impact of strengthening on functional activities and societal participation.

Saunders' systematic review of 24 randomised controlled trials with a total sample of 1147 people with stroke also examined the benefits of physical activity programmes (Saunders et al 2009). The population included adults under the age of 65 years. This systematic review determined that evidence of benefit from exercise training in stroke victims for outcomes such as mortality, independence, and functional ability is unclear. The authors concluded, however, that there is sufficient evidence to include aerobic endurance training such as walking within rehabilitation programmes, as this is likely to be beneficial for improvement to walking aspects of independent walking ability (walking without assistive devices).

Van de Port conducted a systematic review and meta-analysis of 23 randomised controlled trials with 712 participants (van de Port et al 2007). The population included adults under the age of 65 years. Results showed that gait-oriented training interventions provided benefit to gait speed and walking distance, but not balance. Cardio-respiratory fitness programmes did not show benefit for gait speed, but did improve stair-climbing performance. No significant benefits were identified from programmes targeting lower-limb strengthening. Although functional mobility was positively affected, no evidence was found that activities of daily living, instrumental activities of daily living, or health-related quality of life were significantly affected by gait-oriented training.

Pang reported on a randomised controlled trial evaluating a physical activity intervention in a sample of 63 community-dwelling Canadian men and women over the age of 50 with chronic stroke (Pang et al 2005). The physical activity programme was designed to improve cardio-respiratory fitness, mobility, leg muscle strength, balance, and hip bone mineral density. Results showed that there were significantly greater benefits in fitness, mobility, leg muscle strength, and bone density for the physically active group, compared to controls.

Marigold and colleagues conducted a randomised controlled trial with 61 older Canadian men and women, with an average age of 68 years (including people between the age of 60 and 65 years) (Marigold et al 2005). In this study, both of the physical activity groups, agility or flexibility with weight shifting, led to improvements in all clinical outcome measures. The agility group demonstrated greater improvement in step reaction time and paretic rectus femoris postural reflex onset latency than the stretching/weight-shifting group. In addition, the agility group experienced fewer induced falls on the platform. Group exercise programmes that include agility or stretching/weight shifting exercises improve postural reflexes, functional balance, and mobility and may lead to a reduction of falls in older adults with stroke.

Conclusions and implications: management of stroke

Three systematic reviews and two randomised controlled trials were reviewed. Given this collection of evidence, findings can be interpreted with confidence. In particular, the systematic review by Saunders and colleagues makes a strong contribution, due to its number of included studies and participants (Saunders et al 2009).

The types of physical activities in the reviewed studies were heterogeneous, and included aerobic endurance, resistance training, gait-oriented training, mobility, agility, or flexibility exercises.

- The benefits from exercise training by stroke victims for outcomes of mortality, independence, and functional ability are presently unclear (Saunders et al 2009).
- Progressive resistance training programmes were shown to reduce musculoskeletal impairment after stroke, but uncertainty remained with regard to the impact of strengthening on functional activities and societal participation (Morris et al 2004; van de Port et al 2007).
- There is sufficient evidence to include aerobic endurance training such as walking within rehabilitation programmes, as this is likely to improve independent walking ability (walking without assistive devices) and stair-climbing performance (Saunders et al 2009; van de Port et al 2007).
- Gait-oriented training programmes appear to be beneficial for improving walking distance and gait speed, but there is no evidence such programmes improve activities of daily living, instrumental activities of daily living, or health-related quality of life (van de Port et al 2007).
- Various physical activity interventions appear to improve fitness and mobility in persons with stroke (Marigold et al 2005; Pang et al 2005; van de Port et al 2007).

Management of cancer (fatigue, function, and quality of life)

Three studies were reviewed. The findings from these studies are described in the following paragraphs.

Luctkar-Flude's systematic review of nine experimental studies and 10 observational studies of physical activity and fatigue in cancer patients found support for the notion of using physical activity during treatment of cancer (Luctkar-Flude et al 2007). The population included adults under the age of 65 years. Physical activity offers the strongest available evidence among interventions to combat cancer fatigue, and maintain functional status and quality of life.

Windsor reported on a randomised controlled trial of UK men with prostate cancer (aged between 52 and 82 years) which examined the role of a physical activity intervention in dealing with fatigue from cancer radiation treatments (Windsor et al 2004). In this trial, the men randomly assigned to the group advised to rest when feeling fatigued experienced a small decrease in their physical functioning and increase levels of fatigue after their course of radiation treatments. In contrast, those men randomly assigned to walking at home at a moderate intensity thrice weekly for 30 minutes experienced improved physical functioning and a lack of increase in fatigue.

Morey reported on a randomised controlled trial that took place in the UK, US, and Canada with survivors of colorectal, breast, or prostate cancer (Morey et al 2009b). In this study, participants who took part in a tailored diet and physical activity intervention programme that focused on resistance training and aerobic endurance were less likely to report functional decline than participants in the control condition. Furthermore, the intervention group participants experienced improved dietary and physical activity behaviours, greater weight loss, and better overall quality of life than those in the control group.

Conclusions and implications: management of cancer (fatigue, function, and quality of life)

One systematic review and two randomised controlled trials are presented. Given the limited body of evidence, findings should be interpreted with caution.

In the reviewed studies, physical activity typically consisted of walking or resistance training.

- Physical activity appears beneficial to combat cancer fatigue, maintain functional status and maintain quality of life in older people with cancer (Luctkar-Flude et al 2007; Morey et al 2009b; Windsor et al 2004).

Management of arthritis

Nine studies were reviewed. The findings from these studies are described in the following paragraphs.

Brosseau's systematic review included one randomised controlled trial with 39 older participants with mean age of 71 years, who had osteoarthritis of the knee (Brosseau et al 2003). This study found that aerobic physical activity (cycling), of either high intensity or low intensity, provided the benefits of improved gait, improved functional status, decreased pain, and greater aerobic capacity.

Bartels' systematic review of six randomised trials and quasi-experimental studies included about 800 participants with either knee or hip osteoarthritis (Bartels et al 2007). This review found that aquatic physical activity appeared to have positive health outcomes in people with hip and/or knee osteoarthritis, although the long-term benefits from physical activity interventions were not established.

Fransen's 2008 systematic review (Fransen et al 2008) analysed the literature on randomised controlled trials for pain and physical function in older people with osteoarthritis of the knee. It included 32 trials with data for over 3600 individuals. The population included adults under the age of 65 years. There was strong evidence in favour of physical activity, such that a physical activity programme is likely to lead to reduced knee pain and improved physical function for people with knee osteoarthritis. In this study, the size of the benefit was small, but comparable to that obtained by non-steroidal anti-inflammatory drugs.

Fransen's 2009 systematic review of five randomised controlled trials involving 2004 people with osteoarthritis of the hip, a majority of the studies tended to favour physical activity over no-treatment control for the outcome of pain, and pooled analysis supported the superiority of physical activity (Fransen et al 2009). There was, however, no overall difference between physical activity and control for improvements to physical function. The population included adults under the age of 65 years.

Messier reported on a randomised controlled trial of overweight and obese older people with knee osteoarthritis and physical disability to evaluate a long-term physical activity and weight loss programme in relation to physical function, mobility, and pain (Messier et al 2004). In this study, 316 older people (over the age of 60 years) were randomised to a healthy lifestyle (control), diet only, physical activity only, or diet plus physical activity group. Results showed significant benefits in physical function, walking and stair-climbing performance, and knee pain occurred in the diet plus physical activity group. In the physical activity-only group, walking performance improved, while the control group and diet-only group did not improve physical function, mobility, and pain.

In a sample of 36 Danish older men and women (aged 60–86 years) with hip osteoarthritis, Suetta and colleagues used a randomised controlled trial to evaluate a programme of resistance training during recovery from long-term muscle disuse and hip surgery (Suetta et al 2004). Results showed that resistance training was beneficial for increased muscle mass, maximal isometric strength, rate of force development, and muscle activation in these older men and women. Further, the study authors concluded that the improvement in muscle mass and neural function from resistance training was likely to have positive functional implications for older individuals.

Mikesky and colleagues conducted a randomised controlled trial to evaluate a resistance training programme compared to range-of motion training in a sample of men and women with osteoarthritis of the knee (Mikesky et al 2006). Participants were a mean age of 69 years. Results indicated that both resistance training and range-of motion groups decreased in leg strength over the course of 30 months, but this rate of strength loss was faster in the range of motion group. The resistance training group lost less strength and also found benefit in lesser knee joint space narrowing, compared to the range of motion group.

Fransen reported on a randomised controlled trial that compared 12 weeks of tai chi and hydrotherapy exercises with an inactive control group (Fransen et al 2007). Participants were older persons with hip or knee osteoarthritis (aged 64 to 76 years). This study found that both exercise conditions led to improvements in general health status, but that hydrotherapy also achieved significant improvements in physical performance, relative to controls. In addition, all significant improvements were sustained twelve weeks after the exercise classes ended.

Callahan reported on a randomised controlled trial that included 364 older Americans with arthritis (age range 32–94 years) (Callahan et al 2008). This study assessed the basic eight-week People with Arthritis Can Exercise (PACE) programme compared to a wait-listed control group. Results showed that older people in the exercise group experienced greater improvements in arthritis symptoms, better self efficacy for management of arthritis, and better functioning in upper and lower extremities. Furthermore, those who attended more of the physical activity classes had improvements in pain, fatigue, stiffness, functional outcomes, and self-efficacy for arthritis management.

Conclusions and implications: management of arthritis

Four systematic reviews and five randomised controlled trials were reviewed. Given this collection of evidence, findings can be interpreted with confidence. In particular, the two Fransen systematic reviews make a strong contribution, due to their number of included studies and participants (Fransen et al 2008; Fransen et al 2009).

Physical activity interventions were heterogeneous, including those designed to improve range of motion or strength, aerobic endurance cycling or aquatic exercises.

- Aerobic capacity and physical performance are likely to improve from physical activity programmes for older adults with arthritis (Brosseau et al 2003; Fransen et al 2007; Messier et al 2004; Suetta et al 2004).
- Physical activity has been shown to provide physical functioning benefits in arthritic populations (Brosseau et al 2003; Callahan et al 2008), including in overweight older people with arthritis when combined with weight loss (Messier et al 2004), but may not be beneficial for improving physical function in those with arthritis in the hip (Fransen et al 2009).
- Physical activity has been shown to provide benefits for pain in arthritic populations (Brosseau et al 2003; Fransen et al 2008).
- Physical activity may also lead to benefits for gait in arthritic populations (Brosseau et al 2003).
- One randomised controlled trial showed that resistance training was more beneficial than range-of-motion training (Mikesky et al 2006) and a different trial indicated aquatic exercise to provide better benefit than tai chi (Suetta et al 2004), but more studies are needed comparing various intervention approaches.
- Both land-based and water-based physical activities are associated with short-term positive outcomes for physical functioning in those with arthritis, and water-based physical activities may be preferred by some older people (Bartels et al 2007; Fransen et al 2008; Fransen et al 2007).

Management of obesity

Obesity is very common in older populations and is thought to be linked to frailty and exacerbation of the age-related decline in physical function (Villareal et al 2006b).

Six papers were reviewed. One of them focused on the ‘frail’ older adult (Villareal et al 2006b) and this study found a wide range of benefits were achieved from participation in the lifestyle intervention that included a physical activity programme.

Note that the systematic review by Kay and Singh (Kay et al 2006), presented results separately for adults aged 60 years and up.

The findings from these studies are described in the following paragraphs.

Kay and Singh systematically reviewed 27 experimental studies on physical activity in adults, and separate findings are presented for those aged 60 and up (Kay et al 2006). This study found that older-aged groups and type 2 diabetics can benefit from physical activity. With regard to obesity, abdominal adiposity can be reduced in older-aged men and women through moderate to high intensity physical activity, and changes in abdominal adiposity can occur in the absence of changes in body mass. Also, resistance training may be more suitable as a fat reduction strategy for older obese individuals than aerobic physical activity.

Messier reported on a randomised controlled trial of overweight and obese older people with knee osteoarthritis and physical disability (Messier et al 2004). In this study, 316 older people (aged 60 years and above) were randomised to a healthy lifestyle (control), diet only, physical activity only, or diet plus physical activity group. Results showed that diet plus physical activity was beneficial for improving physical function, walking and stair-climbing performance, and knee pain. In the physical activity-only group, walking performance improved, while the control group and diet-only group did not improve.

Nicklas examined additional outcomes using the same randomised controlled trial sample as reported by Messier (so the age range was 60 years and above), and determined that weight training and walking did not have a significant impact on inflammatory biomarkers in the overweight and obese (Nicklas et al 2004).

Villareal published two articles on a randomised controlled trial which assessed a lifestyle intervention versus control condition in 27 obese older men and women from the US (Villareal et al 2006a; Villareal et al 2006b). The lifestyle intervention consisted of six months of weekly weight loss behaviour therapy plus thrice-weekly physical activity training, including aerobic endurance, resistance training, and balance work. Results showed greater reductions in body weight, fat mass, waist circumference, plasma glucose, triglycerides, blood pressure, and proportion of people with metabolic syndrome for the intervention group relative to controls. Also, intervention participants improved in physical performance, aerobic capacity, functional status, strength, walking speed and physical health scores (Villareal et al 2006a; Villareal et al 2006b).

Davidson and colleagues studied older sedentary men and women with abdominal adiposity (aged between 60 years and 80 years) (Davidson et al 2009). In this trial, participants were randomised to resistance training, aerobic endurance training, resistance and aerobic endurance training (combined exercise), or a non-exercise control group. Intervention groups with aerobic endurance training performed 150 minutes per week of physical activity, while the resistance-only group performed 60 minutes per week. The researchers found that functional limitation improved significantly in all groups compared with the control group, insulin resistance improved in aerobic and combined exercise, but a combination of aerobic endurance training with resistance training was optimal for reducing insulin and functional limitations in this population.

Conclusions and implications: management of obesity

One systematic review and five randomised controlled trials are presented. Given this collection of evidence, findings can be interpreted with confidence. In particular, the systematic review by Kay and Singh makes a strong contribution, due to the number of included studies and participants (Kay et al 2006).

Physical activity interventions in the reviewed studies consisted of resistance training, aerobic endurance, or both.

- A lifestyle intervention consisting of six months of weekly weight loss behaviour therapy plus thrice-weekly physical activity training, including aerobic endurance, resistance training, and balance work was shown to reduce body weight, fat mass, waist circumference, plasma glucose, triglycerides, blood pressure, and proportion of people with metabolic syndrome (Villareal et al 2006a).
- Abdominal adiposity can be reduced in older-aged men and women through moderate to high intensity physical activity (Kay et al 2006).
- Physical activity interventions have been shown to lead to improvements in physical function, physical performance, physical fitness and health for overweight or obese older adults (Davidson et al 2009; Messier et al 2004; Villareal et al 2006b).
- Multi-component lifestyle interventions show promise for weight reduction and health improvement for older adults (Davidson et al 2009; Kay et al 2006; Messier et al 2004; Villareal et al 2006a; Villareal et al 2006b), but the individual contribution of physical activity on relevant health outcomes requires further study.

Management of type 2 diabetes (including metabolic syndrome)

Six papers were reviewed. Note that the systematic review by Kay and Singh (Kay et al 2006), presented results separately for adults aged 60 years and up.

The findings from these studies are described in the following paragraphs.

Kay and Singh systematically reviewed 27 experimental studies on physical activity in adults, and separate findings are presented for those aged 60 and up (Kay et al 2006). This study found that older-aged groups and type 2 diabetics can benefit from physical activity. With regard to obesity, abdominal adiposity can be reduced in older-aged men and women through moderate to high intensity physical activity, and changes in abdominal adiposity can occur in the absence of changes in body mass. Also, resistance training may be more suitable as a fat reduction strategy for older obese individuals than aerobic physical activity.

Thomas published a systematic review and meta-analysis, which evaluated 14 randomised controlled trials including 377 older participants with type 2 diabetes to determine potential health benefits from physical activity interventions (Thomas et al 2007). The results of this systematic review and meta-analysis showed that even without weight loss, physical activity beneficially improves control of blood glucose, and reduces levels of visceral adiposity and triglycerides. The population included adults under the age of 65 years.

Villareal published on a randomised controlled trial which assessed a lifestyle intervention versus control condition in 27 obese older men and women from the US (Villareal et al 2006a; Villareal et al 2006b). The lifestyle intervention consisted of six months of weekly weight loss behaviour therapy plus thrice-weekly physical activity training. Results showed greater reductions in body weight, fat mass, waist circumference, plasma glucose, triglycerides, blood pressure, and proportion of people with metabolic syndrome for the intervention group relative to controls. Also, intervention participants improved in physical performance, aerobic capacity, functional status, strength, walking speed and physical health scores (Villareal et al 2006a; Villareal et al 2006b).

LeMaster and colleagues studied 79 older men and women with diabetic peripheral neuropathy in a randomised controlled trial (LeMaster et al 2008). Participants were randomly assigned to either a control group, or to an intervention involving lower-extremity strengthening, balance, self-monitored and graduated walking to increase weight-bearing steps, and self care with telephone support. This study found that the physical activity programme was successful in increasing physical activity without increases in foot ulcers.

Davidson and colleagues studied older sedentary men and women (age range 56–76 years) with abdominal adiposity (Davidson et al 2009). In this trial, participants were randomised to resistance training, aerobic endurance training, resistance and aerobic endurance training (combined exercise), or a non-exercise control group. The researchers found that functional limitation improved significantly in all groups compared with the control group, insulin resistance improved in aerobic and combined exercise, but a combination of aerobic endurance training with resistance training was optimal for reducing insulin and functional limitations in this population.

Conclusions and implications: management of type 2 diabetes (including metabolic syndrome)

Three systematic reviews and two randomised controlled trials are presented (one of which is published in two papers). Given this collection of evidence, findings can be interpreted with confidence. In particular, the two systematic reviews make a strong contribution, due to their number of included studies and participants (Kay et al 2006; Thomas et al 2007).

The physical activity within the reviewed studies showed heterogeneity, including aerobic endurance, resistance training, and other types of physical activity.

- It is difficult to characterise the health benefits arising from the reviewed physical activity interventions, due to the wide variety of physical activities implemented (Thomas et al 2007).
- Carefully planned physical activity programmes may be implemented in older people who have diabetic peripheral neuropathy, without negative side effect of foot ulceration (LeMaster et al 2008).
- Physical activity interventions have been shown to decrease abdominal adiposity (Kay et al 2006; Thomas et al 2007; Villareal et al 2006a), improve control of blood glucose, reduce levels of central adiposity and triglycerides (Thomas et al 2007; Villareal et al 2006a), and reduce insulin resistance (Davidson et al 2009; Thomas et al 2007).

- There is some support for the use of physical activity in the management of type 2 diabetes, but more high-level studies are needed to bolster the evidence base.

Management of pulmonary diseases (interstitial lung disease, chronic obstructive pulmonary disease)

Four papers were reviewed. The findings from these studies are described in the following paragraphs.

Ashworth's systematic review of six controlled trials assessed the impact of physical activity programmes in a total of 392 people over the age of 50 years with peripheral vascular disease or chronic obstructive pulmonary disease (Ashworth et al 2005). This systematic review found that most of the reviewed studies show that exercise programmes, whether at home or at a centre, improve physical function, decrease blood pressure, and improve some tests for exercise, such as walking speed. For chronic obstructive pulmonary disease, however, quality of life and other tests for exercise did not improve.

Holland's systematic review of five randomised or quasi-randomised trials relevant to physical activity for interstitial lung disease found short-term improvements in exercise capacity, dyspnoea, and quality of life for people completing physical activity interventions (Holland et al 2008). Participant age range was 52–70 years. Longer-term benefits from the interventions were unclear. Although longer programmes and more frequent sessions appear to yield greater benefits in people with other chronic lung diseases, the amount and frequency of physical activity needed for beneficial health outcomes in those with interstitial lung disease is uncertain.

In a randomised controlled trial, Mador and colleagues compared the benefits from an aerobic cycling programme to those from a programme of resistance training plus aerobic cycling training (Mador 2004). Participants were 24 older Americans with chronic obstructive pulmonary disease (COPD). Six-minute walk distance, endurance exercise time, and quality of life (as measured by the Chronic Respiratory Questionnaire) significantly improved for both intervention groups. Although this trial found that strength trainers experienced benefits in muscle strength, such improvement in muscle strength did not translate into additive quality of life improvements or improvements in exercise performance beyond that provided by aerobic endurance exercise alone.

Physical activity has been used as part of pulmonary rehabilitation. Guell reported on a small randomised controlled trial which evaluated associated health benefits in participants with chronic obstructive pulmonary disease (Guell et al 2006). Participants were 40 Spanish women and men aged between 58 and 73 years. This study found that pulmonary rehabilitation resulted in beneficial decreases in psychological morbidity, and increases to functional capacity, and health related quality of life.

Conclusions and implications: management of pulmonary diseases

Two systematic reviews and two randomised controlled trials are presented. Given this collection of evidence, findings may be interpreted with confidence for pulmonary diseases generally, but caution is warranted for interpreting findings for sub-types of pulmonary disease.

The physical activity within the reviewed studies included aerobic endurance exercises, in some cases combined with resistance training. Physical activity interventions with aerobic endurance physical activity or aerobic and resistance training, ranged from two to five sessions per week over five weeks to six months (Ashworth et al 2005; Holland et al 2008; Mador 2004).

- Some evidence suggests short-term improvements from physical activity interventions in exercise capacity, difficulty breathing, and quality of life for older people with interstitial lung disease (Holland et al 2008) or chronic obstructive pulmonary disease (Guell et al 2006; Mador 2004), but evidence is equivocal (Ashworth et al 2005) and further research is needed.
- Physical activity programmes, whether at home or at a centre, may improve physical function, decrease blood pressure, and improve some tests for physical fitness for older people with chronic obstructive pulmonary disease (Ashworth et al 2005; Guell et al 2006; Mador 2004).

Management of depression

Eight papers were reviewed. The findings from these studies are as follows:

Frazer and colleagues conducted a systematic review of 23 studies, including meta-analyses of randomised controlled trials to determine which therapies proved beneficial for treatment of depression in older people (over the age of 60) (Frazer et al 2005). Results of this study showed that physical activity was included in the list of treatments with the best evidence of reducing depression, along with treatments such as antidepressants, electroconvulsive therapy, cognitive behaviour therapy, psychodynamic psychotherapy, reminiscence therapy, problem-solving therapy, and bibliotherapy.

Sjösten published a systematic review of 13 randomised controlled trials with a total sample of 1264 participants, aged 60 years and over (Sjösten et al 2006). The results of this systematic review demonstrated that physical activity interventions resulted in substantial short-term benefit for reducing depressive symptoms and in treating depression in people who suffered from minor or major depression.

Blake’s systematic review of 11 randomised controlled trials with a total of 642 participants assessed the ability of physical activity to reduce depressive symptoms (Blake et al 2009). This study found that the reviewed physical activity programmes were able to obtain clinically meaningful benefit for depressive symptoms in older people with depression and improved mood in this group. Short-term benefits related to depression or depressive symptoms were found in nine studies, with a variety of modes, intensities and durations of intervention across studies. Medium- to long-term benefits from physical activity intervention were less clear.

Motl and colleagues conducted a randomised controlled trial with 174 sedentary older men and women, aged 60 to 75 years, who had depressive symptoms (Motl et al 2005). Participants were randomised to either a walking or a resistance training physical activity programme. Results of this trial showed that depressive symptoms scores were decreased immediately after both physical activity interventions, followed by a sustained reduction for 12 and 60 months after intervention initiation. There was no differential pattern of change between the physical activity modes. This study supports the benefits derived from an exercise intervention for the sustained reduction of depressive symptoms among sedentary older people.

Singh conducted a randomised controlled trial with 60 older people in Australia who had minor or major depression (Singh et al 2005). In this trial, participants were randomised to a supervised high-intensity progressive resistance training group, low-intensity progressive resistance training group, or usual care (without physical activity). Results showed a marked decrease in depression for the high intensity group. In addition, the high intensity group also featured the best outcomes for quality of life and sleep quality. The study suggests that high-intensity resistance training is more beneficial than low-intensity training or general practitioner care for the treatment of older people with depression.

Blumenthal's randomised controlled trial of patients with ischemic heart disease in the US evaluated aerobic endurance training and stress management in relation to psychosocial functioning and markers of cardiovascular risk (Blumenthal et al 2005). Participants were aged 40 to 84 years. This study found that both the exercise and the stress management groups had reduced depression, psychological distress, and improved cardiovascular risk, relative to those receiving usual medical care alone (without physical activity).

Kerse and colleagues reported results from a randomised controlled trial with a sample of 193 older New Zealand men and women with depressive symptoms.(Kerse et al 2010). In this trial, participants received either an individualised physical activity programme delivered over 6 months, or the control condition of social visits. Results indicated no differences between groups on the outcomes. There were improvements in mood and mental health-related quality of life in both groups, suggesting a need for future studies to compare physical activity interventions against standard care.

Walker and colleagues conducted a randomised controlled trial with 909 men and women aged 60–74 years in Australia (Walker et al 2010). This trial compared various intervention arms, including dietary supplementation, mental health literacy and physical activity promotion. Results showed that participants in the physical activity promotion arm did not decrease in depressive symptoms at any time point, but this lack of benefit may have stemmed from poor compliance with the physical activity programme among participants.

Conclusions and implications: management of depression

Three systematic reviews and five randomised controlled trials are presented. Given this collection of evidence, findings can be interpreted with confidence. In particular, the systematic reviews by Sjosten and colleagues (Sjösten et al 2006) and by Blake and colleagues (Blake et al 2009) both make a strong contribution, due to their number of included studies and participants.

The physical activity within the reviewed studies showed heterogeneity, including aerobic endurance, resistance training, and other types of physical activity.

- Physical activity interventions, if participants comply with the intervention programme, appear to be beneficial in the treatment of depression for older people (Blake et al 2009; Frazer et al 2005; Kerse et al 2010; Motl et al 2005; Singh et al 2005; Sjösten et al 2006). One randomised controlled trial found no improvement from physical activity intervention, but the authors of that study suggested that the participants were not fully compliant with participation in physical activity (Walker et al 2010).
- A wide variety of types of physical activity interventions have been successful in reducing depression for older people, including walking, aerobic endurance training, progressive resistance training, and combined types of physical activity (Blake et al 2009; Frazer et al 2005; Kerse et al 2010; Motl et al 2005; Singh et al 2005; Sjösten et al 2006).
- There is some evidence that higher intensity progressive resistance training is more beneficial than lower intensity progressive resistance training for the treatment of depression, but current evidence is insufficient, and more high-quality studies are needed to bolster the evidence base (Singh et al 2005).

Management of neurological disorders (Dementia, Parkinson's disease, Alzheimer's disease)

Five papers were reviewed. The findings from these studies are described in the following paragraphs.

Heyn and colleagues reviewed thirty randomised controlled trials addressing physical activity benefits for people with cognitive impairment and dementia (Heyn et al 2004). Results of meta-analyses showed that physical activity provided benefits in strength, physical fitness, functional performance, cognitive performance, and behaviour. Thus, physical activity appears to increase fitness, physical function, cognitive function and positive behaviour in older people with cognitive impairment and dementia.

Forbes conducted a systematic review and identified four randomised controlled trials that assessed physical activity interventions for older people with dementia, but used only two of these trials in analyses (Forbes et al 2008). Results of the systematic review and meta-analysis suggested that there was insufficient evidence for the benefits from physical activity in managing or improving functioning, depression, behaviour, cognition, mortality, or symptoms of dementia in older people.

Goodwin and colleagues systematically reviewed fourteen randomised controlled trials addressing the benefits of physical activity for people with Parkinson's disease (Goodwin et al 2008). Results indicated that various physical activity interventions led to improvements in physical functioning, quality of life, strength, balance, and gait speed for people with Parkinson's disease. In this review, there was insufficient evidence support or refute the value of exercise in reducing falls or depression. Thus, the review found evidence of the potential benefits of exercise for people with Parkinson's disease, though additional high-quality research is needed.

Mehrholz systematically reviewed eight randomised controlled trials covering 203 participants with Parkinson's disease aged between 61–74 years (Mehrholz et al 2010). Results indicated that treadmill walk training was beneficial in improving walking speed, stride length, and walking distance, but cadence did not improve. The acceptability of the training for participants was good and there were few adverse events; however little is known about how long positive outcomes may last and longer-term studies are needed.

Rolland and colleagues conducted a randomised controlled trial to evaluate the effectiveness of a physical activity intervention in older people with Alzheimer's disease (Rolland et al 2007). Participants were randomised to a standard care control group, or to an intervention consisting of walking, resistance training, balance and flexibility components. Results of this study showed that activities of daily living showed a slower decline for those participating in the mixed physical activity intervention, and there was a significant difference between the groups in favour of the exercise programme in six-metre walking speed at 12 months. Physical activity, however, provided no benefit for behavioural disturbance, depression, or nutritional status.

Conclusions and implications: management of neurological disorders

Four systematic reviews and one randomised controlled trial are presented. Given this collection of evidence, general findings on neurological disorders can be interpreted with confidence. Given the diversity of morbidity represented within the neurological disorder category, however, findings for each sub-type of disorder should be interpreted with caution.

The physical activity within the reviewed studies showed heterogeneity, including aerobic endurance, resistance training, and other types of physical activity.

- For older adults with Parkinson's disease, physical activity may result in improved walking speed, stride length, walking distance (Mehrholz et al 2010), physical functioning, quality of life, strength, balance, and gait speed (Goodwin et al 2008) but little is known about long-term outcomes, and further studies are needed (Mehrholz et al 2010).
- Physical activity may increase fitness, physical function, cognitive function and positive behaviour in older people with cognitive impairment and dementia (Heyn et al 2004), although some studies show no benefit, and further high-quality studies are needed (Forbes et al 2008).
- One trial found physical activity to benefit walking speed and activities of daily living for older people with Alzheimer's disease (Rolland et al 2007). This study found that physical activity, however, provided no benefit for behavioural disturbance, depression, or nutritional status.
- Extant evidence on physical activity for older people with neurological disorders in general is insufficient, and more high-quality studies are needed to bolster the evidence base.

Management of disability

Four papers were reviewed. One of the papers focused on ‘frail’ older people in a systematic review (Daniels et al 2008). In this study, three of the eight reviewed interventions reported positive outcomes from physical activity interventions for those frail older people with disability.

The findings from these studies are described in the following paragraphs.

Latham’s systematic review of 62 randomised controlled trials with a total of 3674 participants was conducted to assess the impact of progressive resistance training on measures of disability in older people (Latham et al 2004). This review indicated that progressive resistance training was beneficial in improving muscle strength and certain aspects of functional limitations, but that benefits related to disability were unclear (Latham et al 2004). The population included adults under the age of 65 years.

Daniels’ systematic review of eight clinical trials evaluated physical activity interventions with regard to providing benefits for disability and activities of daily living in frail older people (Daniels et al 2008). Of the eight interventions, three reported beneficial outcomes for disability, but there was no evidence that single lower extremity resistance training provided benefit for disability. Rather, the long-lasting and highly intense multi-component interventions appeared to foster beneficial outcomes in activities of daily living for community-living frail older people.

Forster reported a systematic review of 49 randomised trials was conducted to evaluate rehabilitative physical activity interventions designed to improve physical functioning among older people in long-term care (Forster et al 2009). The collection of studies represented 3611 older participants, typically randomised to a control or intervention group that performed three sessions of exercise for 30–45 minutes per session over less than 20 weeks. This study’s authors concluded that physical activity rehabilitative interventions were worthwhile and safe, and were likely to improve physical condition and to reduce disability without adverse events.

Von Bornsdorff and colleagues conducted a randomised controlled trial in older people (von Bonsdorff et al 2008). Results showed that after the intervention period, independent activities of daily living (IADL) disability had increased in both groups, and was lower in the intervention group, but the group-by-time interaction effect did not reach statistical significance. Subgroup analyses revealed that the intervention prevented incident disability in subjects without disability at baseline but did not assist in recovery from disability. Thus, the physical activity counselling intervention had little benefit for older sedentary community-dwelling persons with a wide range of IADL disability, although it may have prevented incident IADL disability.

Conclusions and implications: management of disability

Three systematic reviews and one randomised controlled trial are presented. Given this collection of evidence, findings can be interpreted with confidence. In particular, the systematic reviews by Forster and colleagues (Forster et al 2009) make a strong contribution, due to the number of included studies and participants.

Physical activity interventions evaluated to manage disability typically involved three physical activity sessions per week, for 30–45 minutes per session over less than 20 weeks.

- A large systematic review of 49 randomised controlled trials concluded that physical activity interventions designed to rehabilitate older people in long-term care were worthwhile and safe, were likely to improve physical condition and were likely to reduce disability without adverse events (Forster et al 2009).
- The benefits of resistance training for disability in one large systematic review was deemed to be unclear, though benefits were seen in muscular strength and functional ability (Latham et al 2004).
- Physical activity interventions may be more useful for prevention of incident disability, than for recovery from disability, but evidence here is limited (von Bonsdorff et al 2008).
- The current evidence is somewhat equivocal with regard to effects of physical activity on disability and more high-quality studies are needed.

Management of sleep problems

Sleep quality and duration is an often overlooked influence on quality of life and physical functioning.

Three papers were reviewed. The findings from these studies are described in the following paragraphs.

A systematic review by Montgomery and colleagues included one randomised controlled trial that examined the influence of physical activity on sleep outcomes in older people over the age of 60 years (Montgomery et al 2002). This study included 43 participants with insomnia assigned to a programme of brisk walking and moderate resistance training. Results indicated that sleep onset latency improved slightly for men and women, total sleep duration, sleep onset latency and scores on a scale of global sleep quality showed significant improvement, but improvements in sleep efficiency were not significant. The authors concluded that physical activity may enhance sleep and contribute to better quality of life, but future trials are needed in this research area.

Singh conducted a randomised controlled trial with 60 older people in Australia who had minor or major depression (Singh et al 2005). In this trial, participants were randomised to a supervised high-intensity progressive resistance training group at 80% of one-repetition maximum, low-intensity progressive resistance training group at 20% of one-repetition maximum, or usual care (without physical activity). Both resistance training groups performed machine-based exercises three times per week three days per week for eight weeks. Along with improvements in depression, the high intensity group also featured the best outcomes for quality of life and sleep quality. The study suggests that high-intensity resistance training

provides greater benefit than low-intensity training or general practitioner care for improving sleep and quality of life in older people with depression.

In a randomised controlled trial by Irwin and colleagues, participants were randomised to tai chi physical activity classes, or to health education classes (Irwin et al 2008). Results showed that participants with moderate sleep complaints experienced improved sleep in the tai chi condition. Tai chi participants with poor sleep quality also showed improvements in rated sleep quality, habitual sleep efficiency, sleep duration, and sleep disturbance. The authors concluded that tai chi was beneficial and useful as a non-pharmacologic method to improve sleep quality in older people who had moderate sleep complaints.

Conclusions and Implications: management of sleep problems

One systematic review and two randomised controlled trials are presented. Given this limited collection of evidence, findings should be interpreted with caution.

The physical activity within the reviewed studies showed heterogeneity including resistance training, combined resistance training and walking, and tai chi.

- Physical activity, consisting of tai chi, resistance training, or resistance training and walking, may enhance sleep and contribute to better quality of life for older people with sleep problems (Irwin et al 2008; Montgomery et al 2002; Singh et al 2005), but future trials are needed in this research area.
- Current evidence is not sufficient and more high-quality studies are needed.

Physical activity and the enhancement of functioning

Background

The physical and cognitive functioning of older people is important for the maintenance of quality of life and independence, ability to perform activities of daily living, and maintenance of social roles. Physical fitness is related to physical functioning, and both reflect general health and susceptibility to disability, morbidities such as injury from falls, and mortality. This section reviews the literature on physical activity's role in the enhancement of physical and cognitive functioning, physical fitness, and quality of life.

Body of evidence

Eighty articles that met the inclusion criteria for physical activity and the enhancement of functioning were identified and appraised or reviewed. All of the included articles were considered to be of good or mixed quality. None of the included articles were considered to be poor quality. There were:

- 24 systematic reviews (Angevaren et al 2008; Baker et al 2007; Brosseau et al 2003; Chien et al 2008; Chin A Paw et al 2008; Daniels et al 2008; Davies 2010; Forster et al 2009; Forster et al 2010; Holland et al 2008; Howe et al 2007; Kay et al 2006; Kruger et al 2009; Latham et al 2004; Liu et al 2009; Luctkar-Flude et al 2007; Montgomery et al 2002; Netz et al 2005; Orr et al 2008; Paterson et al 2010; Shekelle et al 2003; Taylor 2010; van de Port et al 2007; Windle et al 2010)

- 54 randomised controlled trials (Baker et al 2010; Binder et al 2002; Broman et al 2006; Courtney et al 2009; Davidson et al 2009; Dubbert et al 2008; Faber et al 2006; Fatouros et al 2005; Fransen et al 2008; Galvão et al 2005; GASS et al 2004; Ginis et al 2006; Goodpaster et al 2008; Greenspan et al 2007; Guell et al 2006; Haykowsky et al 2005; Hung et al 2004; Kalapotharakos et al 2005; Kerse et al 2005; Kerse et al 2008; Kolt et al 2007; Lautenschlager et al 2008; Li et al 2005; Liu-Ambrose et al 2008; Liu-Ambrose et al 2010; Mador 2004; Manty et al 2009; McDermott et al 2009; Messier et al 2004; Mikesky et al 2006; Morey et al 2009a; Morey et al 2009b; Pahor et al 2006; Pang et al 2005; Peri et al 2007; Petterson et al 2009; Pogliaghi et al 2006; Rydwik et al 2010; Rydwik et al 2008; Seynnes et al 2004; Singh et al 2005; Suetta et al 2004; Sullivan et al 2007; Symons et al 2005; Takeshima et al 2004; Taylor-Piliae et al 2010; Verdijk et al 2009; Villareal et al 2006b; Voukelatos et al 2007; Wieser et al 2007; Williamson et al 2009; Windsor et al 2004; Wisloff et al 2007; Mangione et al 2005) and
- two prospective cohorts (Heesch et al 2007; Yaffe et al 2009).

Summary of findings

The findings of the review in relation to the beneficial role of physical activity in the enhancement of functioning are summarised below, starting with the enhancement of physical functioning.

Enhancement of physical functioning

Seventeen papers were reviewed. Two of the papers studied a population of ‘frail’ older people (Greenspan et al 2007; Seynnes et al 2004).

- One randomised trial found a dose–response relationship between training intensity and strength gain, and strength gains were similarly related to functional improvements for frail older people (Seynnes et al 2004).
- Another randomised trial found that frail women participating in an intensive 48-week tai chi exercise programme achieved benefits in perceived physical health, specifically in the category of ambulation, and borderline significance in the category of body care and movement (Greenspan et al 2007). In this study, significant changes in perceived health status (self-rated health) were not observed for psychosocial health or the independent categories of home management, sleep and rest, and eating.

Some studies within systematic reviews, eg, Liu et al 2009, may be based on or include younger people.

The findings from these studies are described in the following paragraphs.

Shekelle published a large systematic review and meta analysis with 47 studies, in which effect sizes were calculated for physically active intervention outcomes including strength, cardiovascular fitness, physical function, and depression (Shekelle et al 2003). Results showed a trend supporting modest benefits of physical activity, as the six studies that measured physical function had a pooled effect size of 0.15 indicating a small, but non-significant effect on physical function. Thus, this systematic review suggests that physical activity interventions do not provide significant benefits to physical functioning.

Howe and colleagues included 34 randomised controlled trials and quasi-randomised trials involving a total of 2883 participants in a systematic review of physical activity intervention related to balance in older people (Howe et al 2007). Among the results, statistically significant improvements in balance ability were seen in physical activity interventions compared to control groups. Those interventions appearing to provide the greatest balance benefit included components for gait, balance, co-ordination and functional exercises, muscle strengthening, and numerous types of physical activity. However, the results showed limited evidence that benefits from the intervention were long-lasting, suggesting a need for more long-term evaluations and possibly extended physical activity programmes.

Orr's systematic review of literature addressing progressive resistance training and balance included 29 studies, representing work with 2174 total participants (Orr et al 2008). Among the reviewed studies, about 22% reported improvements to balance from resistance training programmes. Researchers concluded that the inconsistently identified balance benefit may be due to heterogeneity of the tests, variability in methodology, statistical power, or the possibility that progressive resistance training alone is insufficient to improve balance.

A systematic review of 20 randomised controlled trials published by Chin A Paw assessed various physical activity programmes as interventions to improve functional performance (Chin A Paw et al 2008). This review included a heterogeneous collection of studies assessing 23 different programmes including resistance training, Tai chi training, or multi-component physical activity, and most were facility-based group physical activity programmes that were performed three times a week for 45–60 minutes. Six of the 20 studies failed to identify a beneficial effect on functional performance among exercising groups, but the majority were beneficial for improving at least one measure of performance, suggesting that older people with differing ability levels are likely to improve their functional performance by exercising regularly.

In the literature on progressive resistance training and physical functioning, Liu has published a large systematic review which assessed findings from 121 randomised trials with a total of 6700 participants (Liu et al 2009). In most of the reviewed trials, physical activities were performed two or three times per week at a high intensity. Such training resulted in small, but significant improvements in physical ability and functional limitations. Based on their review, the authors concluded that progressive resistance training was beneficial as an intervention to improve physical functioning in older people.

Forster published a large systematic review of 49 randomised trials in order to evaluate rehabilitative physical activity interventions that were designed to improve physical functioning among older people in long-term care (Forster et al 2009). The collection of studies represented 3611 older participants, typically randomised to a control or intervention group that performed three sessions of exercise for 30–45 minutes per session over less than 20 weeks. This study's authors concluded that physical activity rehabilitative interventions were worthwhile and safe, and were likely to improve physical condition and to reduce disability without adverse events.

Forster and colleagues conducted a systematic review of 49 physically active rehabilitation interventions for older people in long-term care (Forster et al 2010). Results showed that 33 trials, including the nine trials recruiting over 100 subjects, reported positive findings, mostly improvement in mobility but also strength, flexibility and balance. This study's authors concluded that physical rehabilitation for older people in long-term care is acceptable and potentially beneficial.

In a randomised controlled trial from France, reported by Seynnes, 22 institutionalised frail older people to part in high-intensity resistance training, low-moderate resistance training, or a weight-free placebo control group (Seynnes et al 2004). Results showed a dose–response relationship between training intensity and strength gain, and strength gains were similarly related to functional improvements for these older people. Researchers concluded that the high-intensity supervised training was as safe as lower intensity supervised training, but more beneficial for achieving better strength and physical function.

Kalapotharakos reported on a randomised controlled trial in Greece with 33 healthy inactive older men and women (Kalapotharakos et al 2005). Participants completed 12 weeks of either moderate resistance or heavy resistance training three times per week. Results showed that functional performance was improved significantly in both heavy and moderate resistance training groups compared to controls, although maximal strength was best in the heavy resistance group.

Pahor reported on a study of 424 sedentary older people from the US, in which participants were randomised to either a moderate-intensity physical activity intervention or a successful aging education programme, including gentle stretching plus basic information about physical activity. Both groups were followed for over a year (Pahor et al 2006). In this trial, the participants in the moderate-intensity physical activity group had superior physical performance outcomes and a lower incidence of disability at follow-up, compared to controls.

Greenspan and colleagues conducted a randomised controlled trial to evaluate the potential of an intensive tai chi exercise programme to provide health benefits in the transitionally frail (Greenspan et al 2007). Study participants were 269 American women who were more than 70 years of age and who were recruited from 20 congregate independent senior living facilities. The major finding of this study was that women who are transitionally frail who participated in a 48-week tai chi intervention reported significant beneficial improvements in perceived physical health, specifically in the category of ambulation, and borderline significance in the category of body care and movement. Significant changes in perceived health status (self-rated health) were not observed for psychosocial health or the independent categories of home management, sleep and rest, and eating. Results suggest that older women who are transitionally frail and participate in intensive tai chi exercise demonstrate perceived health status benefits, most notably in ambulation.

Peri reported on a cluster-randomised controlled trial among 149 New Zealand older people in residential care (Peri et al 2007), in which research staff members worked with participants to complete a functional assessment; set an individualised physical functioning goal; designed an individualised activity programme based on daily activities; and worked with residential staff to implement the programme with residents. Results showed significant short-term improvements in health status for the intervention group compared to the control group, but long term results were less favourable, possibly due to contamination (control

group participants were observed taking part in walking groups and exercise classes with the intervention group).

Kerse and colleagues conducted a cluster-randomised trial with 682 men and women from 41 residential care homes in New Zealand (Kerse et al 2008). Residential homes were randomly assigned to a goal setting and individualised activities of daily living programme, or a control condition. Results of the trial showed that the intervention programme had no overall impact, but those with normal cognition in the intervention group may have maintained overall function and lower limb function. Researchers concluded that the functional rehabilitation programme had a small benefit for older people residents with normal cognition, and was not helpful for those with poor cognition.

Morey and colleagues conducted a randomised controlled trial with 398 older male veterans, aged 70 years and up, in the United States (Morey et al 2009a). Results showed that a multi-component physical activity counselling intervention significantly improved rapid gait and physical activity levels but that changes in physical function and disability outcomes were small. Thus, although the intervention resulted in increased physical activity, this increase did not result in significant improvement to overall functioning.

Manty reported on a large population-based randomised controlled trial that took place in Finland with 632 sedentary men and women (Manty et al 2009). The intervention included a physical activity counselling session and two years of telephone support. Results showed significant benefit from the intervention in lower loss of mobility at the two-year follow-up, compared to controls. This benefit remained significant at 18 months post-intervention.

Petterson reported on a randomised controlled trial, in which researchers investigated whether resistance training programmes with and without neuromuscular electrical stimulation provided health benefits for 149 men and women with total knee arthroplasty (Petterson et al 2009). This study showed that progressive strengthening of the quadriceps muscles led to beneficial clinical improvements in physical functioning, with or without neuromuscular electrical stimulation. Both exercise conditions achieved a similar functional recovery after knee arthroplasty, which approached the functional level of healthy older adults, and exceeded typical outcomes from conventional rehabilitation (Petterson et al 2009).

Mangione reported on a small randomised controlled trial of 33 older people (outpatients) recovering from hip fracture, which showed that those who were randomly assigned to either a resistance exercise or aerobic training versus a control group experienced beneficial outcomes in measures of physical performance and functioning (Mangione et al 2005).

Conclusions and implications: enhancement of physical functioning

Seven systematic reviews and 10 randomised controlled trials are presented. Given this collection of evidence, findings can be interpreted with confidence. In particular, the systematic review by Liu and Latham provides strong contribution to the present review (Liu et al 2009).

In the reviewed studies, many different physical activity programmes, including aerobic endurance or resistance training, tai chi training, or multi-component physical activity have been used. Many of these programmes have been facility-based group physical activity programmes that were performed three times a week for 45–60 minutes (Chin A Paw et al 2008; Forster et al 2009).

- Most of the systematic reviews concluded that physical activity has a small overall beneficial effect on mobility, physical ability, strength, flexibility, balance, and functional limitations in older adults (Chin A Paw et al 2008; Forster et al 2009; Forster et al 2010; Howe et al 2007; Liu et al 2009; Orr et al 2008) though many studies within the systematic reviews did not report beneficial outcomes from physical activity (Forster et al 2010; Liu et al 2009; Shekelle et al 2003).
- Among the included randomised controlled trials, most found favourable outcomes from the physical activity interventions on physical functioning (Greenspan et al 2007; Kalapotharakos et al 2005; Kerse et al 2008; Manty et al 2009; Pahor et al 2006; Peri et al 2007; Petterson et al 2009; Seynnes et al 2004) but one found no beneficial physical functioning outcome (Morey et al 2009a).
- Benefits from physical activity interventions may be short-lived without ongoing participation (Howe et al 2007; Liu et al 2009).
- There is good evidence that physical activity programmes can contribute to older people's ability to balance (Forster et al 2010; Howe et al 2007; Orr et al 2008), but many of the reviewed studies have not found significant balance benefits. Those interventions appearing to have the largest impact on balance included components for gait, balance, co-ordination and functional exercises, muscle strengthening, and numerous types of physical activity (Howe et al 2007).
- Limitations from the research literature are evident from heterogeneity of interventions, measures, methodology, and limited statistical power in many of the studies, so additional large high-quality studies with standardised measures and methods are needed.

Enhancement of physical fitness

Twenty-four papers were reviewed. The findings from these studies are described in the following paragraphs.

Five of the papers focused on 'frail' older populations (Binder et al 2002; Rydwik et al 2010; Rydwik et al 2008; Seynnes et al 2004; Sullivan et al 2007).

- Home-based and supervised programmes have both been shown to improve activities of daily living, but a supervised exercise training programme was superior to the home exercise programme in measures of aerobic capacity, functional status, and physical performance (Binder et al 2002).
- In a randomised trial, results from resistance training intervention showed strong dose–response relationships for strength gains, and supervised high intensity training with free weights was deemed safe and beneficial for frail older people (Seynnes et al 2004).
- Another trial showed that high-intensity progressive resistance muscle resistance training over 12 weeks was well-tolerated and safe as an exercise programme for frail older people (Sullivan et al 2007).

- A trial with a group of older community dwelling frail men and women demonstrated no benefit to aerobic capacity measured as maximal workload, or work time, but there was a significant increase in lower extremity muscle strength in the physical activity groups (Rydwik et al 2010; Rydwik et al 2008).

Shekelle reported on a large systematic review and meta analysis with 47 studies, in which effect sizes were calculated for physically active intervention outcomes including strength, aerobic capacity, physical function, and depression (Shekelle et al 2003). For strength, 32 studies were included, and the effect size was equivalent to an increase of seven kilograms in knee extension force. For endurance training interventions, the pooled effect size for aerobic capacity from 17 studies was a small-to-moderate 0.41. This systematic review found physical activity interventions to provide significant strength and aerobic capacity.

Latham reported on a systematic review of 62 randomised controlled trials with a total of 3674 participants, conducted to assess the impact of progressive resistance training on measures of disability in older adults (Latham et al 2004). This review indicated that progressive resistance training was beneficial for improving muscle strength.

Kay and Singh (Kay et al 2006) systematically reviewed 27 experimental studies on physical activity in adults, and separate findings are presented for those aged 60 and up. This study found that older-aged groups can benefit from physical activity. With regard to obesity, abdominal adiposity can be reduced in older-aged men and women through moderate to high intensity physical activity, and changes in abdominal adiposity can occur in the absence of changes in body mass. Also, resistance training may be more suitable as a fat reduction strategy for older obese individuals than aerobic physical activity.

Angevaren and colleagues systematically reviewed 11 randomised controlled trials that evaluated cognitive outcomes from physical activity in older people without impairment (Angevaren et al 2008). The review included studies with various aerobic physical activity interventions (generally three sessions per week). In this study, eight of the 11 trials showed that aerobic endurance training interventions led to increased aerobic capacity.

In the literature on progressive resistance training and physical functioning, Liu reported on a large systematic review that assessed findings from 121 randomised trials with a total of 6700 participants (Liu et al 2009). In most of the reviewed trials, physical activities were performed two or three times per week at a high intensity. Such training resulted in large beneficial improvements to muscle strength.

Forster and colleagues conducted a systematic review of 49 physically active rehabilitation interventions for older people in long-term care (Forster et al 2010). Results showed that Thirty-three trials, including the nine trials recruiting over 100 subjects, reported positive findings, mostly improvement in mobility but also strength, flexibility and balance. This study's authors concluded that physical rehabilitation for older people in long-term care is acceptable and potentially beneficial.

Binder and colleagues randomly assigned 115 older American frail men and women to one of two exercise conditions over nine months of study (Binder et al 2002). One condition involved supervised resistance exercises, flexibility exercises, and balance training, while the other condition consisted of low-intensity flexibility exercise at home. This study found no differences between groups for activities of daily living, but the supervised exercise training programme was superior to the home exercise programme in measures of aerobic capacity, functional status, and physical performance.

In a randomised controlled trial with Australian older men, significant improvements were found from 12 weeks of aerobic cycling exercise on heart functioning measures (GASS et al 2004). In those men randomly assigned to either moderate- or vigorous-intensity groups, cycling three times per week resulted in improved cardiac stroke volume and heart rate at a given workload.

Seynnes and colleagues conducted a randomised controlled trial in 22 institutionalised French frail older people to examine the benefits from high intensity training with free weights compared with lower intensity resistance training (Seynnes et al 2004). This study showed strong dose–response relationships between resistance training intensity and strength gains, and also between strength gains and functional improvements after resistance training. For these older adults, low to moderate intensity resistance training of the knee extensor muscles appeared to be insufficient to achieve optimal improvement of functional performance. This study concluded that supervised high intensity training with free weights for frail older people was safe and provided more benefit than lower-intensity training.

In a sample of 36 Danish older men and women with hip osteoarthritis, Suetta and colleagues examined resistance training during recovery from long-term muscle disuse and hip surgery in a randomised controlled trial (Suetta et al 2004). Results showed that resistance training resulted in benefits such as increased muscle mass, maximal isometric strength, rate of force development, and muscle activation in these older men and women. The researchers concluded that the improvement in muscle mass and neural function from resistance training was likely to have positive functional implications for older individuals.

Takeshima reported on a Japanese study of 35 older men and women which examined benefits derived from interventions including circuit exercise training (Takeshima et al 2004). This 12-week, three-times-per-week physical activity intervention included aerobic endurance training and resistance exercise and showed beneficial improvements in aerobic capacity, muscular strength, body composition, and high-density lipoprotein cholesterol in physically active participants.

Haykowsky reported on a randomised controlled trial, in which researchers evaluated resistance training, aerobic endurance training, and strength plus aerobic endurance training compared to a no-exercise control group (Haykowsky et al 2005). Participants included 31 healthy older Canadian women, who were randomly assigned to one of the 12-week exercise programmes or control condition. Results indicated that resistance training or combined strength/aerobic both led to increased aerobic capacity. However, the resistance training and combined strength and aerobic training conditions benefited older women by improving overall muscle strength to a greater degree than aerobic training.

Galvão reported on a randomised controlled trial in Australia which evaluated one set of resistance training exercises compared to three sets (Galvão et al 2005). All participants performed exercises twice weekly for 20 weeks at eight repetition maximum intensity. Results showed that both conditions led to beneficial increases in muscular strength and endurance, though benefits were typically greater in the higher volume condition. Conclusions from this study were that a single-set of resistance exercise, performed twice per week, can enhance muscular strength and endurance.

Fatouros reported on a Greek randomised controlled trial conducted to determine benefits associated with varying intensities of resistance training in a sample of 50 overweight and inactive older men (Fatouros et al 2005). In this study, the older men were randomly assigned to participate in low-, moderate-, or high-intensity resistance training that consisted of three sets of 10 exercises, performed three times per week for six months. Results showed intensity-dependent changes in strength, aerobic capacity, resting metabolic rate, and exercise energy cost after training. Also, the body composition measures of skinfolds and BMI showed greatest reduction by high-intensity resistance training, relative to low-intensity or moderate-intensity training. Finally, the resistance training programme and a later period of detraining showed dose–response relationships with the hormones leptin and adiponectin.

Kalapotharakos reported on another Greek randomised controlled trial with 33 healthy inactive older men and women (Kalapotharakos et al 2005). Participants completed 12 weeks of either moderate resistance or heavy resistance training three times per week. Results showed that functional performance was improved significantly in both heavy and moderate resistance training groups compared to controls, but maximal strength was best in the heavy resistance group.

Symons reported on a group of 37 healthy older men and women from Canada who participated in a randomised controlled trial evaluating functional outcomes from three types of resistance exercises (Symons et al 2005). In this study, participants were randomly allocated to one of three trial arms: isometric, concentric, or eccentric resistance exercise. Results of this study showed that after the 12 weeks of training, all three types of resistance training resulted in increased strength, concentric power, and work. With regard to functional ability, all types of training resulted in improvements to stair climbing and descending abilities.

Broman and colleagues conducted a randomised controlled trial with 29 healthy older women in Sweden (Broman et al 2006). In this study, women were randomly assigned to a control or exercise training group that did high intensity deep water running with a floatation vest. Results showed that the aquatic exercise training improved submaximal work capacity, maximal aerobic power, and maximal ventilation. Furthermore, the fitness benefits of exercise in the water successfully transferred to land-based activities in these older women (Broman et al 2006).

Pogliaghi reported on an Italian randomised controlled trial, in which researchers studied arm cycling compared to leg cycling in 12 older non-smoking men (Pogliaghi et al 2006). Following training, peak heart rate remained unchanged, but significantly higher workload and measures of aerobic capacity were obtained in both arm and leg training groups. This study found that aerobic training induced by upper-body or lower-body muscle masses

produced similarly beneficial improvements in maximal and sub-maximal exercise capacity (Pogliaghi et al 2006).

Ginis and colleagues (Ginis et al 2006) used a randomised controlled trial to test two weight training interventions in a sample of 64 healthy sedentary Canadian men and women. One weight training intervention received an additional educational component and the other condition was weight training alone. Both conditions trained with weights twice per week for 12 weeks with exercises targeting eight major muscle groups. Results showed that both weight training conditions resulted in significant improvements to strength and activities of daily living. This study showed that the educational intervention could help older people to apply weight training benefits to their activities of daily living.

Sullivan reported on an American randomised controlled trial, in which 29 men and women with functional decline were randomly assigned to either low-resistance exercise or high-intensity progressive resistance muscle strength training, with a drug or placebo (Sullivan et al 2007). This study showed that high-intensity progressive resistance muscle strength training over 12 weeks was well-tolerated and safe as an exercise programme for frail older people, and that the participants who received high-intensity progressive resistance muscular strength training without supplements experienced the greatest strength gains.

Wieser reported on an Austrian randomised controlled trial, involving 24 men and women who were measured for strength, aerobic capacity, and body composition before and after being randomised to a 12 week resistance training group or no-exercise control group (Wieser et al 2007). Results showed that those in the exercise group had significant gains in aerobic capacity, maximum strength and fat-free body mass. Furthermore, this study showed that twice-per-week resistance training could be as beneficial as thrice-per-week training, provided the total number of sets performed were equal.

Rydwik and colleagues conducted a randomised controlled trial with a sample of 96 community-dwelling frail older men and women (Rydwik et al 2008). Participants were randomised: 1) to a physical activity intervention including aerobic, muscle strength, and balance training; 2) to a nutrition intervention; 3) to a combined physical activity and nutrition intervention; or 4) to a control group. Results showed significant beneficial improvements in lower- extremity muscle strength in both training groups compared with the nutrition group at first follow-up, and there were small significant changes for some of the balance measurements in the training group without nutrition treatment. This study illustrates lower-extremity muscle strength benefit from a physical activity intervention.

Verdijk and colleagues conducted a randomised controlled trial in the Netherlands with 26 healthy older men (Verdijk et al 2009). In this study, participants were randomly assigned to a resistance training programme with or without protein supplementation. After completion of 12 weeks of resistance training three times per week, strength increased by about 25–35% in both groups. Similar increases in leg muscle mass were found for both training groups via dual-energy X-ray absorptiometry and computed tomography scans.

Rydwik and colleagues conducted a randomised controlled trial with a sample of 96 community-dwelling frail older men and women (Rydwik et al 2010). Participants were randomised to a physical activity intervention including aerobic, muscle strength, and balance training, to a nutrition intervention, to a combined physical activity and nutrition intervention, or to a control group. Results showed no beneficial increase in aerobic capacity measured as maximal workload, or work time, but there was a significant increase in lower extremity muscle strength in the physical activity groups, compared with nutrition alone.

Conclusions and implications: enhancement of physical fitness

Six systematic reviews and 18 randomised controlled trials are presented. Given this collection of evidence, findings can be interpreted with confidence. In particular, the systematic reviews by Angevaren and colleagues and by Shekelle and colleagues provide very good evidence on the benefits of physical activity for enhancing physical fitness with regard to strength and aerobic capacity (Angevaren et al 2008; Shekelle et al 2003).

With regard to physical activity in the reviewed studies, there was ample heterogeneity, but programmes often consisted of aerobic endurance training or resistance training.

- Systematic reviews indicate that older people are likely to experience significant improvements to strength and aerobic capacity from participation in a physical activity programme (Angevaren et al 2008; Forster et al 2010; Latham et al 2004; Liu et al 2009; Shekelle et al 2003).
- Meta-analyses of physical activity interventions for strength and aerobic capacity in older people confirm beneficial improvements to strength and aerobic capacity (Shekelle et al 2003).
- Abdominal adiposity can be reduced in older-aged men and women through moderate to high intensity physical activity, and resistance training may be more suitable as a fat reduction strategy for older obese individuals than aerobic physical activity (Kay et al 2006).
- All systematic reviews reported overall beneficial results of physical activity programmes on one or more components of physical fitness (strength, aerobic capacity, flexibility, or body composition) in older people (Angevaren et al 2008; Forster et al 2010; Kay et al 2006; Latham et al 2004; Liu et al 2009; Shekelle et al 2003).
- All randomised controlled trials reported overall beneficial outcomes of physical activity programmes on one or more components of physical fitness (strength, aerobic capacity, flexibility, or body composition) in older people (Binder et al 2002; Broman et al 2006; Fatouros et al 2005; Galvão et al 2005; GASS et al 2004; Ginis et al 2006; Haykowsky et al 2005; Kalapotharakos et al 2005; Pogliaghi et al 2006; Rydwik et al 2010; Rydwik et al 2008; Seynnes et al 2004; Suetta et al 2004; Sullivan et al 2007; Symons et al 2005; Takeshima et al 2004; Verdijk et al 2009; Wieser et al 2007).
- One randomised trial showed that a single-set of resistance exercise, performed twice per week, was sufficient to enhance muscular strength and endurance (Galvão et al 2005).

Enhancement of cognitive functioning

Nine papers were reviewed. Some studies within systematic reviews, eg, Angevaren et al 2008, may be based on or include younger people. The findings from these studies are described in the following paragraphs.

Angevaren and colleagues systematically reviewed 11 randomised controlled trials that evaluated cognitive outcomes from aerobic physical activity interventions in people without impairment (Angevaren et al 2008). Eight of the 11 trials showed that aerobic physical activity interventions led to increased aerobic capacity, and this improvement was linked with improvements in cognitive capacity. Overall, the largest effect sizes from physical activity were found for motor function and auditory attention (effect sizes of 1.17 and 0.50 respectively). Other significant beneficial outcomes were found for information processing speed and visual attention. Despite these beneficial findings, most of the investigated relationships between physical activity and cognitive function yielded no significant results, including no benefit to simple or choice reaction times.

Kruger and colleagues conducted a systematic review, using 160 studies addressing the relationship between physical activity and cognitive health (Kruger et al 2009). Results showed that the average prescribed dose of aerobic physical activity provided by interventions for older adults was less than the recommended amount of 150 minutes or more per week of moderate-intensity physical activity. The reviewed studies, however, indicated moderate-intensity physical activity to be beneficially related to cognitive health. The authors further suggest that the benefits of physical activity for enhancing cognition may actually be even greater than what has been found in the reviewed trials, as the trials often administer lower than recommended levels of physical activity to participants.

Marigold and colleagues conducted a randomised controlled trial with 61 older Canadian men and women (Marigold et al 2005). In this study, both of the physical activity groups, agility or flexibility with weight shifting, led to improvements in all clinical outcome measures. Compared to the stretching and weight-shifting group, the agility group demonstrated greater improvement in postural reflex onset latency and step reaction time, a mind-body connection likely to help older people avoid falls.

A randomised controlled trial by Voukelatos and colleagues studied community-dwelling older people and tai chi class as an intervention improve balance and reduce falls (Voukelatos et al 2007). In this study, participation in a tai chi class once per week for an hour over 16 weeks not only led to fewer falls and better balance, but also to improvements in choice stepping reaction time, a mind-body connection likely to help older people avoid falls.

In a randomised controlled trial of 74 older Canadian men and women with a history of falls, Liu Ambrose and colleagues evaluated a home-based resistance and balance training programme, which had been previously shown to reduce falls (Liu-Ambrose et al 2008). Results of this study showed beneficial improvement in executive functioning after six months, specifically response inhibition, but no significant between-group difference in physiological falls risk, including simple reaction time, or functional mobility.

Williamson reported on a randomised controlled trial conducted on a US sample of 102 sedentary older men and women with increased risk of disability (Williamson et al 2009). Participants were randomly assigned to either moderate-intensity physical activity, or a health education group. Results showed that overall differences between these groups were not significant, but that observed improvements in cognitive scores were associated with improvements in physical function.

Yaffe reported a prospective cohort study of 2509 well-functioning black and white older people in the US, in which researchers examined the influence of weekly moderate and vigorous physical activity on maintaining cognitive functioning over eight years of study (Yaffe et al 2009). In a statistical model that controlled for baseline measures, race, education, literacy, and smoking, there was a positive relationship between weekly physical activity and maintenance of cognitive function.

Liu Ambrose and colleagues conducted a randomised controlled trial with a sample of 155 Canadian women, aged 65–75 years to evaluate a resistance training physical activity intervention programme on cognitive health outcomes (Liu-Ambrose et al 2010). Results showed that both resistance training groups significantly improved their performance on the executive function test compared with those in the balance and toning physical activity group. Task performance improved by 12.6% and 10.9% in the once-weekly and twice-weekly resistance training groups, respectively, while task performance deteriorated by 0.5% in the balance and tone group. Hence, this study showed that 12 months of once-weekly or twice-weekly resistance training benefited the executive cognitive function of selective attention and conflict resolution among senior women.

Taylor-Pillae and colleagues conducted a randomised controlled trial with a sample of 132 older American men and women to compare the health outcomes from a western-style physical activity intervention programme to one based on tai chi (Taylor-Piliae et al 2010). Results showed that the western exercise group had greater benefits in upper body flexibility than tai chi and controls. The tai chi group, however, provided greater benefits for balance and cognitive-function compared to western exercise and control groups. The cognitive-function benefits from tai chi were maintained through 12 months. Thus, the tai chi and western exercise interventions resulted in physical functioning benefits, while tai chi resulted in cognitive functioning benefits for generally healthy older adults.

Conclusions and implications: enhancement of cognitive functioning

Two systematic reviews, six randomised controlled trials, and one prospective cohort study are presented. Given this collection of evidence, consistent findings may be robust and interpreted with confidence. In particular, the systematic review by Angevaren and colleagues provides very good evidence on the benefits of physical activity for enhancing cognitive functioning (Angevaren et al 2008).

With regard to physical activity in the reviewed studies, there was ample heterogeneity, but programmes often consisted of aerobic endurance training or resistance training.

- Cognitive function and cognitive health are multi-dimensional in nature, and studies frequently measure various dimensions with heterogeneous methods, leading to difficulty in reviewing or comparing studies.

- Both systematic reviews indicated that the reviewed studies employed a diversity of physical activity interventions, but were frequently associated with benefits for cognitive health (Angevaren et al 2008; Kruger et al 2009), and moderate-intensity physical activity appears to be sufficient to obtain benefits (Angevaren et al 2008).
- One randomised controlled trial found improvements in cognitive functioning from tai chi, but not from a western-style physical activity programme (Taylor-Piliae et al 2010).
- One prospective cohort found that there was a positive relationship between weekly physical activity and maintenance of cognitive function over eight years of follow-up in a sample of 2509 older American men and women (Yaffe et al 2009).
- One systematic review found that participation in aerobic physical activity interventions resulted in significant benefits for motor function and auditory attention. Other significant benefits were found for information processing speed and visual attention (Angevaren et al 2008).
- A systematic review and another randomised controlled trial have shown that physical activity may provide no benefit for simple reaction time or choice reaction time (Angevaren et al 2008; Liu-Ambrose et al 2008), but two randomised controlled trials found physical activity programmes emphasising mobility and balance may provide benefit for step reaction time, a mind-body connection likely to help older people avoid falls (Marigold et al 2005; Voukelatos et al 2007).
- Other studies have shown benefits from physical activity for executive function, task performance, and response inhibition (Liu-Ambrose et al 2008; Liu-Ambrose et al 2010).
- Collectively, there is evidence of benefit to cognitive function from physical activity, but further investigations are warranted to determine which dimensions of cognitive function are most likely to benefit, and to determine the specific characteristics of the physical activities and other factors associated with such benefits.

Enhancement of quality of life and wellbeing

Twenty papers were reviewed. One of the papers separated the ‘frail’ older adult within the study population (Windle et al 2010). This systematic review showed that there is some indication, from two previous studies that physical activity interventions can improve the mental wellbeing of frail older people, aged 75 years and up (Windle et al 2010).

Some studies within systematic reviews, eg, Netz et al 2005, may be based on or include younger people.

The findings from these studies are described in the following paragraphs.

A systematic review by Montgomery and colleagues included one randomised controlled trial that examined the influence of physical activity on sleep outcomes in older people (Montgomery et al 2002). This study included 43 participants with insomnia assigned to a programme of brisk walking and moderate resistance training. Results showed sleep improvements from the intervention. The authors concluded that physical activity may enhance sleep and contribute to better quality of life, though further studies are needed. Netz and colleagues conducted a systematic review and meta-analysis of 36 studies addressing physical activity and wellbeing (Netz et al 2005). Results of the meta-analysis

showed that physical activity intervention groups experienced greater levels of wellbeing than that seen in control groups. Among the findings, aerobic training was most beneficial for wellbeing, and moderate intensity activity was the most beneficial activity level. Longer exercise duration was less beneficial for several types of wellbeing, though findings were inconclusive for duration. Physical activity had the strongest effects on self-efficacy and observed improvements in cardiovascular status, strength, and functional capacity were linked to wellbeing improvement overall.

In a systematic review by Baker and colleagues, researchers examined 15 randomised controlled trials, with a total sample of 2149 participants generally ranging from 67 to 84 years of age (Baker et al 2007). Although the available evidence was limited, this study found that along with benefits related to falls prevention, multi-modal exercise appears to result in benefits including physical, functional, and quality of life outcomes.

Luctkar-Flude's systematic review of nine experimental studies and 10 observational studies of physical activity and fatigue in cancer patients found support for the notion of using physical activity during treatment of cancer (Luctkar-Flude et al 2007). Physical activity offers the strongest available evidence among interventions to combat cancer fatigue, and to maintain functional status and quality of life (Luctkar-Flude et al 2007).

Holland's systematic review of five randomised or quasi-randomised trials relevant to physical activity for interstitial lung disease found short-term improvements in exercise capacity, dyspnoea, and quality of life for older people completing physical activity interventions (Holland et al 2008).

Chien's systematic review of randomised controlled trials in older people with chronic heart failure included 10 studies with a total of 648 older participants (Chien et al 2008). Results showed that home-based exercise increased exercise capacity safely but did not improve quality of life in patients with chronic heart failure. In the meta-analysis of these trials, home-based exercise increased walking performance and peak oxygen consumption more than usual activity, but did not improve heart failure scores or odds of hospitalisation.

In another systematic review, Taylor and colleagues sought to compare home-based to centre-based cardiac rehabilitation (Taylor 2010). Physical activity, or 'exercise therapy', is a central component of cardiac rehabilitation (Taylor et al 2004). The systematic review included 12 randomised controlled trials with a total of 1938 participants, and found that cardiac rehabilitation appeared to be equally beneficial, regardless of setting, in improving the clinical and health-related quality of life outcomes in acute MI and revascularisation patients.

Windle and colleagues conducted a systematic review of literature pertaining to physical activity and mental wellbeing (Windle et al 2010). The included interventions were designed for older people, targeted those who were sedentary, and were delivered in a community setting, primarily through a group-based approach that was led by trained leaders. Meta-analyses found a small benefit from physical activity on mental wellbeing. This systematic review also showed that there is some indication, from two previous studies that physical activity interventions can improve the mental wellbeing of frail older people, aged 75 years and up.

Davies' systematic review analysed physical activity interventions from 19 randomised controlled trials that included 3647 participants with heart failure (Davies 2010). This review of literature found that physical activity programmes, mostly consisting of brisk walking, reduced hospital admission rates and improved health-related quality of life, both in the short term and long term.

Windsor reported on a randomised controlled trial of UK men with prostate cancer, which examined the role of a physical activity intervention in dealing with fatigue from cancer radiation treatments (Windsor et al 2004). In this trial, the men randomly assigned to the group advised to rest when feeling fatigued experienced a small decrease in their physical functioning and increase levels of fatigue after their course of radiation treatments. In contrast, those men randomly assigned to moderate intensity walking at home experienced improved physical functioning and a lack of increase in fatigue. Thus, physical activity programmes hold promise as cancer fatigue interventions for older people, which may assist them in maintaining quality of life during cancer treatment.

In a randomised controlled trial, Mador and colleagues compared an aerobic cycling programme to a programme of resistance training plus aerobic cycling training (Mador 2004). Participants were 24 older Americans with chronic obstructive pulmonary disease (COPD). Six-minute walk distance, endurance exercise time, and quality of life (as measured by the Chronic Respiratory Questionnaire) significantly increased in both groups after rehabilitation with no significant differences in the extent of improvement between groups.

Hung reported on a randomised controlled trial with 21 older women diagnosed with coronary artery disease. In the trial, researchers sought to compare a programme of aerobic endurance training to a combined strength and aerobic endurance training programme (Hung et al 2004). Results showed that both programmes resulted in similar improvements to emotional and global measures of quality of life. The combined programme, however, also improved social and physical quality of life.

Kerse reported on a group-randomised controlled trial with 270 New Zealand men and women, which studied the outcomes of individualised goal setting and physical activity plans in residential care facilities (Kerse et al 2005). Results showed that measures of vitality and general health improved to a clinically relevant degree in intervention group participants, and hospitalizations decreased, but there was no benefit from the intervention for blood pressure, injuries or falls (Kerse et al 2005).

Guell's small randomised controlled trial evaluated the ability of physical activity to provide health benefit in participants with chronic obstructive pulmonary disease (Guell et al 2006). Participants were 40 Spanish women and men, with an average age of 65 years. This study found that pulmonary rehabilitation resulted in decreased psychological morbidity, and increased functional capacity, and health related quality of life (Guell et al 2006).

Heesch and colleagues reported findings of a prospective cohort study that examined the association between physical activity and stiff or painful joints in a sample of 3970 Australian women aged 72–79 years at baseline (Heesch et al 2007). Results of the three-year study showed that the older women in the low (odds ratio = 0.72, 95% CI = 0.55–0.96), moderate (odds ratio = 0.54, 95% CI = 0.39–0.76), and high (odds ratio = 0.61, 95% CI = 0.46–0.82) physical activity categories had lower odds of being among the group most frequently

suffering from stiff or painful joints at study end, compared with their sedentary counterparts, even after adjustment for confounders.

Research by Kolt and colleagues examined a telephone-based counselling intervention promoting individualised physical activities such as walking in 186 low-active men and women from New Zealand (Kolt et al 2007). In this effectiveness study, moderate intensity leisure-time physical activity increased more in intervention group participants than in control group participants, such that a greater proportion of participants in the intervention group achieved 150 minutes of moderate to vigorous intensity leisure-time physical activity per week after 12 months. The study, however, found no quality of life benefit for intervention participants.

Dubbert and colleagues conducted a randomised controlled trial evaluating a home-based walking and centre-based resistance training physical activity programme (Dubbert et al 2008). The participants were older male American veterans, aged 60–85 years, with physical function limitations. Results of this study showed that these older men achieved better quality of life and physical performance after participating in the physical activity intervention programme.

Courtney reported on an Australian randomised controlled trial which evaluated an individualised programme of exercise strategies, nurse-conducted home visits and telephone follow-ups, compared to a no-exercise control group (Courtney et al 2009). The intervention consisted of 24 weeks of an individually designed exercise programme of muscle stretching, daily balance training, walking for endurance, and muscle strengthening using resistance exercises. This study found that along with fewer emergency visits and lower hospital readmission rates, the intervention group reported more beneficial change in quality of life, relative to controls. Thus, this study showed that a physical activity programme with home visits and telephone follow-up may improve quality of life and reduce emergency health services for older people with health problems.

Another randomised controlled trial by McDermott and colleagues evaluated two exercise programmes in a sample of 156 older American men and women with peripheral arterial disease (McDermott et al 2009). Results indicated that both treadmill exercise and resistance training, three times per week over a 24-week period, provided health-related benefits. This trial found that treadmill exercise improved walking performance, blood flow, and quality of life, but not the short physical performance battery score.

Morey reported on a randomised controlled trial that took place in the UK, US, and Canada with survivors of colorectal, breast, or prostate cancer (Morey et al 2009b). In this study, participants who took part in a tailored diet and physical activity intervention programme that focused on resistance training and aerobic endurance training were less likely to report functional decline than participants in the control condition. Furthermore, the intervention group participants experienced improved dietary and physical activity behaviours, greater weight loss, and better overall quality of life than those in the control group.

Conclusions and implications: enhancement of quality of life and wellbeing

Eight systematic reviews, eleven randomised controlled trials, and one prospective cohort study are presented. Given this collection of evidence, findings can be interpreted with confidence. In particular, the systematic review by Windle and colleagues provides strong evidence related to wellbeing, due to its large number of reviewed studies and recent publication (Windle et al 2010).

With regard to physical activity in the reviewed studies, there was ample heterogeneity, but programmes often consisted of aerobic endurance training, resistance training, or combinations of the two.

Quality of life and wellbeing are multi-dimensional in nature, and studies frequently measure various dimensions with a variety of measures, some tailored to specific disease populations.

Among reviewed studies, participants include those with and without identified diseases or conditions (including various cancers, interstitial lung disease, coronary heart disease, acute myocardial infarction, congestive heart failure, chronic obstructive pulmonary disease, coronary artery disease, functional limitation, hospital inpatients, and peripheral arterial disease).

- Nearly all of the reviewed studies show physical activity to have beneficial effects on quality of life or wellbeing in a broad array of healthy and diseased older populations. (Baker et al 2007; Courtney et al 2009; Davies 2010; Dubbert et al 2008; Guell et al 2006; Heesch et al 2007; Holland et al 2008; Hung et al 2004; Kerse et al 2005; Luctkar-Flude et al 2007; Mador 2004; McDermott et al 2009; Montgomery et al 2002; Morey et al 2009b; Netz et al 2005; Taylor 2010; Taylor et al 2004; Windle et al 2010; Windsor et al 2004), though two studies have found no beneficial relationship (Chien et al 2008; Kolt et al 2007).
- Among those showing no beneficial relationship between physical activity and quality of life, participants included those with congestive heart failure (Chien et al 2008) and a low-active sample of men and women from New Zealand (Kolt et al 2007).
- One meta-analysis showed benefit from physical activity on mental wellbeing (Windle et al 2010). Another meta-analysis showed benefit from physical activity intervention, especially aerobic training, on wellbeing, and that physical activity resulted in improvements to self-efficacy (Netz et al 2005). In this latter meta-analysis, moderate intensity physical activity was the most beneficial activity level, and longer exercise duration was less beneficial for several types of wellbeing (Netz et al 2005).
- The evidence presented in one systematic review suggests that a minimum of two exercise sessions per week, each of 45 minutes in duration can foster wellbeing (Windle et al 2010).
- Physical activity interventions have also resulted in improvements to sleep quality (Montgomery et al 2002) and vitality (Kerse et al 2005).
- Limitations from the research literature are evident from heterogeneity of populations, interventions, measures, methodology, and limited statistical power in some studies. Additional large high-quality studies with standardised measures and methods are needed to bolster the evidence base with regard to physical activity's role in providing quality of life benefit for older people.

Overall conclusions

The reviewed literature indicates that there are benefits associated with physical activity for older people in the prevention of negative health outcomes and disability. The evidence is strongest for the following conditions:

- all-cause mortality
- cardiovascular mortality
- cancer mortality
- falls
- stroke
- heart disease
- breast cancer
- colon cancer.

The evidence is not as strong for:

- neurological disorders/cognitive decline
- rectal cancer
- prostate cancer
- sarcopenia
- kidney dysfunction
- osteoporosis
- type 2 diabetes
- depression
- disability/functional limitation
- hospitalisation.

The reviewed literature indicates that there are benefits associated with physical activity for older people in the management of diseases and health-related conditions. The evidence is strongest for the following conditions:

- vascular diseases
- heart disease
- stroke
- arthritis
- obesity
- type 2 diabetes
- depression.

The evidence is not as strong for:

- cancer
- pulmonary diseases
- neurological disorders
- disability
- sleep disorders.

The reviewed literature indicates that there are benefits to older people in enhancing their wellbeing, fitness and quality of life from physical activity. The evidence is strong for the following conditions:

- physical fitness, including strength and aerobic endurance
- quality of life and wellbeing
- cognitive function
- physical function.

Given that there is reasonable evidence as to physical activity being beneficial to older people, are there risks to health and physical function from not being physically active? The literature on this question is looked at in chapter 5.

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5 What are the risks associated with physical inactivity for older people?

Background

The benefits of participation in physical activity have been demonstrated in chapter 4. However, information on benefits does not address whether it is detrimental for older people not to participate in physical activity. This chapter focuses on the risks of physical inactivity, low levels of physical activity, or sedentary behaviour for health outcomes including mortality and various morbidities.

Definitions

The terms **sedentary, sedentary lifestyle, inactivity, inactive**, and **low levels of activity** are frequently used interchangeably in the literature, and this lack of precision of terms creates problems for clarity and consistency. In many epidemiological studies, participants are divided into categories or quantiles of physical activity, based on a relative ranking of the amount of moderate to vigorous physical activity performed in a given timeframe, or whether their reported amounts of moderate to vigorous physical activity meet external recommendations. Often, those in the lowest quantile, or those reporting no moderate to vigorous physical activity are labelled ‘sedentary’ or ‘inactive’.

Separate to and largely independent of these patterns of moderate to vigorous physical activity is **sedentary behaviour**, the proportion of time spent sitting or in low levels of energy expenditure, over a specified timeframe. For the present chapter, we use the terminology of the original author, and clarify terms where necessary.

Body of evidence

In total, 39 peer-reviewed journal articles were identified that met the inclusion criteria for risks of physical inactivity (including both as sedentary behaviour and low levels of moderate to vigorous physical activity) in older people, and were reviewed. All of the included articles were considered to be of good or mixed quality. None of the included articles were considered to be poor quality.

Where high-level evidence was lacking, this collection of journal articles was supplemented by:

- three cross-sectional studies (Finkelstein et al 2006; Riebe et al 2009; Zheng et al 1993)
- two narrative reviews (Hamilton et al 2007; Moayyeri 2008)
- two governmental reports from the United States that contained very large and comprehensive literature reviews (US Department of Health and Human Services 2008; US Surgeon General 1996).

The analyses used in many of the studies in this body of evidence were structured to look at the relationship between physical activity and health outcomes, with physical inactivity as a referent category. For those studies, the present review is a reinterpretation of the data, where applicable, to assess the relationship between physical inactivity and health outcomes.

The body of evidence was viewed in four categories, risks associated with:

- low levels of moderate to vigorous physical activity (mortality)
- low levels of moderate to vigorous physical activity (morbidity)
- sitting or sedentary behaviour (mortality)
- sitting or sedentary behaviour (morbidity).

The four categories contain sub-categories related to health or functioning condition (eg, cancer). A number of the papers contained findings that fit across categories and across sub-categories (eg, a paper may report on all-cause mortalities and also cancer mortality). The nature of the study is repeated in each sub-category and the findings are tailored to the topic covered by the sub-category (eg, prostate cancer). It should also be noted that the structure of this review is different to the structure of the reviewed papers. Therefore, a number of studies will appear across chapters and the same principle applies; the nature of the study is reported and the finding is tailored.

Unless otherwise indicated in the text about the study, the average age of the people included within the studies is 65 years or more at study conclusion. Actual age data for studies are provided in appendix 2, except where is has not been possible to gain an exact age range, eg, for large systematic reviews. In these cases, the studies are likely to include younger adults.

Risks associated with low levels of moderate to vigorous physical activity (mortality)

Body of evidence

Refer to appendix 2 (table 1) for study details.

Risks associated with low levels of moderate to vigorous physical activity (Mortality) – three systematic reviews (Löllgen et al 2009; Nocon et al 2008; Warburton et al 2010) and 10 prospective cohort studies (Byberg et al 2009; Garg et al 2006; Giovannucci et al 2005; Haydon et al 2006; Knoops et al 2004; Lan et al 2006; Leitzmann et al 2007; Manini et al 2006; Schooling et al 2006; Whang et al 2006).

Summary of findings

The findings of the review in relation to the risks associated with low levels of moderate to vigorous physical activity (mortality) are summarised below by condition type, starting generically with all-cause mortality.

All-cause mortality

Nine studies addressed the relationship between low levels of physical activity and mortality from all causes (Byberg et al 2009; Knoops et al 2004; Lan et al 2006; Leitzmann et al 2007; Löllgen et al 2009; Manini et al 2006; Nocon et al 2008; Schooling et al 2006; Warburton et al 2010). All nine studies reported a finding of higher risk for all-cause mortality among those with low levels of moderate to vigorous physical activity compared to more active participants, although one study found no relationship among the healthiest subgroup of the sample (Schooling et al 2006). Higher risk of premature death among the least physically active was found for both men and women, with no moderation effect by sex (Nocon et al 2008).

Nocon and colleagues published a systematic review and meta-analysis, and found that all-cause mortality among the most inactive participants was increased by 33%, compared to most active participants (Nocon et al 2008). This systematic review was based on general 'adult' populations and includes studies with younger people. This study showed that physical inactivity is associated with a marked increase in all-cause mortality in both older men and women, even after adjusting for other relevant risk factors. Nocon also reported on cardiovascular disease mortality (see cardiovascular disease mortality section).

Löllgen and colleagues conducted a systematic review of 38 prospective cohort studies (Löllgen et al 2009). This systematic review was based on general 'adult' populations, but includes separate results for those aged 65 years and older. These authors reported that compared to sedentary older persons, regular physical activity over longer time was strongly associated with a reduction in all-cause mortality. These authors also reported a dose–response relationship between level of moderate to vigorous physical activity and mortality.

In a large systematic review of 254 studies, Warburton and colleagues concluded that compared with lower levels of physical activity, higher levels of physical activity reduce the risk for premature all-cause mortality (Warburton et al 2010). This systematic review was based on general 'adult' populations, and includes studies with younger people, though the health outcome under review is typically more likely to affect older people. Warburton also reported on the risks associated with morbidity for a number of conditions: breast cancer, colon cancer, stroke, cardiovascular disease, hypertension, osteoporosis, and type 2 diabetes (see appropriate section for each).

In a prospective cohort study of 2339 healthy older men and women, Knoops and colleagues investigated the association between physical activity level and mortality. In this 10-year study, participants who were physically inactive had a higher risk of all-cause mortality than those who were physically active (Knoops et al 2004). Knoops also reported on mortality from cancer and cardiovascular disease in this paper (see cancer mortality and cardiovascular disease mortality sections).

In a large prospective cohort study in China with 54,088 men and women aged 65 and up, Schooling and colleagues found higher risks of premature mortality among the least active participants (Schooling et al 2006). In the full sample, there were significant reductions in all-cause mortality for more active individuals. In analyses stratified by health status, compared with participants who reported no physical activity, those who reported some level of daily

physical activity had lower mortality in the group with poor baseline health status, but not in the group with good baseline health status.

Lan and colleagues conducted a prospective cohort study with 2113 older men and women in Taiwan to examine the association between physical activity level and mortality (Lan et al 2006). In this study, the least active participants had a 35% greater risk of death, compared with regular exercisers after adjustment for covariates. Regular exercisers were participants who reported any leisure-time physical activity in the past two weeks. Other results showed that older people with a weekly physical activity amount of energy exceeding 1000 kcal had significant benefit of mortality risk reduction. There was also a significant dose–response relationship between number of activities and the reduction in total mortality, indicating that those who did the least number of physical activities had greater risk of premature death.

Manini and colleagues conducted a prospective cohort study with 302 older men and women (Manini et al 2006). These researchers determined that older people in the lowest tertile of free-living activity energy expenditure were at a significantly higher mortality risk, compared to the most active older people.

A prospective cohort study of 252,925 older men and women (aged 50–71 years) in the US examined whether individuals meeting national physical activity guidelines (30 minutes of moderate activity on most days of the week or 20 minutes of vigorous activity three times per week) had lower risk of death over 1,265,347 person-years of follow-up (Leitzmann et al 2007). This study found a dose–response effect in mortality as follows. Participants who did less than recommended levels of physical activity had decreased mortality risk, relative to the inactive group. Those meeting either guideline had a greater reduction in mortality, and the most active (those meeting both guidelines) had about a 50% lower risk of mortality. Thus, some level of physical activity was better than none, and mortality risk was reduced when physical activity increased.

In a prospective cohort study of 2205 men aged 50 years and up, Byberg and colleagues found that the relative rate increase of mortality attributable to low physical activity was 32% compared to high physical, and 22% compared to medium physical activity levels (Byberg et al 2009).

Cancer mortality

Four studies addressed the relationship between low levels of physical activity and mortality from cancer (Giovannucci et al 2005; Haydon et al 2006; Knoops et al 2004; Schooling et al 2006). Three of four studies found low levels of physical activity to be a risk factor for mortality from cancer (Giovannucci et al 2005; Haydon et al 2006; Knoops et al 2004).

In a 10-year prospective cohort study of 2339 older healthy men and women, Knoops and colleagues found that physical activity was significantly associated with a lower risk of cancer mortality (Knoops et al 2004). Older people who were physically inactive had a higher risk of cancer mortality than those who were physically active. Knoops also reported on all-cause mortality in this paper (see all-cause mortality section) and mortality from cardiovascular disease (see cardiovascular disease section).

In a large prospective cohort of 47,620 male health professionals aged 40–75 at baseline, Giovannucci examined the change in level of physical activity over a 14-year follow-up period in relation to prostate cancer mortality (Giovannucci et al 2005). This study showed that for men over the age of 65, there was a lower risk in those men doing the greatest amounts of vigorous activity for fatal prostate cancer, compared to men who did no vigorous physical activity. Giovannucci also reported on prostate cancer morbidity (see prostate cancer section).

In a prospective cohort study with a sample of 41,528 Australian men and women aged 27–75 at baseline, Haydon and colleagues found that a lack of regular vigorous physical activity (exercising vigorously for at least 20 minutes, at least once per week) prior to the diagnosis of colorectal cancer was associated with poorer overall survival and disease-specific survival (Haydon et al 2006). After adjusting for age, sex, and tumour stage, vigorous exercisers had an improved disease-specific survival compared to non-exercisers.

In a large prospective cohort study in China with 54,088 men and women aged 65 and up, Schooling and colleagues found higher risks of premature mortality among the least active participants (Schooling et al 2006). In the full sample, there were significant reductions in all-cause mortality, but a non-significant trend for reduced cancer mortality among more active individuals. In analyses stratified by health status, compared with participants who reported no physical activity, those who reported some level of daily physical activity had lower mortality in the group with poor baseline health status, but not in the group with good baseline health status.

Cardiovascular disease mortality

Four studies addressed the relationship between low levels of physical activity and mortality from cardiovascular disease (Garg et al 2006; Knoops et al 2004; Nocon et al 2008; Schooling et al 2006). All four studies found that those with lower levels of physical activity had higher rates of mortality from cardiovascular disease.

In their systematic review and meta-analysis, Nocon and colleagues found that physical inactivity was associated with a marked increase in cardiovascular mortality in both men and women, even after adjusting for other relevant risk factors (Nocon et al 2008). This systematic review was based on general ‘adult’ populations and includes studies with younger people, though the health outcome under review is typically more likely to affect older people. For cardiovascular mortality, being in the lowest physical activity group was associated with a 35% increased risk, compared to the most physically active group. Nocon also reported on all-cause mortality (see all-cause mortality section).

In the prospective cohort study with 2339 healthy older men and women, Knoops and colleagues found that physical activity was significantly associated with a lower risk of cardiovascular disease mortality (Knoops et al 2004). In this 10-year study, participants who were physically inactive had a higher risk of mortality from coronary heart disease and cardiovascular diseases than those who were physically active. Knoops also reported on all-cause mortality (see all-cause mortality section) in this paper and mortality from cancer (see cancer mortality section).

Garg and colleagues studied 460 men and women with peripheral arterial disease, average age around 72 years (64–81years) at baseline, using a prospective cohort design (Garg et al 2006) Compared to participants in the highest quartile of objectively-measured physical activity, those in the lowest quartile had higher total mortality. Also, the researchers found that lower weekly numbers of stair flights climbed were associated with higher total mortality. Garg also reported findings from this study on cardiovascular disease morbidity (see cardiovascular disease section).

In a large prospective cohort study in China with 54,088 men and women aged 65 and up, Schooling and colleagues found higher risks of premature mortality among the least active participants (Schooling et al 2006). In the full sample, there were significant reductions in cardiovascular mortality for more active individuals. In analyses stratified by health status, compared with participants who reported no physical activity, those who reported some level of daily physical activity had lower mortality in the group with poor baseline health status, but not in the group with good baseline health status.

Whang and colleagues reported results from a large cohort of 69,693 women aged 40 to 65 at baseline, followed over about 18 years (Whang et al 2006). In the cohort analyses, women with higher levels of moderate to vigorous physical activity had lower long-term risk of sudden cardiac death in age-adjusted and multivariable models, compared to less active women.

Risks associated with low levels of moderate to vigorous physical activity (morbidity)

Body of evidence

Refer to appendix 2 (table 2) for study details.

Risks associated with low levels of moderate to vigorous physical activity (morbidity) – four systematic reviews (Lee et al 2003; Monninkhof et al 2007; Warburton et al 2010; Wendel-Vos et al 2004), 19 prospective cohort studies (Agarwal et al 2005; Bardia et al 2006; Calton et al 2006; Chao et al 2004; Dallal et al 2007; Demakakos et al 2010; Garg et al 2006; Giovannucci et al 2005; Gurwitz et al 1994; Koster et al 2008; Kritchevsky et al 2005; Larson et al 2006; Lee et al 1994; Mozaffarian et al 2008; Myint et al 2009; Norman et al 2002; Robinson-Cohen et al 2009; Scarmeas et al 2009; Weuve et al 2004); supplemented by one narrative review with meta-analysis (Moayyeri 2008), two cross-sectional studies (Finkelstein et al 2006; Riebe et al 2009), and two governmental reports with large literature reviews (US Department of Health and Human Services 2008; US Surgeon General 1996).

Summary of findings

The findings of the review in relation to the risks associated with low levels of moderate to vigorous physical activity (morbidity) are summarised below by condition type, starting with breast cancer.

Breast cancer

Four studies addressed the relationship between low levels of physical activity and breast cancer (Bardia et al 2006; Dallal et al 2007; Monninkhof et al 2007; Warburton et al 2010). All four studies indicate that low physical activity levels may be a risk factor for breast cancer.

Monninkhof and colleagues conducted a systematic review examining the link between low levels of physical activity and breast cancer (Monninkhof et al 2007). This systematic review was based on general 'adult' populations, and includes studies with younger people. This study found that about half of the reviewed studies showed protective effects of physical activity on breast cancer, relative to low levels of physical activity. Risk reductions of 20–80% were observed for physically active post-menopausal women relative to inactive post-menopausal women.

Warburton and colleagues' large systematic review found clear support for a protective dose–response relationship between physical activity and breast cancer (Warburton et al 2010). This systematic review was based on general 'adult' populations, and includes studies with younger people. Warburton and colleagues also reported on all-cause mortality, colon cancer, stroke, cardiovascular disease, hypertension, osteoporosis, and type 2 diabetes (see appropriate sections for each).

In a prospective cohort study of 41,836 postmenopausal American women aged 55–69 years at baseline, Bardia and colleagues examined the link between low levels of physical activity and breast cancer (Bardia et al 2006). In this study, high levels of recreational physical activity were associated with a lower risk of breast cancer, relative to low levels of activity (Bardia et al 2006). Thus, low levels of physical activity levels were positively associated with risk of breast cancer.

Dallal reported on a prospective cohort study of 110,599 US women which examined the role of long-term vigorous recreational physical activity on the risk of breast cancer (Dallal et al 2007). Participants were aged 20–79 years at baseline, and followed for over six years. This study found that women who reported less than 30 minutes of vigorous physical activity had a greater risk of invasive and in situ breast cancer. Invasive breast cancer risk was inversely associated with long-term vigorous physical activity, as was in situ breast cancer risk. Long-term moderate to vigorous physical activities were associated with reduced risk of estrogen receptor-negative but not estrogen receptor-positive invasive breast cancer.

Prostate cancer

Three studies addressed the relationship between low levels of physical activity and prostate cancer (Giovannucci et al 2005; Lee et al 1994; Norman et al 2002). These studies indicated low physical activity levels were a risk factor for prostate cancer.

Lee and Paffenbarger reported findings on the relationship between physical activity level and prostate cancer from the Harvard Alumni Study in a prospective cohort analysis of 17,607 American men (Lee et al 1994). Over 22 years of follow-up, a total of 454 cases of prostate cancer developed. Results of this study indicated that physical inactivity was not significantly related to prostate cancer, as the least physically active tertile showed no greater risk than either the middle or most active tertile of men.

In a very large nationwide prospective cohort published by Norman and colleagues, Swedish men were categorised according to occupational physical activity level in 1960 and 1970 (Norman et al 2002). Linkage data to the Swedish Cancer Register provided the ability to link occupational physical activity with incident prostate cancer between 1971 and 1989. This study presented separate results for men aged 70 years and older. Results showed that older men with sedentary jobs in both 1960 and 1970 had a small, excess relative risk (RR = 1.12, 95% CI = 1.08–1.17) compared to men who had very high or high levels of activity at work. Thus, a low level of occupational physical activity was a risk factor for prostate cancer in this large national cohort.

In the prospective cohort of 47,620 older male health professionals aged 40–75 years at baseline, Giovannucci found that for men over the age of 65, there was a lower risk in those men doing the greatest amounts of vigorous activity for advanced prostate cancer, compared to men who did no vigorous physical activity (Giovannucci et al 2005). This study also found that relative to older adult men who had consistently low levels of vigorous physical activity, the relative risks for advanced prostate cancer were greater for men who had reduced their physical activity from a high to a low category, much lower for men who had increased their physical activity from a low to a high level, and much lower for men who had consistently remained in a high level of activity. Giovannucci also reported on cancer mortality (see cancer mortality section).

Colon or rectal cancer

Three studies addressed the relationship between low levels of physical activity and colon and rectal cancer (Calton et al 2006; Chao et al 2004; Warburton et al 2010). The systematic review (Warburton et al 2010) and the larger of the two other prospective cohort studies (Chao et al 2004) indicated that relatively lower amounts of physical activity posed a risk factor for colon or rectal cancer.

In their large systematic review, Warburton and colleagues found that low levels of physical activity are a risk factor for colon cancer (Warburton et al 2010). This systematic review was based on general ‘adult’ populations, and may include studies with younger people. Warburton and colleagues also reported on all-cause mortality, breast cancer, stroke, cardiovascular disease, hypertension, osteoporosis, and type 2 diabetes (see appropriate sections for each).

Chao and colleagues conducted a prospective cohort study with 151,174 older men and women aged 50–74 at baseline to examine the relationship between low levels of physical activity and colorectal cancer (Chao et al 2004). Results showed that colon cancer risk increased significantly with decreasing amounts of physical activity. In this study, lower amounts of physical activity were related to significantly higher risks of cancer.

Carlton and colleagues published a prospective cohort study assessing the long-term association between physical activity and colon cancer in 31,783 US women aged 61 years at baseline (Calton et al 2006). This study showed that there was no significant relationship between activity level and colon cancer. The multivariable relative risk of colon cancer across increasing quintiles of total physical activity showed no significant trend. The multivariable relative risk comparing women at the high end of moderate and vigorous physical activity to less active women was also not significant. Further, the relationship between physical activity

and colon cancer risk did not vary by anatomic sub-site or across subgroups defined by age, body mass, dietary fibre intake, menopausal status, menopausal hormone use or aspirin use.

Cardiovascular disease

Three studies addressed the relationship between low levels of physical activity and cardiovascular disease or cardiovascular disease events, including atrial fibrillation (Garg et al 2006; Mozaffarian et al 2008; Warburton et al 2010). All three studies showed evidence of a relationship between low physical activity level and cardiovascular disease.

Warburton and colleagues' systematic review of 254 studies also found clear support for a protective dose–response relationship between physical activity and cardiovascular disease (Warburton et al 2010). This systematic review was based on general 'adult' populations, and may include studies with younger people. Warburton and colleagues also reported on all-cause mortality, colon cancer, breast cancer, stroke, hypertension, osteoporosis, and type 2 diabetes (see appropriate section for each).

Garg and colleagues conducted a prospective cohort study of 460 American older men and women (aged between 64 and 81 years) with peripheral arterial disease (Garg et al 2006). Among the findings, people who were less physically active and reported fewer flights of stairs climbed in an average week had higher number of cardiovascular events, demonstrating an increased risk from lesser amounts of physical activity. Garg also reported findings from this study on cardiovascular disease mortality (see cardiovascular disease mortality section).

Mozzaffarian and colleagues analysed the relationship between physical activity levels and atrial fibrillation in 5446 older people from the Cardiovascular Health Study (United States) (Mozaffarian et al 2008). Compared with those doing no exercise, atrial fibrillation incidence was lower in those who did moderate-intensity exercise, but not significantly different in those who performed regular high-intensity exercise.

Stroke

Four studies addressed the relationship between low levels of physical activity and stroke including ischemic and hemorrhagic types of stroke (Lee et al 2003; Myint et al 2009; Warburton et al 2010; Wendel-Vos et al 2004). All four studies showed evidence of a relationship between low physical activity level and stroke.

A systematic review and meta-analysis of 23 studies by Lee and colleagues found that moderate and high levels of physical activity were associated with reduced risk of ischemic strokes, haemorrhagic strokes, and total strokes (Lee et al 2003). This systematic review was based on general 'adult' populations, and may include studies with younger people. In this study, low-active individuals had a 27% higher risk of both ischemic and hemorrhagic strokes or mortality, relative to highly active persons, and similar results were observed for risks of stroke for low-active, compared to moderately active individuals.

Wendel-Vos and colleagues conducted a systematic review and meta-analysis of 31 studies examining the influence of both occupational physical activity and leisure-time physical activity on total stroke risk (Wendel-Vos et al 2004). This systematic review was based on general ‘adult’ populations, and includes studies with younger people. In this study, pooled relative risks of total, hemorrhagic, and ischemic stroke were consistently lower among the more physically active study participants, compared to less active participants.

In their large systematic review of 254 studies, Warburton and colleagues found those with lower levels of physical activity had greater risk for stroke, compared to those with higher physical activity levels (Warburton et al 2010). This systematic review was based on general ‘adult’ populations, and may include studies with younger people. Warburton and colleagues also reported on all-cause mortality, breast cancer, colon cancer, cardiovascular disease, hypertension, osteoporosis, and type 2 diabetes (see appropriate sections for each).

Myint and colleagues conducted a prospective cohort study of 20,040 men and women aged 40–79 in the UK (Myint et al 2009). Participants were measured at baseline on four health behaviours (including physical activity level, smoking, alcohol and fruit/vegetable consumption) and followed for about 12 years. After adjustment for age, sex, social class, body mass index, blood pressure, cholesterol, and history of diabetes and aspirin use, there was a significant relationship between the four health behaviours and risk of stroke, but the individual contribution of physical activity level was not assessed.

Hypertension

One study addressed the relationship between low levels of physical activity and hypertension (Warburton et al 2010). This study indicated low physical activity levels were a risk factor for hypertension.

In their systematic review of 254 studies, Warburton and colleagues reported that higher levels of physical activity were associated with lower risk for hypertension, in comparison with lower levels of physical activity (Warburton et al 2010). This systematic review was based on general ‘adult’ populations, and may include studies with younger people. Warburton and colleagues also reported on all-cause mortality, breast cancer, colon cancer, stroke, cardiovascular disease, osteoporosis, and type 2 diabetes (see appropriate sections for each).

In supplement to the above study, two very large governmental reports from the United States were used to provide evidence on the relationship between physical inactivity and hypertension (US Department of Health and Human Services 2008; US Surgeon General 1996). These reports included literature reviews based on a general adult population. The landmark Surgeon General’s report from 1996 concluded that relative to maintaining a physically inactive lifestyle, regular physical activity can prevent or delay the development of hypertension (US Surgeon General 1996). The latter report by the US Department of Health and Human Services concurred with the Surgeon General’s report, and found that adults and older adults who achieve little to no moderate to vigorous physical have higher risk of hypertension and many other diseases, compared with those achieving 150 minutes per week (US Department of Health and Human Services 2008). Furthermore, this report indicated the evidence for this relationship was strong, and that there is strong evidence the association exists for men and women of all ages.

Mobility limitation

Three studies addressed the relationship between low levels of physical activity and mobility limitation (Koster et al 2008; Kritchevsky et al 2005; Riebe et al 2009). These studies indicated low physical activity levels were a risk factor for mobility limitation.

Kritchevsky and colleagues followed 3075 well-functioning community-dwelling older women and men in a four-year prospective cohort study (Kritchevsky et al 2005). Results showed that the physically inactive participants (those who reported less than 1000 kilocalories per week of physical activity) were more likely to develop mobility limitation.

In Korster and colleagues' prospective cohort study that followed older Americans for nearly seven years, 46% of the participants developed a mobility limitation during the period of study (Koster et al 2008). Participants included black and white men and women aged 70–79. Results showed that being in the lowest quartile of physical activity was associated with a 70% greater risk of mobility limitation in all groups (men, women, black, and white). Findings also indicated that those with combined high adiposity and low physical activity had particularly high risk of mobility limitation. Thus, high adiposity and low physical activity both independently predicted the onset of mobility limitation in well-functioning older persons.

To supplement this high-level evidence, a cross-sectional study published by Riebe was identified. This study investigated the association between physical activity levels and mobility limitation in 821 American people over age 60 (Riebe et al 2009). In this study, ageing was associated with lower levels of physical activity and physical function in this sample. Results from analyses stratified by both body mass index and by age group showed that those who were physically inactive were significantly more likely to have impaired functional mobility. Thus, physical inactivity was a risk factor for mobility limitation in this study, independent of age.

Cognitive impairment or dementia

Three studies addressed the relationship between low levels of physical activity and cognitive impairment or dementia, including Alzheimer's disease (Larson et al 2006; Scarmeas et al 2009; Weuve et al 2004). Both studies examining Alzheimer's disease found low physical activity levels to be a significant risk factor (Larson et al 2006; Scarmeas et al 2009), whilst the third study found low physical activity levels to be significantly related to problems in cognitive function (Weuve et al 2004).

In a prospective cohort study of 18,766 older women, Weuve and colleagues examined the longitudinal association between physical activity level and cognitive function (Weuve et al 2004). Results showed that the least physically active women were 20% more likely to become cognitively impaired, compared to the most active women. The lack of regular physical activity was associated with significantly worse cognitive function and more cognitive decline in older women.

Larson and colleagues conducted a prospective cohort study, following 1740 older men and women without cognitive impairment at study start over a period of six years (Larson et al 2006). This study found that a low level of physical activity was positively associated with onset of Alzheimer's disease and dementia. The age- and sex-adjusted risk of dementia was lower in more frequent exercisers, relative to less frequent exercisers.

In a prospective cohort study of 1880 older men and women without dementia at study start, physical activity was associated with a reduced risk of Alzheimer's disease (Scarmeas et al 2009). In this study, participants reporting higher levels of physical activity had a 33% reduction in Alzheimer's risk, compared to the least active participants.

Kidney dysfunction

One study addressed the relationship between low levels of physical activity and rapid decline in kidney function (Robinson-Cohen et al 2009). This study indicated low physical activity levels were a risk factor for rapid decline in kidney function.

Robinson-Cohen and colleagues conducted a prospective cohort study with 4011 older men and women in the US (Robinson-Cohen et al 2009). Results showed that the two highest physical activity groups were associated with a 28% lower risk of rapid decline in kidney function than the two lowest physical activity groups. In this study, lower amounts of leisure-time physical activity and walking pace were also each associated with a higher incidence of rapid decline in kidney function.

One additional study provided evidence on the relationship between physical inactivity and kidney dysfunction (Finkelstein et al 2006). This cross-sectional study by Finkelstein and colleagues investigated the association between various self-report measures of physical activity and the kidney function measures of glomerular filtration rate and urine microalbuminuria. Participants were US adults, aged 18 and older, from the NHANES III study, but Finkelstein and colleagues analysed data and reported findings for separate age groups, including 4549 men and women aged 56 years and older. Results showed that in statistical models adjusting for potential confounding factors, there was no significant relationship between physical activity variety, frequency, or energy expenditure and the two kidney function measures for older people.

Osteoporosis

Two studies addressed the relationship between low levels of physical activity and osteoporosis or bone mineral density (Agarwal et al 2005; Warburton et al 2010). The systematic review indicated low physical activity levels were a risk factor for osteoporosis, but the small prospective study did not show a significant relationship.

In their systematic review, Warburton and colleagues found those people with lower levels of physical activity had greater risk for osteoporosis, compared to those with higher physical activity levels (Warburton et al 2010). This systematic review was based on general 'adult' populations, and may include studies with younger people. Warburton and colleagues also reported on all-cause mortality, breast cancer, colon cancer, stroke, cardiovascular disease, hypertension, and type 2 diabetes (see appropriate sections for each).

Agarwal and colleagues prospectively studied 50 Indian men with prostate cancer who opted to undergo orchidectomy (Agarwal et al 2005). Cross-sectional analyses showed that patients with lower physical activity levels had statistically significant lower bone mineral density compared with their active counterparts. In prospective analyses, however, lower levels of physical activity were not statistically significantly related to higher levels of bone mineral loss. Major limitations of this prospective study include the small clinical sample of men and having only six to twelve months of follow-up.

In supplement to the above studies, Moayyeri conducted a narrative review and meta-analysis of literature on physical activity and osteoporotic fractures (Moayyeri 2008). Based on 13 prospective cohort studies, a review of the relationship between physical activity and osteoporotic fractures indicated that a physically inactive lifestyle raises the risk of hip fracture. According to the author, the consistency and strength of protective relationship in the reviewed observational studies suggests that older adults should be physically active to prevent osteoporotic fractures.

Type 2 diabetes

Three studies addressed the relationship between low levels of physical activity and type 2 diabetes (Demakakos et al 2010; Gurwitz et al 1994; Warburton et al 2010). All studies indicated that low physical activity levels were associated with greater risk for type 2 diabetes.

Gurwitz and colleagues conducted a prospective cohort study with 2737 older American men and women, followed over three years (Gurwitz et al 1994). Researchers investigated the association between physical inactivity and other factors with type 2 diabetes, using a statistical model that adjusted for the influence of age, sex, blood pressure, and self-reported high blood sugar. Results showed that independent of the risk associated with high body mass (adjusted odds ratio = 2.4, 95% CI = 1.3–4.4), older people with a low physical activity level (adjusted odds ratio = 1.5, 95% CI = 1.0–2.1) were significantly more likely to become type 2 diabetics. These findings suggest that there is a positive relationship between low physical activity level and the development of type 2 diabetes in older people.

Warburton and colleagues reported that low physical activity levels were a risk factor for type 2 diabetes in their systematic review of 254 studies (Warburton et al 2010). This systematic review was based on general ‘adult’ populations, and may include studies with younger people. Warburton and colleagues also reported on all-cause mortality, breast cancer, colon cancer, stroke, cardiovascular disease, hypertension, and osteoporosis (see appropriate sections for each).

Demakakos and colleagues conducted a prospective cohort study with 7466 men and women, with a mean age of 64 at baseline, who were free of type 2 diabetes at study entry, and were followed over 10 years (Demakakos et al 2010). Results showed that participants who participated in moderate to vigorous intensity physical activity less than once a week had greater risk of type 2 diabetes, after adjustment for all covariates. For those aged 70 years and over at study entry, results also showed that participants who did low-intensity physical activity less than once a week had greater risk of type 2 diabetes, after adjustment for all covariates. Compared with physical inactivity, any type of physical activity was associated with reduced risk of type 2 diabetes in adults aged 70 years and over.

Risks associated with sitting or sedentary behaviour (mortality)

Body of evidence

Refer to appendix 2 (table 3) for study details.

Risks associated with sitting or sedentary behaviour (mortality) – three prospective cohort studies (Katzmarzyk et al 2009; Patel et al 2010; Warren et al 2010).

Summary of findings

The findings of the review in relation to the risks associated with high levels of sedentary behaviour (morbidity) are summarised below by condition type, starting with all-cause and cardiovascular disease mortality.

All-cause and cardiovascular disease mortality

Three studies addressed the relationship between sitting or sedentary behaviour and mortality (Katzmarzyk et al 2009; Patel et al 2010; Warren et al 2010). All of these studies showed that sedentary behaviour was a risk factor for all-cause and cardiovascular disease mortality.

Katzmarzyk and colleagues conducted a prospective cohort study in 17,013 Canadian men and women aged between 18 and 90 years, and reported results that were stratified or adjusted for age and physical activity level (Katzmarzyk et al 2009). Across the age spectrum, results showed a dose–response relationship between sitting time and mortality from all causes and mortality from cardiovascular disease, and these associations were independent of leisure time physical activity. Among those over age 60, there was a progressively higher risk of all-cause mortality across higher levels of sitting time.

Patel and colleagues conducted a prospective cohort study over 14 years with 53,440 older men and 69,776 older women (aged 57–68 years at baseline) who were disease free at the commencement of data collection (Patel et al 2010). Results showed that, after statistically controlling for body mass index, smoking, and other potential confounders, time spent sitting was associated with mortality in both sexes, and the risk from sitting was strongest for cardiovascular disease mortality. Sitting time was independently associated with total mortality, regardless of physical activity level.

In another prospective cohort study, Warren and colleagues assessed the relationship between sedentary behaviour and mortality by following 7744 men who were around the age of 47 years at baseline over 21 years of follow-up (Warren et al 2010). Results showed that men who reported more than 10 hours per week of riding in a car had 82% greater risk of dying from cardiovascular disease than those who reported less than four hours per week. Also, men who reported more than 23 hours per week of combined sedentary behaviour had 64% greater risk of dying from cardiovascular disease than those who reported less than 11 hours per week. Regardless of the amount of sedentary activity reported by these men, being older, having normal weight, having normal blood pressure, and being physically active were associated with a reduced risk of cardiovascular disease mortality.

Risks associated with sitting or sedentary behaviour (morbidity)

Body of evidence

Refer to appendix 2 (table 4) for study details.

Risks associated with sitting or sedentary behaviour (morbidity) – three prospective cohort studies (George et al 2010; Hu et al 2001; Patel et al 2006) supplemented by one narrative review (Hamilton et al 2007) and one cross-sectional study (Zheng et al 1993).

Summary of findings

The findings of the review in relation to the risks associated with high levels of sedentary behaviour (morbidity) are summarised below by condition type, starting with breast cancer.

Breast cancer

One study addressed the relationship between sitting or sedentary behaviour and invasive breast cancer (George et al 2010). This study indicated that sedentary behaviour was a risk factor for breast cancer.

A large prospective cohort study by George and colleagues examined the relationship between sedentary behaviour and breast cancer by following 97,039 women with an average age of 63 years at baseline (range of 50 to 71 years at baseline) over a period of about seven years (George et al 2010). This study found that routine activity during the day that included heavy lifting or carrying versus spending the day mostly sitting was associated with reduced risk of invasive breast cancer.

In supplement to this study, Zheng published an observational study that investigated 2736 cases of breast cancer incidence of Chinese women over five years in relation to occupational physical activity level (Zheng et al 1993). This study found that there was a significantly higher incidence of breast cancer among women who had greater sitting time at work (eg, professionals, government officials, and clerical workers), compared to those who had more active occupations (eg, service workers, craftsmen). Age was not reported in the study, but the observed associations held for both working and retired women. Thus, jobs having greater sedentary behaviour were a risk factor for breast cancer in this study of Chinese women.

Ovarian cancer

One study addressed the relationship between sitting or sedentary behaviour and ovarian cancer (Patel et al 2006). This study indicated that sedentary behaviour was a risk factor for ovarian cancer.

Patel and colleagues prospectively studied the relationship between prolonged periods of sedentary behaviour and ovarian cancer (Patel et al 2006). In this study, 59,695 American postmenopausal women with a mean age of 63 years at baseline (range 57–68) were cancer-free at enrolment, and were followed over a period of nine years. Results showed that participants who reported long periods of sedentary behaviour showed an increased risk of

ovarian cancer. A prolonged duration of sedentary behaviour was associated with a 55% increased risk of ovarian cancer (for six or more hours per day of sitting versus less than three hours per day.

In supplement to this study, Zheng published an additional observational study that investigated 595 cases of breast cancer incidence over five years in relation to the occupational sitting time of Chinese women (Zheng et al 1993). This study found that there was a significantly higher incidence of cancer among women with high sitting time, compared to less sedentary occupations. Age was not reported in the study, but the observed associations held for both working and retired women. Thus, jobs having greater sedentary behaviour were a risk factor for ovarian cancer in this study of Chinese women.

Type 2 diabetes

One study addressed the relationship between sitting or sedentary behaviour and type 2 diabetes (Hu et al 2001). This study indicated that sedentary behaviour was a risk factor for type 2 diabetes.

Hu and colleagues used a prospective cohort design to analyse the relationship between time spent watching television (a proxy for sedentary behaviour) and 10-year risk of diabetes in a cohort of 37,918 men and women aged 40 to 75 at baseline (Hu et al 2001). Results showed that time spent watching TV was significantly associated with higher risk for diabetes. After adjustment for age, smoking, physical activity levels, and other covariates, the relative risks of diabetes across categories of average hours spent watching TV per week showed a dose–response relationship, as TV watching was linearly related to increasing risk of diabetes.

In supplement to the above evidence, Hamilton and colleagues published a narrative review based on a range of literature on physical inactivity from a physiological and epidemiological perspective (Hamilton et al 2007). No age or population distinctions were made in the selection of evidence for this review, so study samples included people under the age of 65 years. Hamilton and colleagues found that metabolic syndrome risk factors and type 2 diabetes are associated with indexes of sedentary behaviour. Specifically, studies in this review based on prolonged TV and computer time led to the conclusion that too much sitting can more than double the risk for metabolic syndrome, independent of the risk posed by excess weight or adiposity.

Conclusions

The evidence on the risks of physical inactivity among older people suggests that having a less active or more sedentary lifestyle increases the risk of premature mortality and other undesirable health-related outcomes, relative to leading an active lifestyle. The lack of moderate to vigorous physical activity and the presence of large amounts of time spent sitting appear to be independent risk factors for negative health outcomes.

From our review, older people who have low levels of physical activity are at higher risk of:

- all-cause mortality
- cardiovascular mortality
- cancer mortality
- breast cancer
- cardiovascular diseases
- stroke
- mobility limitation
- cognitive impairment and dementia
- osteoporosis
- type 2 diabetes.

In addition, there is some evidence that older people with lower levels of physical activity may be at higher risk of cancer of the prostate, colon, and rectum, hypertension, and kidney dysfunction.

From our review, older people with high levels of sedentary behaviour are at higher risk of:

- all-cause and cardiovascular mortality
- cancer of the breast and ovaries
- type 2 diabetes.

These findings suggests that many negative health outcomes could be prevented in older people through increases to moderate to vigorous physical activity, through decreases to sedentary behaviours, or a combination of both approaches.

Overall, the body of reviewed evidence shows consistent dose–response relationships both for levels of physical activity, and for sedentary behaviours. Incremental increases in physical activity or decreases in sedentary behaviour are both independently associated with marked reduction in mortality and morbidity risk. Health promotion efforts targeting physically inactive older people could emphasize both the reduction of sedentary behaviours and increase of moderate to vigorous physical activity to achieve better health outcomes. Information regarding the effectiveness of various physical activity interventions and descriptions of those interventions is provided in the next chapter.

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6 What are effective types of physical activity interventions in improving outcomes for older people?

Background

Chapter 4 provided an evidence base for the benefits of physical activity for older people in improving health and functional outcomes. Chapter 5 provided an evidence base for the health- and function-related risks of physical inactivity and sedentary behaviour for older people. Broadly speaking, these two chapters provide a case for promoting physical activity in older people as a means of improving health and functional outcomes.

Given this collection of evidence on benefits and risks, which types of physical activity interventions are effective in delivering health and functional benefits and reducing the risks? This chapter provides the evidence base from the literature that can be used to answer this question. It also provides information on the characteristics (ie, type, duration, intensity, frequency) of physical activity intervention programmes that the literature indicates are most effective. There is large overlap between chapters 4, 5, and 6 with regard to literature reviewed due to the similarity in research questions, but the present focus is on effective interventions, primarily as evaluated within randomised controlled trials. Because some studies feature multiple physical activity interventions or address multiple health-related outcomes, those studies are cited multiple times throughout this chapter.

Prevention

Many studies reviewed in chapter 4 displayed benefits derived from physical activity that are relevant to the primary or secondary prevention of disease, injury, or other undesirable health outcomes. Many of the major chronic diseases impacting older people, such as heart disease, stroke, cancer, and type 2 diabetes typically have roots much earlier in life, develop over years or decades, and/or have long lag times between exposure to key lifestyle behaviours and health-related outcomes. Given this extended developmental process of chronic disease, much of the best evidence around prevention of these diseases comes from longitudinal prospective cohort studies, which are observational in nature, and are presented in chapter 4. Interventions that are evaluated in randomised controlled trials are often too short in duration to capably address the question of primary or secondary prevention of chronic diseases through participation in physical activity. Despite that inherent limitation within the literature, we present here effective physical activity intervention evidence for falls, hospitalisation, osteoporosis, disability, hypertension, and insulin resistance/type 2 diabetes. Beyond these topics, much of the evidence presented in the enhancement section has general implications for prevention.

Management

Chapter 4 presented evidence of the benefits of physical activity for older people, with a particular focus on benefits for those with disease or health-related conditions. For older people, various physical activity interventions have been designed to manage or treat specific diseases or conditions, and effective interventions are presented in this chapter. Relevant details of the effective physical activity interventions for the management of vascular diseases, heart disease, stroke, various types of cancer, osteoarthritis, frailty, obesity or overweight, type 2 diabetes, pulmonary diseases, depression, neurological disorders, hip injury, and sleep problems are described in this chapter.

Enhancement

Chapter 4 reviewed the literature regarding the benefits of physical activity relevant to physical and cognitive functioning, physical fitness, and quality of life. Relevant details of the effective physical activity interventions for the enhancement of cognitive functioning, physical functioning and mobility, activities of daily living, balance, aerobic capacity, strength, and quality of life are presented in this chapter.

Definitions

The reviewed literature discusses four broad types of physical activity interventions: aerobic endurance, resistance training, mobility and balance, and mixed or various types. This chapter is structured around these intervention types.

An **aerobic endurance physical activity intervention** is a structured programme involving continuous movement of large muscle groups, sustained for a minimum of 10 minutes (Sims et al 2006). In older people, aerobic endurance physical activities are frequently performed by walking briskly. In research intervention studies, walking is frequently performed on treadmills in supervised physical activity programmes. However, other forms of aerobic endurance physical activities among older people may include bicycling, swimming, rowing, aerobic dance, or aquatic physical activities:

- High intensity, also known as vigorous or very vigorous, aerobic endurance training is frequently performed at greater than 70% of maximum heart rate, or greater than 50% of heart rate reserve, aerobic capacity, or V02max.
- Moderate intensity aerobic endurance training is frequently performed at 50–70% of maximum heart rate. This intensity is lower than 50% of heart rate reserve and aerobic capacity, or VO2max.

A **resistance training physical activity intervention** is a structured programme involving multiple intermittent movements of large or small muscle groups, performed repetitively and with resistance to movement. In older people, resistance training can be done with free weights, machines, body weight alone, stretch bands, or other methods. In studies, supervised physical activity programmes frequently use exercise machines to monitor a progressive resistance and prescribed range of motion. Resistance training can vary not only in amount of resistance and type of equipment, but also in speed of movement, specific physical activities performed, and number of sets and repetitions of exercises. Most of the included resistance training intervention programmes have used multiple exercises for both

upper and lower body, multiple sets of exercises, and multiple repetitions within sets of exercises, but there is tremendous heterogeneity and often insufficient detail provided in published literature. Due to the large heterogeneity in reporting of programme details within reviewed studies, our approach is to present information focused on the frequency, intensity and duration of resistance exercises, when available:

- High intensity resistance training is frequently performed with a resistance set at or around 80% of one-repetition maximum (the maximum amount of resistance able to be performed in a movement one time).
- Moderate intensity resistance training is frequently performed at or around 50% of one-repetition maximum.
- Low intensity resistance training is frequently performed at or around 20% of one-repetition maximum.

A **mobility and balance physical activity intervention** is a structured programme involving multiple intermittent movements that focus on: maintaining control of the body to avoid falling; improving gait or function; and building co-ordination, flexibility, and muscular strength and endurance. In older people, mobility and balance is frequently performed in dancing, yoga, lawn bowls, golf, and tai chi. Tai chi is derived from martial arts, and involves balance, strength, co-ordination, and flexibility (Sims et al 2006).

A **mixed physical activity intervention** is a structured programme involving one or more of the above types of intervention: aerobic endurance, resistance training, and mobility and balance. Interventions or articles containing more than one type of physical activity intervention programme or programme components, often within a systematic review, are categorised as mixed or various physical activity interventions if they cannot be categorised solely into one of the other three types of interventions above.

The terms **effective** and **effectiveness**, as used in this paper, refer to demonstrated statistically significant differences in study outcomes between intervention and control groups within randomised controlled trials. For systematic reviews, effectiveness is similarly based on statistically significant differences and/or author conclusions from the review of interventions.

The **frail** old are defined as people over the age of 65 years who are subject to a loss of physical function, combined with a set of linked deteriorations including, but not limited to, the musculoskeletal, cardiovascular, metabolic, and immunologic systems (known as **frailty**) (Faber et al 2006).

Quality of life is defined as a subjective overall feeling of wellbeing or satisfaction with life, and includes the facets of physical, emotional, social, functional, and spiritual wellbeing (Hung et al 2004; Warburton et al 2006).

Body of evidence

In total, 104 peer-reviewed journal articles were identified that met the inclusion criteria for physical activity interventions in older people, and were reviewed. All of the included articles were considered to be of good or mixed quality. None of the included articles were considered to be poor quality. Of the 104 journal articles, some articles present multiple types of physical activity interventions, and so these articles are presented more than once.

The body of evidence was viewed in four parts:

- Aerobic endurance physical activity interventions – 31 studies (Angevaren et al 2008; Ashworth et al 2005; Baker et al 2010; Bartels et al 2007; Bendermacher et al 2006; Bonaiuti et al 2002; Broman et al 2006; Brosseau et al 2003; Davidson et al 2009; Davies 2010; DiPietro et al 2006; Faber et al 2006; GASS et al 2004; Haykowsky et al 2005; Howe et al 2007; Huang et al 2006; Hung et al 2004; Kelley et al 2001; Kruger et al 2009; Lautenschlager et al 2008; Mangione et al 2005; McDermott et al 2009; Mehrholz et al 2010; Motl et al 2005; Netz et al 2005; Paterson et al 2010; Pogliaghi et al 2006; Shekelle et al 2003; van de Port et al 2007; Windsor et al 2004; Wisloff et al 2007).
- Resistance training physical activity interventions – 25 studies (Bonaiuti et al 2002; Fatouros et al 2005; Galvão et al 2005; Ginis et al 2006; Haykowsky et al 2005; Howe et al 2007; Kalapotharakos et al 2005; Latham et al 2004; Liu et al 2009; Liu-Ambrose et al 2010; Mangione et al 2005; McDermott et al 2009; Mikesky et al 2006; Morris et al 2004; Orr et al 2008; Paterson et al 2010; Petterson et al 2009; Seynnes et al 2004; Shekelle et al 2003; Singh et al 2005; Suetta et al 2004; Sullivan et al 2007; Symons et al 2005; Verdijk et al 2009; Wieser et al 2007).
- Mobility and balance promoting interventions – 11 studies (Faber et al 2006; Fransen et al 2007; Gillespie et al 2009; Greenspan et al 2007; Howe et al 2007; Irwin et al 2008; Li et al 2005; Marigold et al 2005; Taylor-Piliae et al 2010; van de Port et al 2007; Voukelatos et al 2007).
- Mixed or various physical activity interventions – 56 studies (Arnold et al 2008; Ashworth et al 2005; Baker et al 2010; Binder et al 2002; Blake et al 2009; Blumenthal et al 2005; Callahan et al 2008; Cameron et al 2010; Chang et al 2004; Chien et al 2008; Chin A Paw et al 2008; Courtney et al 2009; Daniels et al 2008; Davidson et al 2009; Davies 2010; Dubbert et al 2008; Forster et al 2009; Forster et al 2010; Fransen et al 2008; Fransen et al 2009; Gillespie et al 2009; Goodpaster et al 2008; Goodwin et al 2008; Guell et al 2006; Haykowsky et al 2005; Heyn et al 2004; Holland et al 2008; Howe et al 2007; Hung et al 2004; Kay et al 2006; Kelley 1998; Kerse et al 2005; Luctkar-Flude et al 2007; Mador 2004; Manty et al 2009; McClure et al 2005; Messier et al 2004; Montgomery et al 2002; Morey et al 2009; Motl et al 2005; Pahor et al 2006; Pang et al 2005; Peri et al 2007; Rolland et al 2007; Rydwik et al 2010; Rydwik et al 2008; Shekelle et al 2003; Sherrington et al 2008; Sjösten et al 2006; Takeshima et al 2004; Taylor 2010; Taylor et al 2004; Thomas et al 2007; Villareal et al 2006b; Watson et al 2008; Windle et al 2010).

Summary of findings

Within each section there are tables that provide the core information about the type of physical activity intervention and the duration, intensity and frequency of the intervention. Where information is not provided, it was not available in the source literature. The order of the studies in each table is based on an assessment of the quality of the study, with highest quality being presented first.

Effective physical activity interventions for the prevention of injury, disease, or health-related conditions in older people

Prevention of falls

Effective mobility and balance training interventions

The literature review identified four papers indicating effective mobility and balance interventions for preventing falls amongst people over the age of 65.

Table 6.1

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Gillespie 2009	N = 111 studies; men and women, any age	Mobility and balance	Majority of 111 trials reported 30–90 minutes per session	Not specified	Majority of 111 trials reported 1 to 3 sessions weekly (6 weeks to 1 year)
Li 2005	N = 256; men and women, mean age 77.5 + 5.0 years	Mobility and balance	60 minutes per session	Not specified	Three times per week (6 months)
Faber 2006	N = 278; women, mean age 85 ± 6 years	Mobility and balance (tai chi)	60 minutes per session	Moderate	One time per week for 4 weeks, then 2 times per week for 16 weeks (20 weeks)
Voukelatos 2007	N = 702; women (85%) and men, aged 60 years and over	Mobility and balance	60 minutes per session	Not specified	One session weekly (16 weeks)

Gillespie and colleagues conducted a systematic review of interventions for preventing falls among older people living in the community, that included 111 randomised controlled trials with a participant total of 55,303 (Gillespie et al 2009). The results of this systematic review found that programmes containing two or more of those components were more likely to reduce the rate of falls, or number of people falling. Furthermore, effectiveness of physical activity interventions was found for group tai chi exercise, individual home-based physical activity, or supervised multiple-component group physical activity.

Li reported on a randomised trial that showed favourable fall rates relative to controls for previously inactive people aged 70 years and older attending a thrice-weekly tai chi physical activity group (Li et al 2005). Furthermore, improvements were seen in fear of falling, functional balance, and physical performance.

In a randomised controlled trial evaluating group physical activity for 278 men and women, Faber randomly assigned participants to a non-exercise control group, a functional walking group, or to a balance group, which consisted of physical activities based on principles of tai chi (Faber et al 2006). This study found that fall-preventive tai chi programmes were effective for reducing falling and improving physical performance in pre-frail, but not in the frail old.

Voukelatos reported a randomised controlled trial studying community-dwelling older people, in which results showed that participation in one weekly tai chi class for 16 weeks led to less frequent falls and better balance, relative to controls (Voukelatos et al 2007).

Effective mixed or various physical activity interventions

The literature review identified eight papers indicating effective mixed or various physical activity interventions for preventing falls amongst people over the age of 65.

Table 6.2

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Shekelle 2003	N = 47 studies; men and women, mostly aged 65 years and over	Mixed or various physical activities	Not specified	Not specified	Not specified
Chang 2004	N = 40 studies; men and women, any age	Mixed or various physical activities	Not specified	Not specified	Not specified
McClure 2005	N = 6 studies; men and women, aged 65 years and over	Mixed or various physical activities	Not specified	Not specified	Not specified
Baker 2007	N = 15 studies; men and women with mild cognitive impairment, aged 55–85 years	Mixed or various physical activities	Not specified	Not specified	Commonly 3 days per week
Arnold 2008	N = 22 studies; men and women, aged 50 years and over	Mixed or various physical activities	Not specified	Not specified	Majority between one and three sessions per week (4 weeks to 14 months)
Sherrington 2008	N = 44 studies; men and women, mostly aged 65 years and over	Mixed or various physical activities	Programme duration constituted total of 50 hours of physical activity time	Not specified	Not specified

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Gillespie 2009	N = 111 studies; men and women, any age	Mixed or various physical activities	Majority of 111 trials reported 30–90 minutes per session	Not specified	Majority of 111 trials reported 1 to 3 sessions weekly (6 weeks to 1 year)
Cameron 2010	N = 41 studies; men and women, mean age 83 years	Mixed or various physical activities	Not specified	Not specified	Not specified

Shekelle and colleagues conducted a large systematic review and found strong evidence from the meta-analysis pertaining to fall reduction (Shekelle et al 2003). In this study, results showed that physical activity interventions resulted in a 12% decrease in fall risk and a 19% decrease in the number of falls. In the review, several types of intervention programmes were assessed, but data were not sufficient to identify the most effective type of physical activity. Physical activity programmes for falls prevention typically included one or more of these: aerobic endurance, muscular strength, flexibility, and balance.

Chang reported a systematic review and meta-analysis of 40 randomised clinical trials, which found that interventions to prevent falls in older people have been effective in reducing both the risk of falling and the monthly rate of falling (Chang et al 2004). Further, although various physical activity intervention programmes had a beneficial effect on older people's risk of falling and monthly fall rate, the most effective intervention was a multi-factorial fall risk assessment and management programme.

McClure assessed the impact of population-based fall countermeasure interventions through a systematic review of six evaluation studies in Australia, Denmark, Norway, Taiwan, and Sweden (McClure et al 2005). Those studies with a physical activity component showed relative reductions in fall-related injuries. None of the studies was a randomised controlled trial, but findings of effectiveness were consistent across studies.

In a systematic review by Baker and colleagues, researchers examined 15 randomised controlled trials, with a total sample of 2149 participants generally ranging from 67 to 84 years of age (Baker et al 2007). Although the available evidence was limited, this study found a positive effect on falls prevention from multi-modal physical activity programmes.

Arnold and colleagues reported on a systematic review of randomised controlled trials, and concluded that individualised and group physical activity programmes were both effective in reducing fall risk (Arnold et al 2008). Seventeen of 19 studies that measured fall risk and eight of 14 studies that measured falls had positive outcomes associated with physical activity. Both short-term and long-term interventions manifested favourable results for decreased fall risk, but for interventions indicating actual prevention of falls or lower fall rates, nearly all were longer than six months in duration. The authors, however, could not define the most effective physical activity programme for fall prevention in community-dwelling older people (type, frequency, and amount of physical activity).

Sherrington and colleagues reported on a systematic review of 44 trials, most of which were based on men and women above the age of 75 years (Sherrington et al 2008). This systematic review found that physical activity programmes can prevent falls in older people. Greater relative effects were seen in programmes that included physical activities that challenge balance, use a higher dose of physical activity, and do not include a walking programme.

Gillespie reported a systematic review of interventions for preventing falls among older people living in the community (Gillespie et al 2009). The review found that physical activity programmes had targeted various physical functioning components: 1) strength; 2) balance; 3) flexibility; and 4) endurance for the prevention of falls amongst study participants. Results showed that intervention programmes containing two or more of the above components were more likely to reduce the rate of falls, or number of people falling, relative to single-component interventions. Furthermore, physical activity interventions based on group tai chi, individual home-based physical activity, or supervised multiple-component group physical activity were found to be effective.

Cameron's systematic review of intervention programmes for older people included 41 studies that represented 25,422 participants from nursing-care facilities or hospitals (Cameron et al 2010). A key finding was that supervised physical activity interventions resulted in statistically significant reductions of fall risk, but that there was no evidence that interventions targeting single fall risk factors could reduce falls. The review, however, found evidence for the effectiveness of multi-factorial interventions (those including physical activity in combination with other intervention components) as a means to reduce falls and the risk of falling in hospitals.

Conclusions: prevention of falls

The following efficacious physical activity interventions were identified in relation to fall prevention:

- mobility and balance interventions, typically consisting of one to three sessions of tai chi per week for around 16 weeks, each session about 60 minutes in duration
- mixed or various physical activity interventions, typically consisting of one to three sessions of physical activity per week for at least four weeks and up to a year, each session between 30 to 90 minutes. Most articles did not specify details of the effective physical activity programmes
- a fall prevention programme for the frail old (Faber et al 2006). The fall-preventive tai chi programme was effective for reducing falling and improving physical performance in pre-frail, but not in the frail old.

Prevention of osteoporosis

Effective aerobic endurance interventions

The literature review identified one paper indicating effective aerobic endurance training interventions for preventing osteoporosis amongst people over the age of 65.

Table 6.3

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Bonaiuti 2002	N = 18 studies; post-menopausal women, aged 45–70 years	Aerobic endurance	Various; about 60 minutes	Various; 60% to 70% heart rate reserve	Various; about 3 times per week (52 weeks)

Bonaiuti's systematic review of 18 randomised controlled trials including 1423 participants showed that aerobic endurance physical activities were effective in increasing bone mineral density of the spine (Bonaiuti et al 2002). In this study, walking was also effective in increasing bone mineral density of the hip.

Effective resistance training interventions

The literature review identified one paper indicating effective resistance training interventions for preventing and managing osteoporosis amongst people over the age of 65.

Table 6.4

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Bonaiuti 2002	N = 18 studies; post-menopausal women, aged 45–70 years	Resistance training	Various; some around 60 minutes	Various: some 2 to 3 sets at 40% to 80% of one-repetition maximum	Various; some around 3 times per week (52 weeks)

Bonaiuiti and colleagues' systematic review of 18 randomised controlled trials including 1423 participants showed that weight bearing physical activity and resistance training, were effective in increasing bone mineral density of the spine, which is associated with lower risk of osteoporosis (Bonaiuti et al 2002).

Effective mixed or various physical activity interventions

The literature review identified one paper indicating effective mixed or various training interventions for preventing osteoporosis amongst people over the age of 65.

Table 6.5

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Kelley 1998	N = 6 studies; post-menopausal women, aged 53–79 years	Mixed or various physical activities	Various; 45 to 60 minutes	Various; 60% to 85% of maximum heart rate	Various; 2 to 4 times per week (8 months to 2 years)

Kelley and colleagues reported on a systematic review of six intervention studies that evaluated the effectiveness of physical activity for promoting bone density (Kelley 1998). The population included people under the age of 65 years. Five of the six interventions reviewed had an aerobic endurance component, and some specified that physical activity was weight bearing and at least one intervention included resistance training. This study's meta-analysis found an overall effect size from physical activity that was equivalent to a preferential change of over 2% in bone density, relative to controls who did not participate in a physical activity intervention.

Supplemental evidence

A large literature review by Warburton and colleagues addressed primary and secondary prevention of osteoporosis across all ages (Warburton et al 2006). The populations within reviewed studies included people under the age of 65 years. This review indicated that weight-bearing and impact types of physical activity prevent bone loss associated with ageing. This review indicated that physical activity interventions were found to prevent or reverse about 1% of bone loss per year in postmenopausal women, but the details of intervention components were not described. Warburton and colleagues concluded that regular physical activity was an effective method for maintenance of bone health and prevention of osteoporosis.

Conclusions: prevention of osteoporosis

The following efficacious physical activity interventions were identified in relation to prevention of osteoporosis:

- an aerobic endurance intervention, consisting of about three sessions per week, each around 60 minutes of moderate intensity physical activity over 52 weeks
- a resistance training intervention, consisting of about three sessions per week, each around 60 minutes with multiple sets of resistance exercises at moderate to high intensity over 52 weeks
- mixed or various physical activity interventions consisting of about three sessions per week each around 50 minutes of moderate to vigorous intensity physical activity over at least eight months.

A supplemental literature review lends support to these articles, suggesting that physical activity is effective for maintenance of bone health in older people.

Prevention of physical disability

Effective aerobic endurance physical activity interventions

The literature review identified one papers indicating effective aerobic endurance physical activity interventions for preventing physical disability amongst people over the age of 65.

Table 6.6

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Paterson 2010	N = 66 studies; men and women, aged 65 years and over	Aerobic endurance	Generally 30 to 45 minutes	Moderate intensity	Generally 3 times per week (average: 24 weeks)
Faber 2006	N = 278; women, mean age 85 ± 6 years	Aerobic endurance	60 minutes	Moderate	1 time per week for 4 weeks, then 2 times per week for 16 weeks (20 weeks)

In a systematic review by Paterson and colleagues, 66 studies were used to assess the relationship between physical activity and physical function, including disability (Paterson et al 2010). In this systematic review, aerobic endurance interventions for older people demonstrated efficacy for physiological and functional improvements, reduced risk of functional limitations, and a likely reduction in long term disability.

Furthermore, the review showed consistent findings across varying types of studies with a broad range of functional independence measures. From the reviewed studies, researchers concluded that moderate to vigorous intensity aerobic endurance physical activity confers protection of physical function, and that intensity may have to be at least moderate to be effective.

In a randomised controlled trial evaluating group physical activity for 278 men and women, Faber and colleagues randomly assigned participants to a no-intervention control group, a functional walking group, consisting of physical activities related to daily mobility activities, or to a balance group (Faber et al 2006). Results showed small improvements in mobility assessment and physical performance for participants in both physical activity groups, and those in the walking group showed small improvement in disability rating.

Effective resistance training physical activity interventions

The literature review identified one paper indicating effective resistance training physical activity interventions for preventing physical disability amongst people over the age of 65.

Table 6.7

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Paterson 2010	N = 66 studies; men and women, aged 65 years and over	Resistance training	25 to 60 minutes	2 to 3 sets of 8 to 12 repetitions at around 50% of one repetition maximum	3 times per week (6 to 24 weeks)

In a systematic review by Paterson and colleagues, 66 studies were used to assess the relationship between physical activity and physical function (Paterson et al 2010). In this systematic review, resistance training interventions for older people effectively provided physiological and functional improvements, reduced risk of functional limitations, and a likely reduction in long term disability. Furthermore, the review showed consistent findings across varying types of studies with a broad range of functional independence measures.

Effective mixed or various physical activity interventions

The literature review identified two papers indicating effective mixed or various physical activity interventions for preventing physical disability amongst people over the age of 65.

Table 6.8

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Daniels 2008	N = 10 studies; frail men and women, aged 65 years and over	Mixed or various physical activities	40 to 90 minutes	Low- to moderate-intensity	1 to 3 times per week (10 to 78 weeks)
Binder 2002	N = 115; frail men and women, aged 83 ± 4 years	Mixed or various physical activities (flexibility, balance, resistance, aerobic endurance)	Aerobic endurance was 15 to 30 minutes; other components not specified	Resistance training: building from 65% of one-repetition maximum; aerobic endurance: building from 65% of aerobic capacity	3 times per week (36 weeks)

A systematic review by Daniels and colleagues looked at eight clinical trials to evaluate the effects of physical activity on disability and activities of daily living (Daniels et al 2008). Results of the review showed that of the eight interventions, three reported that mixed or various physical activity interventions reduced measures of disability in the older frail men and women studied.

Binder and colleagues randomly assigned 115 older American frail men and women to one of two physical activity conditions over nine months of study (Binder et al 2002). One condition involved supervised resistance training, flexibility exercises, and balance training, while the other condition consisted of low intensity flexibility exercise at home. This study demonstrated that mixed resistance training, balance and flexibility can improve measures of physical function and preclinical disability in older people who have impairments in physical performance and oxygen uptake.

Conclusions: prevention of disability

The following efficacious physical activity interventions were identified in relation to prevention of disability:

- an aerobic endurance intervention, consisting of two to three sessions per week, each around 30 to 60 minutes of moderate intensity physical activity over 20 to 24 weeks
- a resistance training intervention, consisting of about three sessions per week, each lasting 25 to 60 minutes of multiple moderate intensity resistance exercises, over about six to 24 weeks
- mixed or various physical activity interventions consisting of one to three sessions per week each lasting 40 to 90 minutes of various intensities of physical activity over at least 10 weeks.

One article addressed prevention of disability in the frail old (Binder et al 2002). This study demonstrated that mixed resistance training, balance and flexibility done three times per week at moderate to high intensity over 36 weeks can improve measures of physical function and preclinical disability in older people who have impairments in physical performance and oxygen uptake.

Prevention of hospitalisation

Effective aerobic endurance training interventions

The literature review identified one paper indicating effective aerobic endurance interventions for preventing hospitalisation in people over the age of 65.

Table 6.9

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Davies 2010	N = 19 studies; men and women with heart failure, any age	Aerobic endurance (brisk walking)	Range: 15 to 120 minutes	40% of maximal heart rate to 85% of aerobic capacity	Range: 2 to 7 times per week (24 to 52 weeks)

Davies and colleagues analysed physical activity training interventions from 19 randomised controlled trials that included 3647 participants with heart failure (Davies 2010). The kinds of physical activity programmes in this review were mostly aerobic endurance. This review found that aerobic endurance physical activity reduced hospital admission rates over both short term and long-term assessments.

Effective mixed or various physical activity interventions

The literature review identified two papers indicating mixed or various physical activity interventions for preventing hospitalisation in people over the age of 65.

Table 6.10

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Kerse 2005	N = 270; men and women; age = 71.6 ± 4.4 years	Mixed or various physical activities	Aiming for 30 minutes per session: 150 minutes per week	Moderate to vigorous intensity	Aiming for 5 sessions per week (12 months)
Courtney 2009	N = 128; men and women, aged 78.8 ± 6.9 years	Mixed or various physical activities	Not specified	Not specified	Not specified (24 weeks)

Kerse's group-randomised controlled trial with 270 New Zealand men and women studied the outcomes of individualised goal setting and physical activity plans in residential care facilities (Kerse et al 2005). Leisure-time moderate intensity physical activity and energy expenditure increased to a greater degree in the individualised intervention group and hospitalizations decreased, compared to the control group.

Courtney's randomised controlled trial in Australia evaluated an individualised programme of physical activity strategies and nurse-conducted home visits and telephone follow-ups, compared to a control group (Courtney et al 2009). This study found that along with better emergency visits and hospital readmission rates, the intervention group reported more improvement in quality of life, relative to controls. Thus, this study showed that a physical activity programme with home visits and telephone follow-up may reduce emergency health services for older people with health problems.

Conclusions: prevention of hospitalisation

The following efficacious physical activity interventions were identified in relation to prevention of hospitalisation:

- an aerobic endurance intervention, consisting of two to seven sessions of brisk walking per week for 24 to 52 weeks, each session lasting from 15 to 120 minutes in duration
- mixed or various physical activity interventions, aiming for five sessions of physical activity per week for 52 weeks, for a total of 150 minutes per week.

Prevention of hypertension

Effective aerobic endurance physical activity interventions

The literature review identified two papers indicating effective aerobic endurance physical activity interventions for preventing hypertension amongst people over the age of 65.

Table 6.11

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Kelley et al 2001	N = 7 studies; men and women, aged 50 to 87 years	Aerobic endurance	12 to 60 minutes	60 to 88% of maximum heart rate	2 to 6 times per week (16 to 52 weeks)
Huang 2006	N = 52; men and women, aged 75 years and over	Aerobic endurance	40 minutes	Moderate intensity building to 65 to 70% or high intensity, building to 85 to 90% of maximum heart rate	3 times per week (10 weeks)

Kelley and colleagues conducted a systematic review and meta-analysis of literature that addressed the effectiveness of aerobic endurance physical activity on resting blood pressure in older people (Kelley et al 2001). This study included participants younger than age 65 years. Results of the meta-analysis showed that aerobic endurance physical activity intervention programmes led to a statistically significant drop in systolic blood pressure, with an effect size of about 2mm Hg.

Huang and colleagues conducted a randomised controlled trial with a community-based sample of men and women aged 75 and up (Huang et al 2006). In this study, previously inactive participants were randomised to an aerobic endurance physical activity group doing moderate intensity or high intensity exercises, or to an inactive control group. Results showed that the high intensity aerobic endurance physical activity led to significant reductions in resting systolic and diastolic blood pressure readings, about 8mm Hg to 10mm Hg. The moderate intensity group also achieved a significant drop in diastolic blood pressure of about 8mm Hg.

Prevention of hypertension

The literature review identified one paper indicating effective mixed or various physical activity interventions for preventing hypertension amongst people over the age of 65.

Table 6.12

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Taylor 2004	N = 48 studies; men and women with heart disease, any age	Mixed or various physical activities	Average of 53 minutes per session	Average of 76% of maximum heart rate	Average of 3.7 sessions of week

In Taylor and colleagues' systematic review of 48 randomised controlled trials representing 8940 participants with heart disease, researchers conducted a meta-analysis of the effects of cardiac rehabilitation, including mixed or various physical activity components, relative to usual care without physical activity intervention (Taylor et al 2004). Results showed that participants in cardiac rehabilitation programmes that included mixed or various physical activity types had statistically significant reductions in systolic blood pressure, about 3mm Hg in size.

Conclusions: prevention of hypertension

The following efficacious physical activity interventions were identified in relation to prevention of hypertension:

- aerobic endurance interventions, consisting of at least two sessions per week, each around 12 to 60 minutes of moderate to vigorous intensity physical activity over 10 to 52 weeks
- mixed or various physical activity interventions consisting of three to four sessions per week each lasting about 53 minutes of physical activity at an average intensity of 76% of maximum heart rate.

Prevention of insulin resistance and type 2 diabetes

Effective aerobic endurance physical activity interventions

The literature review identified two papers indicating effective aerobic endurance physical activity interventions for preventing hypertension amongst people over the age of 65.

Table 6.13

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
DiPietro 2006	N = 25; women aged 62–84 years	Aerobic endurance	55 to 65 minutes	Moderate 65%; or high 80% of aerobic capacity	4 times per week (9 months)
Davidson 2009	N = 136; men and women, abdominally obese, aged 60–80 years	Aerobic endurance	30 minutes walking	60–75% of aerobic capacity	5 times per week (24 weeks)
Baker 2010	N = 33; men and women with mild cognitive impairment, aged 55–85 years	Aerobic endurance	45 to 60 minutes	75 to 85% of heart rate reserve	4 times per week (6 months)

DiPietro and colleagues randomly assigned older women to one of three conditions in their trial: moderate intensity or high intensity aerobic endurance training, or a low intensity placebo control group (DiPietro et al 2006). Results showed that there were significant improvements in glucose utilisation and insulin-stimulated suppression for the high intensity aerobic endurance training group. Findings suggest that long-term higher intensity exercise training provides more enduring benefits to insulin action compared with moderate or low intensity exercise, likely due to greater transient effects.

Davidson and colleagues studied older sedentary people with excess abdominal adiposity (Davidson et al 2009). In this trial, participants were randomised to resistance training, aerobic endurance training, resistance and aerobic endurance training (combined), or a no-intervention control group. The researchers found that insulin resistance improved in both the aerobic endurance and combined groups.

A randomised controlled trial was conducted by Baker and colleagues with 33 men and women who had mild cognitive impairment (Baker et al 2010). Participants were randomised to either to six months of supervised vigorous (high intensity) aerobic endurance physical activity, or a low intensity flexibility-focused control group. Results showed that for women, aerobic endurance improved glucose disposal during the metabolic clamp, and reduced fasting plasma levels of insulin.

Effective mixed or various physical activity interventions

The literature review identified one paper indicating effective mixed or various physical activity interventions for preventing insulin resistance and type 2 diabetes amongst people over the age of 65.

Table 6.14

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Davidson 2009	N = 136; men and women, abdominally obese, aged 60–80 years	Mixed or various physical activities (walking and resistance training)	30 minutes walking; 20 minutes resistance training: 1 set of 9 exercises	Walking at 60–75% of aerobic capacity; resistance training to volitional fatigue	Walking 3 times per week and resistance training 3 times per week (24 weeks)

Davidson and colleagues studied older sedentary people with excess abdominal adiposity (Davidson et al 2009). In this trial, participants were randomised to resistance training, aerobic endurance training, resistance and aerobic endurance training (combined), or a no-intervention control group. The researchers found that insulin resistance improved in aerobic endurance and combined groups, but a combination of aerobic endurance with resistance training was optimal for reducing insulin resistance in this population.

Conclusions: prevention of insulin resistance and type 2 diabetes

The following efficacious physical activity interventions were identified in relation to prevention of insulin resistance and type 2 diabetes:

- aerobic endurance interventions, consisting of four to five sessions per week, each around 30 to 65 minutes of moderate to vigorous intensity physical activity over six to nine months
- mixed or various physical activity interventions consisting of three sessions per week each lasting about 50 minutes of physical activity at moderate to vigorous intensity over 24 weeks.

Effective physical activity interventions for the management of health-related conditions in older people

Management of vascular disease (peripheral arterial disease)

Effective aerobic endurance interventions

The literature review identified three papers indicating effective aerobic endurance interventions for managing vascular diseases amongst people over the age of 65.

Table 6.15

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Ashworth 2005	N = 6 studies; men and women 50 years and over	Aerobic endurance	15 to 60 minutes per session	60 to 88% maximum heart rate	3 to 5 times per week (12 weeks)
Bendermacher 2006	N = 8 studies; men and women, aged 40–86 years	Aerobic endurance (treadmill)	30 to 60 minutes	Until pain onset or 60 to 70% of maximal	1 to 3 times per week (12 to 24 weeks)
McDermott 2009	N = 156; men and women with peripheral arterial disease, aged 60 years and over	Aerobic endurance (treadmill)	15 minutes, gradually increasing to 40 minutes	Not specified	3 times per week (24 weeks)

Ashworth's systematic review (in which the population had either peripheral vascular disease or chronic obstructive pulmonary disease) found that for patients with peripheral vascular disease, both centre-based and home-based aerobic endurance physical activity programmes were effective for improving health and physical function (Ashworth et al 2005). Thus, aerobic endurance physical activity can effectively improve health and physical function in older people with peripheral vascular disease (Ashworth et al 2005).

Bendermacher's systematic review of eight randomised trials addressed the impact of aerobic endurance physical activity interventions on those with intermittent claudication (a main symptom of peripheral arterial disease) (Bendermacher et al 2006). This systematic review assessed whether supervised treadmill training was superior to an unsupervised walking programme. This review found that supervised treadmill physical activity was superior to the unsupervised routine, but both aerobic endurance intervention programmes were effective for improving quality of life in this population.

McDermott's randomised controlled trial evaluated the effect of two aerobic endurance physical activity programmes amongst 156 US men and women with peripheral arterial disease (McDermott et al 2009). The researchers found that treadmill exercise had positive effects on health. In this sample, aerobic endurance treadmill exercise improved walking performance, blood flow, and quality of life.

Effective resistance training intervention

The literature review identified one paper indicating effective resistance training interventions for managing vascular diseases amongst people over the age of 65.

Table 6.16

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
McDermott 2009	N = 156; men and women with peripheral arterial disease, aged 60 years and over	Resistance training	15 minutes, gradually increasing to 40 minutes	Resistance: 50% of 1 repetition maximum, gradually increasing to 80% of 1 repetition maximum	3 times per week (24 weeks)

McDermott's randomised controlled trial evaluated the effect of two physical activity programmes amongst 156 US men and women with peripheral arterial disease (McDermott et al 2009). The researchers found that resistance training had positive effects on health. Those in the resistance training group improved walking performance, quality of life, and stair climbing ability, suggesting that physical activities other than the typically recommended walking programme, may be effective for managing peripheral arterial disease.

Effective mixed or various physical activity interventions

The literature review identified one paper indicating effective mixed or various physical activity interventions for managing vascular diseases amongst people over the age of 65.

Table 6.17

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Watson 2008	N = 22 studies; men and women with intermittent claudication	Mixed or various physical activities (walking, leg exercises, treadmill training)	30 to 60 minutes per session	Not specified	Commonly 2 to 3 times per week

Watson and colleagues conducted a systematic review of literature on physical activity programmes for managing intermittent claudication (Watson et al 2008). Successful programmes generally involved physiotherapy and supervised physical activity. Physical activities often included walking, leg exercises or treadmill training, and some encouraged additional home physical activity. Results from the review indicated that physical activity improved walking performance measures, including pain-free walking distance, and that these improvements were seen up to two years later.

Conclusions: management of vascular disease

The following efficacious physical activity interventions were identified in relation to management of vascular disease:

- aerobic endurance interventions, typically consisting of a total of 90 to 120 minutes per week of walking at a moderate to vigorous intensity divided over three to five sessions per week over 12 to 24 weeks
- a resistance training intervention, consisting of three sessions per week of 15 to 40 minutes of resistance training over 24 weeks, building from 50% to 80% of one repetition maximum
- mixed or various physical activity interventions, consisting of 30 to 60 minutes of walking and leg exercises per session, done twice or three times per week.

Management of heart disease

Effective aerobic endurance intervention

The literature review identified three papers indicating effective aerobic endurance interventions for managing heart diseases amongst people over the age of 65.

Table 6.18

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Davies 2010	N = 19 studies; men and women with heart failure, any age	Aerobic endurance (brisk walking)	Range: 15 to 120 minutes	40% of maximal heart rate to 85% of aerobic capacity	Range: 2 to 7 times per week (24 to 52 weeks)
Hung 2004	N = 21; women, aged 60–80 years	Aerobic endurance	30 minutes	70% to 85% of peak heart rate	3 times per week (8 weeks)
Wisloff 2007	N = 27; men and women with heart failure, mean age 75.5 ± 11.1 years	Aerobic endurance	38 minutes (interval group); 47 minutes (continuous group)	95% of peak heart rate (interval group); 70% of peak heart rate (continuous group)	3 times per week (12 weeks)

Davies and colleagues analysed physical activity interventions from 19 randomised controlled trials that included 3647 participants with heart failure (Davies 2010). The kinds of physical activity programmes in this review varied greatly, but were mostly aerobic endurance physical activities. This review found that aerobic endurance physical activity programmes reduced hospital admission rates and improved health-related quality of life for those with heart disease, both in the short term and for long-term assessments.

Hung and colleagues conducted a randomised controlled trial with 21 older women diagnosed with coronary artery disease that sought to compare a programme of aerobic endurance training to a combined strength and aerobic endurance training programme (Hung et al 2004). Results showed that both programmes were effective and resulted in similar improvements to aerobic capacity, distance walked over six minutes, lower-body strength, and some measures of quality of life.

Wisloff and colleagues conducted a randomised controlled trial of 27 older Norwegian men and women with heart failure to evaluate the effects of high intensity aerobic endurance interval training compared to continuous moderate intensity aerobic endurance training (Wisloff et al 2007). In this study, participants who were randomly assigned to high intensity interval training experienced greater improvement in endothelial function, and an increased mitochondrial function in the lateral vastus muscle was observed for this aerobic interval training group only. This study found that physical activity intensity was an important factor for reversing left ventricular remodelling and improving aerobic capacity, endothelial function, and quality of life in patients with post-infarction heart failure.

Effective mixed or various physical activity interventions

The literature review identified five papers indicating effective mixed or various physical activity interventions for managing heart disease amongst people over the age of 65.

Table 6.19

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Taylor 2004	N = 48 studies; men and women with heart disease, any age	Mixed or various physical activities	Average of 53 minutes per session	Average of 76% of maximum heart rate	Average of 3.7 sessions of week
Chien 2008	N = 10 studies; men and women with chronic heart failure, aged 50 years and over	Mixed or various physical activities	30 to 60 minutes	40 to 70% maximal heart rate	1 to 5 times per week (2 to 24 weeks)
Taylor 2010	N = 12 studies; men and women with heart disease, any age	Mixed or various physical activities	Range: 20 to 60 minutes	Varying intensities	Range: 3 to 5 times per week (1.5 to 6 months)
Hung 2004	N = 21; women, aged 60–80 years	Mixed or various physical activities	Combined strength and aerobic training: 30 minutes plus additional strength training	Combined strength and aerobic training: as aerobic training plus strength training at 55% of 1 repetition maximum, increasing by 2.5% every week	3 times per week (8 weeks)
Blumenthal 2005	N = 134; men and women with ischemic heart disease, aged 40–84 years	Mixed or various physical activities	35 minutes	60 to 85% heart rate reserve	3 times per week (16 weeks)

Taylor and colleagues reported on cardiac rehabilitation programmes, which are designed to restore the health of people with heart disease using various types of physical activity, education, and psychological support (Taylor 2010). Taylor has conducted two systematic reviews (Taylor 2010; Taylor et al 2004) to assess the impact of cardiac rehabilitation programmes. In the 2004 systematic review, the authors conducted a meta-analysis of cardiac rehabilitation effects, relative to usual care (without physical activity). This study found that cardiac rehabilitation was associated with a reduction in all-cause mortality of about 20%, and a reduction in cardiac mortality of about 25%. Cardiac rehabilitation also resulted in greater reductions in total cholesterol and triglyceride levels.

Chien's systematic review of randomised controlled trials in older people with chronic heart failure included 10 studies with a total of 648 participants (Chien et al 2008). In the meta-analysis of these trials, home-based physical activity of various types increased walking performance and peak oxygen consumption more than usual activity, but did not improve heart failure scores or odds of hospitalisation.

In their subsequent systematic review, Taylor and colleagues sought to compare home-based to centre-based cardiac rehabilitation (Taylor 2010). The systematic review found that cardiac rehabilitation (with various types of physical activity) appeared to be effective, regardless of setting, for improving health-related outcomes for those with heart disease.

Hung and colleagues conducted a randomised controlled trial with 21 older women diagnosed with coronary artery disease, that sought to compare a programme of aerobic endurance training to a combined strength and aerobic endurance training programme (Hung et al 2004). Results showed that both programmes were effective and resulted in similar improvements to aerobic capacity, distance walked over six minutes, lower-body strength, and some measures of quality of life. The combination training programme, however, also improved upper-body strength and additional measures of quality of life.

Blumenthal's randomised controlled trial of patients with ischemic heart disease in the US evaluated the effect of aerobic endurance training and stress management on psychosocial functioning and markers of cardiovascular risk (Blumenthal et al 2005). This study found that both the physical activity and the stress management groups had reduced depression, reduced psychological distress, and improved cardiovascular risk, relative to those receiving usual medical care (without physical activity) alone.

Conclusions: management of heart disease

The following efficacious physical activity interventions were identified in relation to management of heart disease:

- aerobic endurance interventions, typically consisting of two to seven sessions of brisk walking per week over at least eight weeks, each session lasting between 15 to 120 minutes at a moderate to vigorous intensity
- mixed or various physical activity interventions, typically consisting of walking and other physical activities done three to five sessions per week over two to 24 weeks Each session's duration was 20 to 60 minutes, at moderate to vigorous intensity.

Management of stroke

Effective aerobic endurance interventions

The literature review identified one paper indicating effective aerobic endurance interventions for managing stroke amongst people over the age of 65.

Table 6.20

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Van de Port 2007	N = 23 studies; men and women with stroke, any age	Aerobic endurance	30 to 60 minutes	Not specified	3 to 5 times per week (8 weeks)

Van de Port conducted a systematic review and meta-analysis of 23 randomised controlled trials with 712 participants (van de Port et al 2007). The population included people under the age of 65 years. In this review, strong evidence was found to support the effectiveness of aerobic endurance training to improve stair-climbing performance.

Effective resistance training interventions

The literature review identified one paper indicating effective resistance training interventions for managing stroke amongst people over the age of 65.

Table 6.21

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Morris 2004	N = 8 studies; men and women with stroke, any age	Resistance training	Varying durations	Varying intensities	Range: 2 to 5 sessions per week (4 to 12 weeks)

A systematic review was conducted by Morris and colleagues, using eight studies to determine whether resistance training improves functional status in older people who are recovering from stroke (Morris et al 2004). Based on the review, the authors concluded that progressive resistance strength training programmes were efficacious in reducing musculoskeletal impairment after stroke.

Effective mobility and balance interventions

The literature review identified two papers indicating effective mobility and balance physical activity interventions for managing stroke amongst people over the age of 65.

Table 6.22

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Van de Port 2007	N = 23 studies; men and women with stroke, any age	Mobility and balance	Range: 8 minutes to 2 hours	Not specified	Range: 3 to 5 times per week (3 weeks to 6 months)
Marigold 2005	N = 61; men and women with stroke, mean age 68 + 8 years	Mobility and balance	60 minutes	Low intensity	3 times per week (10 weeks)

Van de Port conducted a systematic review and meta-analysis of 23 randomised controlled trials with 712 participants (van de Port et al 2007). The population included people under the age of 65 years. Results showed that gait-oriented training interventions resulted in improvements to gait speed and walking distance for people recovering from stroke.

Marigold and colleagues conducted a randomised controlled trial with 61 older Canadian men and women (Marigold et al 2005). In this study, both of the physical activity groups, agility or flexibility with weight shifting, led to improvements in all clinical outcome measures. The agility group demonstrated greater improvement in step reaction time and paretic rectus femoris postural reflex onset latency than the stretching/weight-shifting group. In addition, the agility group experienced fewer induced falls on the platform. Group physical activity programmes that include agility or stretching/weight shifting physical activities improve

postural reflexes, functional balance, and mobility and may lead to a reduction of falls in older people recovering from stroke.

Effective mixed or various physical activity interventions

The literature review identified one paper indicating effective mixed or various physical activity interventions for managing stroke amongst people over the age of 65.

Table 6.23

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Pang 2005	N = 63; men and women with stroke, aged 50 years and over	Mixed or various physical activity	60 minutes	Range: 40 to 80% of heart rate reserve	3 times per week (19 weeks)

Pang and colleagues conducted a randomised controlled trial to determine the impact of a fitness and mobility physical activity programme designed to improve cardio-respiratory fitness, mobility, leg muscle strength, balance, and hip bone mineral density in those with stroke (Pang et al 2005). Compared to control participants, the intervention group had greater gains in cardio-respiratory fitness, mobility, and paretic leg muscle strength, and better outcomes for bone mineral density in the femur.

Conclusions: management of stroke

The following efficacious physical activity interventions were identified in relation to management of stroke:

- an aerobic endurance intervention, consisting of three to five sessions per week, each session lasting 30 to 60 minutes at an unspecified intensity, over eight weeks
- a resistance training intervention, consisting of two to five sessions of resistance training per week, over four to 12 weeks
- mobility and balance interventions, consisting of three to five sessions per week with a wide variation in session duration, and programme duration. Intensity was low or not specified
- mixed or various physical activity intervention, consisting of three sessions of moderate to vigorous intensity physical activities, done for about an hour each session over 19 weeks.

Management of cancers

Effective aerobic endurance interventions

The literature review identified one paper indicating effective aerobic endurance interventions for managing cancer amongst people over the age of 65.

Table 6.24

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Windsor 2004	N = 66; men with prostate cancer, aged 52–82 years	Aerobic endurance	30 minutes	60% to 70% of maximum heart rate	3 times per week (4 weeks)

Windsor and colleagues reported on a randomised controlled trial of UK men with prostate cancer examined the role of a physical activity intervention in dealing with fatigue from cancer radiation treatments (Windsor et al 2004). In this trial, the men randomly assigned to the group advised to rest when feeling fatigued experienced a decreased physical functioning and increased fatigue after their course of radiation treatments. In contrast, those men assigned to moderate intensity walking at home experienced improved physical functioning and a lack of increase in fatigue. Thus, aerobic endurance physical activity was effective for ameliorating fatigue from prostate cancer treatment.

Effective mixed or various physical activity interventions

The literature review identified two papers indicating effective mixed or various physical activity interventions for managing cancer amongst people over the age of 65.

Table 6.25

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Luctkar-Flude 2007	N = 19 studies; men and women with cancer, aged 65 years and older	Mixed or various physical activities	Not specified	Not specified	Not specified
Morey 2009	N = 641; overweight cancer-surviving men and women, aged 65 years and over	Mixed or various physical activities (supported self directed physical activity programme)	Not specified	Not specified	Not specified (52 weeks)

Luctkar-Flude's systematic review of nine experimental studies and 10 observational studies of physical activity and fatigue in cancer patients found support for the notion of using various types of physical activity during treatment of cancer (Luctkar-Flude et al 2007). According to this review, physical activity offers the strongest available evidence among interventions to combat cancer fatigue, and to maintain functional status and quality of life (Luctkar-Flude et al 2007).

Morey and colleagues describe a recent randomised controlled trial that took place in the UK, US, and Canada with survivors of colorectal, breast, or prostate cancer (Morey et al 2009). In this study, participants who took part in a tailored diet and physical activity intervention programme that focused on strength training and aerobic endurance physical activity were less likely to report functional decline than participants in the control condition. Furthermore, the intervention group participants experienced improved dietary and physical activity

behaviours, greater weight loss, and better overall quality of life than those in the control group.

Conclusions: management of cancers

The following efficacious physical activity interventions were identified in relation to management of cancers:

- an aerobic endurance intervention, consisting of three sessions per week of 30 minutes of moderate intensity walking
- mixed or various physical activity interventions, without reported detail of the nature of those interventions.

Management of osteoarthritis

Effective aerobic endurance interventions

The literature review identified two papers indicating effective aerobic endurance interventions for managing osteoarthritis amongst people over the age of 65.

Table 6.26

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Brosseau 2003	N = 1 study, with 39 participants; men and women, mean age 71 years	Aerobic endurance	60 minutes (25 minutes devoted to bicycling)	Low- and high-intensity	3 times per week (10 weeks)
Bartels 2007	N = 6 studies; men and women, aged 65 years and over	Aerobic endurance	30 to 60 minutes	Low to moderate	2 to 3 times per week (6 to 52 weeks)

A systematic review by Brosseau and colleagues included one randomised controlled trial with 39 participants (Brosseau et al 2003). This study of people with osteoarthritis of the knee found that aerobic endurance physical activities, either high intensity or low intensity, were effective for improving gait, functional status, pain, and aerobic capacity. Both high intensity (defined here as exercising at 70% of heart rate reserve) and low intensity (40% of heart rate reserve) aerobic endurance physical activity appeared to be equally effective in improving a patient's functional status, gait, pain, and aerobic capacity for people with osteoarthritis of the knee.

Bartels' systematic review of six randomised trials and quasi-experimental studies included about 800 participants with either knee or hip osteoarthritis (Bartels et al 2007). This review found that aquatic aerobic endurance physical activity appeared to be effective for promoting positive health outcomes in people with hip and/or knee osteoarthritis, although the long-term effectiveness of such physical activity has not been established.

Effective resistance training interventions

The literature review identified two papers indicating effective resistance training interventions for managing osteoarthritis amongst people over the age of 65.

Table 6.27

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Liu 2009	N = 6 studies; men and women with osteoarthritis, aged 60 years and over	Resistance training	Not specified	High intensity (50–80% of 1 repetition maximum)	2 or 3 times per week
Mikesky 2006	N = 221; men and women with osteoarthritis, mean age 69 years	Resistance training	Time taken to complete exercises (not specified)	3 sets of 8 to 10 repetitions for 4 exercises	3 times per week (52 weeks)

Liu conducted a large systematic review that assessed findings from 121 randomised trials with a total of 6700 participants (Liu et al 2009). Resistance training resulted in large effects on muscle strength and small, but statistically significant improvements in physical ability and functional limitations. Results from six trials also showed that resistance training had a reduction in arthritis pain, but there was no evidence for other bodily pain reductions. Based on their review, the authors concluded that resistance training was effective as an intervention to improve physical functioning in older people.

Mikesky and colleagues conducted a randomised controlled trial to evaluate the effectiveness of strength training compared to range-of motion training in a sample of men and women with osteoarthritis of the knee (Mikesky et al 2006). Results indicated that both strength training and range-of motion groups decreased in leg strength over the course of 30 months, but this rate of strength loss was faster in the range of motion group. The strength training group lost less strength and also displayed less knee joint space narrowing, compared to the range of motion group. Thus, strength training was effective for maintaining leg strength in those with osteoarthritis.

Effective mobility and balance interventions

The literature review identified one paper indicating effective mobility and balance interventions for managing osteoarthritis amongst people over the age of 65.

Table 6.28

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Fransen, 2007	N = 152; men and women with osteoarthritis, mean age 70 + 6 years	Mobility and balance	60 minutes	Not specified	2 times per week (12 weeks)

Fransen reported on a randomised controlled trial that compared twelve weeks of tai chi and hydrotherapy physical activities with an inactive control group (Fransen et al 2007). Participants were older persons with hip or knee osteoarthritis. This study found that both physical activity conditions led to improvements in general health status, but that hydrotherapy also achieved statistically significant improvements in physical performance, relative to controls. In addition, these improvements were sustained twelve weeks after the physical activity classes ended.

Effective mixed or various physical activity interventions

The literature review identified four papers indicating effective mixed or various physical activity interventions for managing osteoarthritis amongst people over the age of 65.

Table 6.29

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Fransen 2008	N = 32 studies; men and women with osteoarthritis, any age	Mixed or various physical activities	Range: 30 to 90 minutes	Varying intensities	Varying frequencies (range: 1 to 6 months)
Fransen 2009	N = 5 studies; older men and women	Mixed or various physical activities	Not specified	Not specified	Varying frequencies 6 to 12 weeks
Messier 2004	N = 316; overweight or obese men and women with osteoarthritis and physical disability, aged 60 years and over	Mixed or various physical activities	60 minutes	Aerobic: 50% to 75% of heart rate reserve; resistance: 2 sets of 12 repetitions	3 times per week (18 months)
Callahan 2008	N = 364; women (90%) and men with self-reported arthritis, mean age 70 years	Mixed or various physical activities	1 hour	Not specified	2 times per week (8 weeks)

Fransen's 2008 systematic review (Fransen et al 2008) analysed the literature on randomised controlled trials for pain and physical function in older people with osteoarthritis of the knee. There was strong evidence in favour of physical activity, such that a supervised physical activity programme is likely to lead to reduced knee pain and improved physical function for people with knee osteoarthritis.

Fransen's 2009 systematic review of five randomised controlled trials included 2004 people with osteoarthritis of the hip (Fransen et al 2009). In this systematic review, a majority of the studies tended to favour physical activity over no-treatment control for the effectively treating pain, and pooled analysis supported the superiority of physical activity for treating osteoarthritis hip pain.

Messier reported on a randomised controlled trial of overweight and obese older people with knee osteoarthritis and physical disability to determine the effectiveness of long-term physical activity and weight loss on physical function, mobility, and pain (Messier et al 2004). In this study, 316 older people were randomised to a healthy lifestyle (control), diet only, physical activity only, or diet plus physical activity group. Results showed statistically significant improvements in physical function, walking and stair-climbing performance, and knee pain occurred in the diet plus physical activity group. In the physical activity-only group, walking performance improved.

Callahan reported on a randomised controlled trial that included 364 older Americans with arthritis (Callahan et al 2008). This study assessed the basic eight-week People with Arthritis Can Exercise (PACE) programme compared to a wait-listed control group. Results showed that older people in the PACE group experienced greater improvements in arthritis symptoms, better self efficacy for management of arthritis, and better functioning in upper and lower extremities. Furthermore, those who attended more of the physical activity classes had improvements in pain, fatigue, stiffness, functional outcomes, and self-efficacy for arthritis management.

Conclusions: management of osteoarthritis

The following efficacious physical activity interventions were identified in relation to management of osteoarthritis:

- aerobic endurance interventions, typically consisting of two to three sessions per week, each 30 to 60 minutes in duration, over six to 52 weeks. Bicycling at low or high intensity and aquatic physical activity at moderate intensity were all effective
- resistance training interventions, typically consisting of two or three sessions per week with multiple sets of several exercises in programmes lasting up to 52 weeks
- mobility and balance intervention, consisting of either tai chi or hydrotherapy exercises twice per week over 12 weeks for an hour each time
- mixed or various physical activity interventions, typically consisting of two or more sessions per week over one to 18 months, each session lasting 30 to 90 minutes.

Management of frailty

Effective resistance training interventions

The literature review identified two papers indicating effective resistance training interventions for managing frailty amongst people over the age of 65.

Table 6.30

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Seynnes 2004	N = 22; men and women, mean age 81.5 ± 1.4 years	Resistance training	Not specified	40% of 1 repetition maximum or 80% of 1 repetition maximum	3 times per week (10 weeks)
Sullivan 2007	N = 29; men and women with functional decline, mean age 79.4 ± 7.4 years	Resistance training	Not specified	Building from 20% to 80% 1 repetition maximum	Not specified (12 weeks)

Seynnes reported on a randomised controlled trial from France, in which 22 institutionalised frail older people took part in high intensity strength training, low moderate intensity strength training, or a weight-free placebo control group (Seynnes et al 2004). Results showed a dose–response relationship between training intensity and strength gain, and strength gains were similarly related to functional improvements for these older people. Researchers concluded that the high intensity supervised training was as safe as lower intensity supervised training, but more effective for achieving better strength and physical function.

In a randomised controlled trial by Sullivan and colleagues, 29 men and women with functional decline were randomly assigned to either low resistance intensity physical activity or high intensity progressive resistance muscle strength training, with a drug or placebo (Sullivan et al 2007). This study showed that high intensity progressive resistance muscle strength training was well-tolerated and safe as a physical activity programme for frail older people, and that the participants who received high intensity progressive resistance muscular strength training without supplements experienced the greatest strength gains.

Effective mobility and balance interventions

The literature review identified one paper indicating effective mobility and balance interventions for managing frailty amongst people over the age of 65.

Table 6.31

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Greenspan 2007	N = 269; women, aged 70 years and over	Mobility and balance (tai chi)	Approximately 10 minutes, progressing to 50 minutes	Not specified	2 times per week (48 weeks)

Greenspan and colleagues studied a large sample of 269 frail American women in a randomised controlled trial, and found that those who took part in an intensive 48-week tai chi programme improved perceived health status and ability to walk (Greenspan et al 2007). Findings suggest that intensive tai chi done twice per week is effective for improving perceived health status, particularly ambulation for older women who are transitionally frail.

Effective mixed or various physical activity interventions

The literature review identified five papers indicating effective mixed or various physical activity interventions for managing frailty amongst people over the age of 65.

Table 6.32

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Daniels 2008	N = 10 studies; older frail men and women	Mixed or various physical activities	40 to 90 minutes	Low- to moderate-intensity	1 to 3 times per week (10 to 78 weeks)
Binder 2002	N = 115; frail men and women, aged 83 ± 4 years	Mixed or various physical activities	15 to 30 minutes	Resistance training at 65–100% 1RM; aerobic endurance at 60–75% VO2 max	3 times per week (36 weeks)
Peri 2007	N = 149; frail men and women, mean age 85 years	Mixed or various physical activities	Not specified	Not specified	Not specified
Rydwik 2008	N = 96; frail men and women, mean age 83 years	Mixed or various physical activities	60 minutes	Aerobic endurance: not specified; resistance training: “60–80% intensity”	2 times per week (12 weeks)
Rydwik 2010	N = 96; frail men and women, mean age 83 years	Mixed or various physical activities	60 minutes	Aerobic endurance: not specified; resistance training: “60–80% intensity”	2 times per week (12 weeks)

A systematic review by Daniels and colleagues looked at eight clinical trials to evaluate the effects of physical activity on disability and activities of daily living (Daniels et al 2008). Of the eight interventions, three reported effectiveness for disability reduction, and the long-lasting and highly intense multi-component interventions appeared to have favourable effects on activities of daily living for community-living frail older people.

Binder and colleagues randomly assigned 115 older American frail men and women to one of two physical activity conditions over nine months of study (Binder et al 2002). One condition involved supervised resistance training, flexibility exercises, and balance training, while the other condition consisted of low intensity flexibility exercise at home. This study found the supervised physical activity training programme was superior to the home physical activity programme in measures of aerobic capacity, functional status, and physical performance for these frail elders.

Peri reported on a cluster-randomised controlled trial among 149 New Zealand older people in residential care, in which research staff members worked with participants to complete a functional assessment and set an individualised physical functioning goal, then designed an individualised activity programme based on daily activities and worked with residential staff to implement the programme with residents (Peri et al 2007). Results showed statistically

significant short-term improvements in health status for the intervention group compared to the control group.

Rydwik and colleagues conducted a randomised controlled trial with a sample of 96 community-dwelling frail older men and women (Rydwik et al 2008). Participants were randomised to a physical activity intervention including aerobic, muscle strength, and balance training, to a nutrition intervention, to a combined physical activity and nutrition intervention, or to a control group. Results showed that there were statistically significant improvements in lower- extremity muscle strength in both physical activity and combined groups compared with the nutrition group at first follow-up, and there were small, but statistically significant changes for some of the balance measurements in the physical activity group. This study shows the positive effect on lower-extremity muscle strength directly after the intervention.

Rydwik and colleagues later reported further findings from the same randomised controlled trial with a sample of 96 community-dwelling frail older men and women (Rydwik et al 2010). Participants were randomised to a physical activity intervention including aerobic, muscle strength, and balance training, to a nutrition intervention, to a combined physical activity and nutrition intervention, or to a control group. Results showed that there was a statistically significant increase in lower extremity muscle strength in the physical activity groups, compared with nutrition alone.

Conclusions: management of frailty

The following efficacious physical activity interventions were identified in relation to management of frailty:

- resistance training interventions, typically consisting of moderate to high intensity resistance training exercises done three times per week for 10 to 12 weeks
- mobility and balance intervention, consisting of tai chi done twice per week for 10 to 50 minutes over 48 weeks
- mixed or various physical activity interventions, typically consisting of 15 to 90 minute sessions done one to three times per week over 10 to 78 weeks at over a wide range of intensities.

Management of obesity and overweight

Effective resistance training interventions

The literature review identified one paper indicating effective resistance training interventions for managing obesity amongst people over the age of 65.

Table 6.33

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Fatouros 2005	N = 50; overweight men, aged 65–78 years	Resistance training	60 minutes	Low-, moderate- and high-intensity	3 times per week (6 months)

Fatouros and colleagues conducted a randomised controlled trial to determine the effectiveness of varying intensities of resistance training (Fatouros et al 2005). In this study, the older men were randomly assigned to participate in low, moderate, or high intensity resistance training. Results showed some effectiveness from all interventions, and intensity-dependent increases in strength, aerobic capacity, resting metabolic rate, and physical activity energy cost after training. Also, the body composition measures of skinfolds and body mass index showed greatest reduction by high intensity resistance training, relative to low intensity or moderate intensity training.

Effective mixed or various physical activity interventions

The literature review identified four papers indicating effective mixed or various physical activity interventions for managing obesity and overweight amongst people over the age of 65.

Table 6.34

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Kay 2006	N = 27 studies; men and women, aged 60 years and over	Mixed or various physical activities	30 to 60 minutes	Moderate- to high-intensity	2 to 4 times per week (8 to 60 weeks)
Villareal 2006b	N = 27; obese men and women, aged 65 years and over	Mixed or various physical activities (aerobic endurance and resistance training, balance work)	90 minutes	Around 70% of aerobic capacity; around 80% of 1 repetition maximum	3 times per week (6 months)
Davidson 2009	N = 136; men and women, abdominally obese, aged 60–80 years	Mixed or various physical activities (walking and resistance training)	30 minutes walking; 20 minutes resistance training: 1 set of 9 exercises	Walking at 60–75% of aerobic capacity; resistance training to volitional fatigue	Walking 3 times per week and resistance training 3 times per week (24 weeks)
Morey 2009	N = 641; overweight cancer-surviving men and women, aged 65 years and over	Mixed or various physical activities	Not specified	Not specified	Not specified (52 weeks)

Kay and Singh systematically reviewed 27 experimental studies on physical activity in adults, and separate findings are presented for those aged 60 and up (Kay et al 2006). The study found that abdominal adiposity can be reduced in older-aged men and women through various types of moderate to high intensity physical activity, and changes in abdominal adiposity can occur in the absence of changes in body mass. Furthermore, authors concluded that resistance training may play an important role as a fat reduction strategy for older obese individuals who have cardiovascular disease, arthritis, osteoporosis, or mobility disorders.

Villareal and colleagues conducted a randomised controlled trial assessing a lifestyle intervention that included resistance training, aerobic endurance training, and balance training, versus an inactive control condition in 27 obese older men and women from the US (Villareal et al 2006a). Results showed greater reductions in body weight, fat mass and waist circumference for the intervention group, relative to controls. Also, intervention participants improved in physical performance, aerobic capacity, functional status, strength, walking speed, and physical health scores.

Davidson and colleagues studied older sedentary people with abdominal adiposity (Davidson et al 2009). In this trial, participants were randomised to resistance training, aerobic endurance training, resistance and aerobic endurance training (combined), or a no-intervention control group. The researchers found that functional limitation improved to a statistically significant degree in all physical activity groups compared with the control group, insulin resistance improved in aerobic endurance and combined groups, but a combination of aerobic endurance with resistance training was optimal for reducing insulin resistance and functional limitations in this population.

Morey and colleagues conducted a randomised controlled trial that took place in the UK, US, and Canada with overweight survivors of colorectal, breast, or prostate cancer (Morey et al 2009). In this study, participants who took part in a tailored diet and physical activity intervention programme that focused on strength training and aerobic endurance were less likely to report functional decline than participants in the control condition. Furthermore, the intervention group participants experienced improved dietary and physical activity behaviours, greater weight loss, and better overall quality of life than those in the control group.

Conclusions: management of obesity and overweight

The following efficacious physical activity interventions were identified in relation to management of obesity and overweight:

- a resistance training intervention, consisting of three sessions per week of 60 minutes per session over six months. This study showed high intensity resistance training to be more effective than less intense resistance training
- mixed or various physical activity interventions, typically consisting of sessions lasting 30 to 90 minutes, done 2 to 4 times per week at a moderate intensity over 8 to 60 weeks. Of note in one study, the combination of aerobic and resistance exercise was optimal for reducing insulin resistance and functional limitations.

Management of type 2 diabetes (including insulin resistance, metabolic syndrome)

Effective mixed or various physical activity interventions

The literature review identified three papers indicating effective mixed or various physical activity interventions for managing type 2 diabetes amongst people over the age of 65.

Table 6.35

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Thomas 2007	N = 14 studies; men and women, aged 45 years and over	Mixed or various physical activities	30 to 120 minutes	Moderate aerobic training or Moderate progressive resistance training	1 to 7 times per week (8 weeks to 52 weeks)
Villareal 2006b	N = 27; obese men and women, aged 65 years and over	Mixed or various physical activities (aerobic endurance and resistance training, balance work)	90 minutes	Around 70% of aerobic capacity; around 80% of 1 repetition maximum	3 times per week (6 months)
Davidson 2009	N = 136; men and women, abdominally obese, aged 60–80 years	Mixed or various physical activities (walking and resistance training)	30 minutes walking; 20 minutes resistance training: 1 set of 9 exercises	Walking at 60–75% of aerobic capacity; resistance training to volitional fatigue	Walking 3 times per week and resistance training 3 times per week (24 weeks)

Thomas published a systematic review and meta-analysis, which evaluated 14 randomised controlled trials including 377 older participants with type 2 diabetes to determine the effectiveness of physical activity interventions (Thomas et al 2007). The results of this systematic review and meta-analysis showed that even without weight loss, mixed physical activity effectively improves control of blood glucose, and reduces levels of visceral adiposity and triglycerides.

Villareal and colleagues conducted a randomised controlled trial assessing a mixed physical activity intervention with aerobic endurance, resistance, and balance components versus a control condition in 27 diabetic obese older men and women from the US (Villareal et al 2006a). Results showed greater reductions in plasma glucose, triglycerides, blood pressure, and proportion of people with metabolic syndrome for the intervention group relative to controls. Also, intervention participants improved in physical performance, aerobic capacity, functional status, strength, walking speed, and physical health scores.

Davidson and colleagues studied older sedentary people with abdominal adiposity (Davidson et al 2009). In this trial, participants were randomised to resistance training, aerobic endurance training, resistance and aerobic endurance training (combined), or a no-intervention control group. The researchers found that functional limitation improved to a statistically significant degree in all groups compared with the control group, insulin resistance improved in aerobic endurance and combined groups, but a combination of aerobic endurance with resistance training was optimal for reducing insulin resistance and functional limitations in this population.

Conclusions: management of type 2 diabetes

The following efficacious physical activity interventions were identified in relation to management of type 2 diabetes:

- mixed or various physical activity interventions, consisting of a wide range of session durations and frequencies, over 8 to 52 weeks, and typically done at moderate intensity.

Management of pulmonary disease

Effective mixed or various physical activity interventions

The literature review identified four papers indicating effective mixed or various physical activity interventions for managing pulmonary disease amongst people over the age of 65.

Table 6.36

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Ashworth 2005	N = 6 studies; men and women, 50 years and over	Mixed or various physical activities	30 to 60 minutes	Not specified	4 times per week (8 weeks)
Holland 2008	N = 5 studies; men and women interstitial lung disease, aged 52–70 years	Mixed or various physical activities	Not specified	Varying intensities	Range: 2 to 5 times per week (5 to 12 weeks for outpatients, 6 months for home-based)
Mador 2004	N = 24; men and women with COPD aged 68 ± 2 years (aerobic); and 74 ± 2 years (combined)	Mixed or various physical activities (strength training plus aerobic endurance)	Not specified	50% of maximal work capacity; and 1 set of 60% one-repetition maximum, increasing to 3 sets	3 times per week (8 weeks)
Guell 2006	N = 40; men and women with severe chronic flow limitation, aged 65 ± 8 years	Mixed or various physical activities	30 minutes	Not specified	Week 1 to 8: 2 times per week; week 9 to 16: 5 times per week (16 weeks)

Ashworth and colleagues systematically reviewed literature to assess the impact of physical activity programmes in six studies of older people with chronic obstructive pulmonary disease (Ashworth et al 2005). This systematic review found that most of the reviewed studies showed that mixed physical activity interventions, whether at home or at a centre, improved physical function, decreased blood pressure, and improved some tests for physical performance in older people with pulmonary disease.

Holland's systematic review of five randomised or quasi-randomised trials relevant to physical activity for interstitial lung disease found short-term improvements in physical fitness, difficulty breathing, and quality of life for people completing physical activity interventions (Holland et al 2008). Although longer programmes and more frequent sessions appear to be more effective for people with other chronic lung diseases, the amount and frequency of physical activity needed for beneficial health outcomes in those with interstitial lung disease is uncertain.

In a randomised controlled trial, Mador and colleagues compared the effects of an aerobic endurance physical activity programme to a programme of strength plus aerobic endurance training (Mador 2004). Participants included 24 older Americans with chronic obstructive pulmonary disease (COPD). This trial found that the most effective intervention was combined strength training and aerobic endurance training. Participants in the combined physical activity intervention experienced superior improvements in muscle strength, as well as improvements in six-minute walk distance, endurance exercise time, and quality of life.

Guell evaluated the effectiveness of mixed physical activity as part of pulmonary rehabilitation through a small randomised controlled trial of participants with chronic obstructive pulmonary disease (Guell et al 2006). This study found that pulmonary rehabilitation resulted in decreased psychological morbidity, and increased functional capacity, and health related quality of life (Guell et al 2006).

Conclusions: management of pulmonary disease

The following efficacious physical activity interventions were identified in relation to management of pulmonary disease:

- mixed or various physical activity interventions, typically consisting of 2 to 5 sessions per week, each lasting 30 to 60 minutes, over eight weeks to six months. Physical activities were done at varying intensities. Resistance training within one intervention was done at a moderate intensity, over eight weeks.

Management of neurological disorders

Effective aerobic endurance interventions

The literature review identified one paper indicating effective aerobic endurance interventions for managing neurological disorders amongst people over the age of 65.

Table 6.37

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Mehrholz 2010	N = 8 studies; men and women, aged 61–74 years	Aerobic endurance (treadmill)	30 to 45 minutes	Low to moderate	1 session once, or 3 to 4 times per week (4 to 8 weeks)

Mehrholz reviewed eight randomised controlled trials that compared treadmill walk training to no treadmill walk training, and included 203 participants with Parkinson's disease (Mehrholz et al 2010). In this study, the acceptability of the treadmill walk training among participants was found to be good, and there were few adverse events. Furthermore, results indicated that treadmill walk training was effective in improving walking speed, stride length, and walking distance.

Effective mixed or various physical activity interventions

The literature review identified three papers indicating effective mixed or various physical activity interventions for managing neurological disorders amongst people over the age of 65.

Table 6.38

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Heyn 2004	N = 30 studies; men and women with dementia, aged 65 and up	Mixed or various physical activities	Mean of 36 to 50 minutes	Not specified	Mean of 3 to 4 times per week (14 to 24 weeks)
Goodwin 2008	N = 14 studies; men and women with Parkinson's disease, mean age 63 to 76 years	Mixed or various physical activities	20 to 60 minutes	Not specified	1 to 3 times per week (4 to 12 weeks)
Rolland 2007	N = 134; men and women with Alzheimer's disease, aged 83 + 8 years	Mixed or various physical activities	60 minutes	Building from light to moderate intensity	2 times per week (52 weeks)

The findings from this study are as follows:

Heyn and colleagues reviewed thirty randomised controlled trials addressing the effectiveness of physical activity interventions for people with cognitive impairment and dementia (Heyn et al 2004). Results of meta-analyses showed significant effects for strength, physical fitness, functional performance, cognitive performance, and behaviour. Thus, physical activity appears to increase fitness, physical function, cognitive function and positive behaviour in older people with cognitive impairment and dementia.

Goodwin and colleagues reviewed fourteen randomised controlled trials addressing the effectiveness of physical activity interventions for people with Parkinson's disease (Goodwin et al 2008). Results indicated that various physical activity interventions were effective for improving physical functioning, quality of life, strength, balance, and gait speed for people with Parkinson's disease.

Rolland and colleagues conducted a randomised controlled trial to evaluate the effectiveness of a physical activity intervention in older people with Alzheimer's disease (Rolland et al 2007). Participants were randomised to a standard care control group, or to an intervention consisting of walking, resistance training, balance and flexibility components. Results of this study showed that activities of daily living showed a slower decline for those participating in the mixed physical activity intervention, and there was a significant difference between the groups in favour of the exercise programme in 6-meter walking speed at 12 months.

Conclusions: management of neurological disorders

The following efficacious physical activity interventions were identified in relation to management of neurological disorders:

- an aerobic endurance physical activity intervention, consisting of treadmill walk sessions performed three to four times per week, each lasting 30 to 45 minutes at a low to moderate intensity over four to eight weeks
- mixed or various physical activity interventions, consisting of 20 to 60 minutes of physical activity done one to four times per week at varying intensities over four to 52 weeks.

Physical activity interventions have included treadmill walking, along with many other combinations of exercise for older people with Parkinson's disease, Alzheimer's disease, and other cognitive impairments or dementia. From such interventions, improvements have been shown for physical fitness, physical function, balance, gait, cognitive performance, behaviour, and quality of life.

Management of depression

Effective aerobic endurance interventions

The literature review identified one paper indicating effective aerobic endurance interventions for managing depression amongst people over the age of 65.

Table 6.39

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Motl 2005	N = 174; men and women with depression, aged 60–75 years	Aerobic endurance	Building up from 10 to 45 minutes	50–65% of aerobic capacity	3 times per week (6 months)

Motl and colleagues conducted a randomised controlled trial in the United States that included 174 sedentary men and women with depressive symptoms (Motl et al 2005). Participants were randomly allocated to an aerobic endurance mall walking programme, or to a programme involving resistance and flexibility exercises. Results showed that both physical activity interventions were effective in reducing depressive symptoms and increasing self esteem in the exercising participants. Further, these improvements were maintained at 12- and 60-month follow-up periods.

Effective resistance training interventions

The literature review identified one paper indicating effective resistance training interventions for managing depression amongst people over the age of 65.

Table 6.40

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Singh 2005	N = 60; men and women with depression, mean age 70 ± 6 years	Resistance training	About 60 minutes (plus 5 minutes of stretching)	80% or 20% of one repetition maximum	3 times per week (8 weeks)

In a randomised controlled trial by Singh and colleagues, participants were randomised to a supervised high intensity resistance training group, low intensity resistance training group, or usual care (Singh et al 2005). Results showed a marked decrease in depression for the high intensity group. In addition, the high intensity group also featured the best outcomes for quality of life and sleep quality. Thus, high intensity resistance training was more effective than low intensity training or general practitioner care for the treatment of older people with depression.

Effective mixed or various physical activity interventions

The literature review identified four papers indicating effective mixed or various physical activity interventions for managing depression amongst people over the age of 65.

Table 6.41

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Sjösten 2006	N = 13 studies; men and women with depression, aged 60 years and over	Mixed or various physical activities	Not specified	Not specified	Frequency not specified (range: 6 to 357 weeks)
Blake 2009	N = 11 studies; men and women, aged 65 to 82 years	Mixed or various physical activities	20 to 60 minutes	Low, moderate and high intensity interventions	3 times per week (6 to 19 weeks)
Blumenthal, 2005	N = 134; men and women with ischemic heart disease, aged 40–84 years	Mixed or various physical activities	35 minutes	60 to 85% heart rate reserve	3 times per week (16 weeks)
Motl 2005	N = 174; men and women with depression, aged 60–75 years	Mixed or various physical activities (resistance training + flexibility)	Building up to 40 to 45 minutes: 1 set of 12 exercises + flexibility	Low-intensity	3 times per week (6 months)

Sjosten and colleagues conducted a systematic review of 13 randomised controlled trials and found that various physical activity intervention programmes showed substantial short-term effectiveness in reducing depressive symptoms (Sjösten et al 2006). Various types of physical activity were effective in treating depression among those experiencing minor or major depression, and in reducing depressive symptoms among those with high levels of depressive symptoms at baseline.

In a systematic review of 11 randomised controlled trials with a total of 642 participants, Blake and colleagues assessed the effect of physical activity on depressive symptoms and concluded that various physical activity intervention programmes were able to obtain clinically relevant outcomes in the treatment of depressed older people (Blake et al 2009). Although the type of physical activity, intensity, and duration for reviewed interventions varied across studies, results indicated that nine of the studies showed a short-term improvements in depression or depressive symptoms.

Blumenthal's randomised controlled trial of patients with ischemic heart disease in the US evaluated the effect of aerobic endurance training and stress management on psychosocial functioning and markers of cardiovascular risk (Blumenthal et al 2005). This study found that both the physical activity and the stress management groups had reduced depression, psychological distress, and improved cardiovascular risk, relative to those receiving usual medical care (without physical activity) alone.

Motl and colleagues conducted a randomised controlled trial in the United States that included 174 sedentary men and women with depressive symptoms (Motl et al 2005). Participants were randomly allocated to an aerobic endurance mall walking programme, or to a programme involving resistance training and flexibility exercises. The resistance training group performed one set of 12 low intensity exercises, plus flexibility exercises. Each programme met three times per week for six months, building up to sessions lasting 40 to 45 minutes in duration. Results showed that both physical activity interventions were effective in reducing depressive symptoms and increasing self esteem in the exercising participants. Further, these improvements were maintained at 12 and 60-month follow-up periods.

Conclusions: management of depression

The following efficacious physical activity interventions were identified in relation to management of minor or major depression:

- an aerobic endurance intervention, consisting of three sessions per week of walking at a moderate intensity for 10 to 45 minutes over six months
- a resistance training intervention, consisting of high or low intensity resistance exercises, done for an hour, three times per week, over eight weeks. Of note, high intensity resistance training was more effective than low intensity
- mixed or various physical activity interventions, typically consisting of 20 to 60 minutes of physical activity per session, done three times per week, over six to 357 weeks.

Multiple types of physical activity, done about three times per week, have been shown to be effective in managing depression among older people experiencing minor or major depression.

Management of hip injury

Effective aerobic endurance interventions

The literature review identified one paper indicating effective aerobic endurance interventions for managing hip injury amongst people over the age of 65.

Table 6.42

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Mangione 2005	N = 33; men and women with hip fracture, mean age 78.6 ± 6.8 years	Aerobic endurance	30 to 40 minutes	65–75% of age-predicted maximum heart rate	20 times over 12 weeks

Mangione and colleagues reported on a small randomised controlled trial of 33 older outpatients recovering from hip fracture, which showed that those who were randomly assigned to either a resistance training or aerobic training versus a control group fared better in measures of physical performance and functioning (Mangione et al 2005). This study found that home-based high intensity aerobic endurance physical activity was feasible and effective for improving physical performance and physical function in hip fracture survivors.

Effective resistance training interventions

The literature review identified two papers indicating effective resistance training interventions for managing hip injury amongst people over the age of 65.

Table 6.43

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Suetta 2004	N = 36; men and women with osteoarthritis, aged 60–86 years	Resistance training	Time to complete exercises (not specified)	3 to 5 sets of 8 to 10 repetitions (at 8 repetition maximum intensity)	Daily to 3 times per week (8 weeks)
Mangione 2005	N = 33; men and women with hip fracture, mean age 78.6 ± 6.8 years	Resistance training	30 to 40 minutes	3 sets of 8 repetitions at 8 repetition maximum intensity	20 times over 12 weeks

In a sample of 36 Danish older men and women with hip osteoarthritis, Suetta and colleagues tested the effectiveness of strength training during recovery from long-term muscle disuse and hip surgery in a randomised controlled trial (Suetta et al 2004). Results showed that strength training increased muscle mass, maximal isometric strength, rate of force development, and muscle activation in these older men and women. The researchers concluded that the improvement in muscle mass from strength training was likely to have positive functional implications for older individuals.

Mangione and colleagues reported on a small randomised controlled trial of 33 older outpatients recovering from hip fracture, which showed that those who were randomly assigned to either a resistance training or aerobic training versus a control group fared better in measures of physical performance and functioning (Mangione et al 2005). This study found that home-based high intensity resistance training was feasible and effective for improving physical performance and physical function in hip fracture survivors.

Conclusions: management of hip injury

The following efficacious physical activity interventions were identified in relation to management of hip injury:

- aerobic endurance interventions, consisting of 20 sessions of moderate intensity physical activity over 12 weeks, lasting 30 to 40 minutes each time
- resistance training interventions, typically consisting of about two to seven sessions per week of three to five sets of resistance exercises at eight repetitions maximum.

Management of sleep problems

Effective resistance training interventions

The literature review identified one paper indicating effective resistance training interventions for managing sleep disorders amongst people over the age of 65.

Table 6.44

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Singh 2005	N = 60; men and women with depression, mean age 70 ± 6 years	Resistance training	About 60 minutes (plus 5 minutes of stretching)	80% of one-repetition maximum	3 times per week (8 weeks)

In a randomised controlled trial by Singh and colleagues, participants were randomised to a supervised high intensity resistance training group, low intensity resistance training group, or usual care (Singh et al 2005). Results showed that sleep quality improved for all participants, but high intensity resistance training appeared to be most effective for improving sleep quality.

Effective mobility and balance interventions

The literature review identified one paper indicating effective mobility and balance training interventions for managing sleep disorders amongst people over the age of 65.

Table 6.45

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Irwin 2008	N = 112; healthy men and women; mean age 69 + 6 years	Mobility and balance	40 minutes	Not specified	3 times per week (16 weeks)

In a randomised controlled trial by Irwin and colleagues, participants were randomised to tai chi physical activity classes, or to health education classes (Irwin et al 2008). Results showed that participants who had moderate sleep complaints were more likely to achieve a treatment effect in the tai chi condition, compared to those in health education. Tai chi participants with poor sleep quality also showed statistically significant improvements in rated sleep quality, habitual sleep efficiency, sleep duration, and sleep disturbance. The authors concluded that tai chi was effective and useful as a non-pharmacologic method to improve sleep quality in older people who had moderate sleep complaints.

Effective mixed or various physical activity interventions

The literature review identified one paper indicating effective mixed or various physical activity interventions for managing sleep disorders amongst people over the age of 65.

Table 6.46

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Montgomery, 2002	N = 1 study with 43 participants; men and women, aged 60 years and over	Mixed or various physical activities (walking + resistance training)	30 to 40 minutes	Moderate intensity	4 times per week (16 weeks)

Montgomery and colleagues conducted a systematic review of literature and found one randomised controlled trial that examined the influence of physical activity on sleep outcomes in older people with insomnia (Montgomery et al 2002). Results indicated that physical activity was associated with improvements to sleep onset latency and sleep quality. Thus, the review showed that mixed activity physical activity may enhance sleep, which may contribute to better quality of life.

Conclusions: management of sleep problems

The following efficacious physical activity interventions were identified in relation to management of sleep problems:

- a resistance training intervention, consisting of three 60-minute sessions per week at high intensity, over eight weeks
- a mobility and balance physical activity intervention, consisting of three 40-minute tai chi sessions per week, over 16 weeks
- a mixed or various physical activity interventions, consisting of four sessions per week of 30 to 40 minutes per session at a moderate intensity.

Effective physical activity interventions for the enhancement of functioning in older people

Enhancement of cognitive function

Effective aerobic interventions

The literature review identified four papers indicating effective aerobic endurance interventions for enhancing cognitive function amongst people over the age of 65.

Table 6.47

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Angevaren 2008	N = 11 studies; men and women, aged 55 years and over	Aerobic endurance	Mostly 30 to 90 minutes	Varying intensity	Range: 1 to 5 times per week (8 to 26 weeks)
Kruger 2009	N = 160 studies; men and women, aged 60 years and over	Aerobic endurance	30 to 60 minutes	Moderate-intensity	2 to 3 times per week (12 to 48 weeks)
Lautenschlager 2008	N = 170; men and women with memory problems, mean age 68 years	Aerobic endurance	50 minutes	Moderate	3 times per week (24 weeks)
Baker 2010	N = 33; men and women with mild cognitive impairment, aged 55–85 years	Aerobic endurance	45 to 60 minutes	75 to 85% of heart rate reserve	4 times per week (6 months)

Angevaren and colleagues systematically reviewed 11 randomised controlled trials that evaluated cognitive outcomes from aerobic physical activity interventions in people without impairment (Angevaren et al 2008). Eight of the 11 trials showed that aerobic physical activity interventions led to increased aerobic capacity, and this improvement was linked with improvements in cognitive capacity. Overall, the largest effect sizes from physical activity were found for motor function and auditory attention. Other statistically significant effects were found for information processing speed and visual attention.

Kruger and colleagues conducted a systematic review, using 160 studies addressing the relationship between physical activity and cognitive health (Kruger et al 2009). Results showed that moderate intensity aerobic endurance physical activity has a positive effect on cognitive health. The authors further suggest that the effectiveness of physical activity for enhancing cognition may actually be even stronger than what has been found in the reviewed trials, as the trials often administer lower than recommended levels of physical activity to participants.

A randomised trial was conducted by Lautenschlager and colleagues in Australia with 170 adults who had memory problems, but were not meeting criteria for dementia (Lautenschlager et al 2008). In this study, participants were randomly assigned to an education plus usual care group, or to a 24-week home-based aerobic endurance physical activity programme. The physical activity programme encouraged a total of 150 minutes of moderate intensity aerobic endurance physical activity per week. Results showed a modest improvement in cognition among the exercising group over an 18-month follow-up period, relative to controls.

A randomised controlled trial was conducted by Baker and colleagues with 33 men and women who had amnestic mild cognitive impairment (Baker et al 2010). Participants were randomised to either to six months of supervised vigorous (high intensity) aerobic endurance physical activity, or a low intensity flexibility-focused control group. Results showed that besides improvements to fitness and body composition, aerobic endurance improved multiple tests of cognitive function in women, although only one cognitive test improved for men. Thus, this trial provides support for physical activity as an effective intervention to improve cognition in older women at risk of cognitive decline.

Effective resistance training interventions

The literature review identified one paper indicating effective resistance training interventions for enhancing cognitive function amongst people over the age of 65.

Table 6.48

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Liu-Ambrose 2010	N = 155; women, aged 65–75 years	Resistance training	60 minutes	Moderate to high intensity; 2 sets of 6 to 8 repetitions	1 to 2 times per week (52 weeks)

Liu Ambrose and colleagues conducted a randomised controlled trial with a sample of 155 Canadian women, aged 65–75 years to evaluate the effects of a resistance training physical activity intervention programme on cognitive health outcomes (Liu-Ambrose et al 2010). Results showed that both resistance training groups improved their performance on the executive function test compared with those in the balance and toning physical activity group. Task performance improved by 12.6% and 10.9% in the once-weekly and twice-weekly resistance training groups, respectively, while task performance deteriorated by 0.5% in the balance and tone group. Hence, this study showed that twelve months of once-weekly or twice-weekly resistance training was effective for improving executive cognitive function of selective attention and conflict resolution among senior women.

Effective mobility and balance interventions

The literature review identified one paper indicating effective mobility and balance interventions for enhancing cognitive function amongst people over the age of 65.

Table 6.49

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Taylor-Piliae 2010	N = 132; men and women, mean age 69 + 5.8 years	Mobility and balance	60 minutes	Moderate-intensity	4 to 5 times per week (52 weeks)

Taylor-Pillae and colleagues conducted a randomised controlled trial with a sample of 132 older American men and women to compare the effectiveness of a western-style physical activity intervention programme to one based on tai chi (Taylor-Piliae et al 2010). Results showed that the tai chi group was most effective for improving cognitive-function, compared to western-style physical activity and control groups. The differential cognitive-function improvements observed in tai chi were maintained through 12 months.

Conclusions: enhancement of cognitive function

The following efficacious physical activity interventions were identified in relation to enhancement of cognitive function:

- aerobic endurance interventions, typically consisting of one to five sessions per week of 30 to 90 minutes of moderate to vigorous intensity physical activity, over 12 to 48 weeks
- a resistance training intervention, consisting of two sets of six to eight repetitions of resistance exercises for about 60 minutes, done once or twice per week over 52 weeks
- a mobility and balance intervention, consisting of four to five sessions per week of moderate intensity exercises done for about an hour each session over 52 weeks.

Enhancement of physical function and mobility

Effective aerobic endurance interventions

The literature review identified five papers indicating effective aerobic endurance interventions for enhancing physical function and mobility amongst people over the age of 65.

Table 6.50

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Brosseau 2003	N = 1 study, with 39 participants; men and women, mean age 71 years	Aerobic endurance	1 hour sessions (25 minutes devoted to bicycling)	Low- and high-intensity	3 times per week (10 weeks)
Van de Port 2007	N = 23 studies; men and women with stroke, any age	Aerobic endurance	Range: 30 to 60 minutes	Not specified	Range: 3 to 5 times per week (8 weeks)
Paterson 2010	N = 34 studies; men and women, aged 65 years and over	Aerobic endurance	Generally 30 to 45 minutes	Moderate intensity	Generally 3 times per week (average: 24 weeks)
Windsor 2004	N = 66; men with prostate cancer, aged 52–82 years	Aerobic endurance	30 minutes	60% to 70% of maximum heart rate	3 times per week (4 weeks)
Faber 2006	N = 278; women, mean age 85 ± 6 years	Aerobic endurance	60 minutes	Moderate	1 time per week for 4 weeks, then 2 times per week for 16 weeks (20 weeks)

Brosseau's systematic review included one randomised controlled trial with 39 older participants with mean age of 71 years, who had osteoarthritis of the knee (Brosseau et al 2003). Researchers found that aerobic endurance physical activity (bicycling), of either high intensity or low intensity, was effective in improving functional status.

Van de Port conducted a systematic review and meta-analysis of 23 randomised controlled trials with 712 participants, who were recovering from stroke (van de Port et al 2007). The population included adults under the age of 65 years. Results showed that aerobic endurance physical activity programmes improved stair-climbing performance.

In a systematic review by Paterson and colleagues, 66 studies were used to assess the relationship between physical activity and physical function (Paterson et al 2010). In this systematic review, aerobic endurance interventions for older people demonstrated efficacy for physiological and functional improvements, reduced risk of functional limitations, and a likely reduction in long term disability. Furthermore, the review showed consistent findings across varying types of studies with a broad range of functional independence measures. From the reviewed studies, researchers concluded that moderate to vigorous intensity aerobic endurance physical activity confers protection in physical function, and that intensity may have to be at least moderate to be effective.

Windsor's randomised controlled trial of UK men with prostate cancer examined the role of a physical activity intervention in dealing with fatigue from cancer radiation treatments (Windsor et al 2004). In this trial, the men randomly assigned to the group advised to rest when feeling fatigued experienced a small decrease in their physical functioning after their course of radiation treatments. In contrast, those men randomly assigned to moderate intensity walking at home experienced improved physical functioning.

In a randomised controlled trial evaluating group physical activity for 278 men and women, Faber and colleagues randomly assigned participants to a no-intervention control group, a functional walking group, consisting of physical activities related to daily mobility activities, or to a balance group (Faber et al 2006). Results showed small improvements in mobility assessment and physical performance for participants in both physical activity groups, and those in the walking group showed small improvement in disability rating.

Effective resistance training interventions

The literature review identified nine papers indicating effective resistance training interventions for enhancing physical function and mobility amongst people over the age of 65.

Table 6.51

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Latham 2004	N = 62 studies; men and women, mean age 60 years or over	Resistance training	Varying durations	Low- to moderate-intensity	Mostly 2 to 3 times per week (2 to 78 weeks)
Liu 2009	N = 121 studies; men and women, mean age 60 years or over	Resistance training	Not specified	Most at high-intensity	Most 2 to 3 times per week, 2 trials daily (2 to 104 weeks)
Paterson 2010	N = 34 studies; men and women, aged 65 years and over	Resistance training	Not specified	Moderate intensity	Average: 24 weeks
Seynnes 2004	N = 22; men and women, mean age 81.5 ± 1.4 years	Resistance training	Not specified	40% of 1 repetition maximum or 80% of 1 repetition maximum	3 times per week (10 weeks)
Galvão 2005	N = 28; men and women, aged 65–78 years	Resistance training	Not specified	8 repetition maximum intensity	2 times per week (20 weeks)
Kalapotharakos 2005	N = 33; Men and women, aged 60–74 years	Resistance training	60 minutes	Heavy (80% of 1 repetition maximum) or moderate (60% of 1 repetition maximum	3 times per week (12 weeks)
Symons 2005	N = 37; men, aged 73 ± 5 years; and women, aged 73 ± 7 years	Resistance training	Not specified	3 sets of 10 maximal voluntary contractions	3 times per week (12 weeks)

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
McDermott 2009	N = 156; men and women with peripheral arterial disease, aged 60 years and over	Resistance training	15 minutes, gradually increasing to 40 minutes	Resistance: 50% of 1 repetition maximum, gradually increasing to 80% of 1 repetition maximum	3 times per week (24 weeks)
Petterson 2009	N = 149; men and women with total knee arthroplasty, aged 50–85 years	Resistance training	Not specified	2 to 3 sets of 10 repetitions at 10 repetition maximum intensity	2 to 3 times per week (6 weeks)

Latham's systematic review of 62 randomised controlled trials with a total of 3674 participants was conducted to assess the impact of resistance training on measures of disability in older people (Latham et al 2004). This review indicated that resistance training was effective in improving muscle strength and certain aspects of functional limitations, such as gait speed.

Liu's large systematic review assessed findings from 121 randomised trials with a total of 6700 participants (Liu et al 2009). Results showed that resistance training resulted in large effects on muscle strength and small, but statistically significant improvements in physical ability and functional limitations. Based on their review, the authors concluded that resistance training was effective as an intervention to improve physical functioning in older people.

In a systematic review by Paterson and colleagues, 66 studies were used to assess the relationship between physical activity and physical function (Paterson et al 2010). In this systematic review, resistance training interventions for older people effectively provided physiological and functional improvements, reduced risk of functional limitations, and a likely reduction in long term disability. Furthermore, the review showed consistent findings across varying types of studies with a broad range of functional independence measures.

Seynnes and colleagues conducted a randomised controlled trial in 22 institutionalised French elders to determine the effectiveness of high intensity training with free weights, compared with lower intensity resistance training (Seynnes et al 2004). This study showed strong dose–response relationships between strength gains and functional improvements after resistance training. This study concluded that supervised high intensity training with free weights for frail elders was safe and more effective physiologically and functionally than lower-intensity training.

In a randomised controlled trial by Galvão and colleagues, researchers tested the effectiveness of one set of resistance training exercises compared to three sets (Galvão et al 2005). Results showed that both interventions were effective for improving chair rise ability, backward walking, 400m walk speed, and stair climbing ability. Researchers concluded that one set of resistance training exercises was sufficiently effective for improving physical performance.

Kalapotharakos conducted a randomised controlled trial in Greece, in which 33 healthy inactive older men and women underwent either moderate intensity resistance or high intensity resistance training (Kalapotharakos et al 2005). Results showed that functional performance was improved to a statistically significant degree in both resistance training groups compared to controls.

Symons conducted a randomised controlled trial evaluating the effects of three types of resistance exercises on a group of healthy older men and women from Canada (Symons et al 2005). In this study, participants were randomly allocated to one of three trial arms: isometric, concentric, or eccentric resistance training. Results of this study showed that after the 12-week intervention period, all types of resistance training resulted in improvements to stair climbing and descending abilities.

A randomised controlled trial by McDermott and colleagues evaluated two resistance training physical activity interventions in a sample of 156 older American men and women with peripheral arterial disease (McDermott et al 2009). Results showed that resistance training was effective for improved walking performance, quality of life, and stair climbing ability.

In a randomised controlled trial, Petterson investigated the effectiveness of strength training programmes with and without neuromuscular electrical stimulation in 149 men and women with total knee arthroplasty (Petterson et al 2009). This study showed that progressive resistance training for the quadriceps muscles led to improvements in physical functioning, with or without neuromuscular electrical stimulation. Both resistance training physical activity programmes achieved a similar functional recovery after knee arthroplasty, which approached the functional level of healthy older people, and exceeded typical outcomes from conventional rehabilitation.

Effective mobility and balance interventions

The literature review identified three papers indicating effective mobility and balance interventions for enhancing physical function and mobility amongst people over the age of 65.

Table 6.52

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Van de Port 2007	N = 23 studies; men and women with stroke, any age	Mobility and balance	Range: 8 minutes to 2 hours	Not specified	Range: 3 to 5 times per week (3 weeks to 6 months)
Faber 2006	N = 278; women, mean age 85 ± 6 years	Mobility and balance (tai chi)	60 minutes	Moderate	1 time per week for 4 weeks, then 2 times per week for 16 weeks (20 weeks)
Taylor-Piliae 2010	N = 132; men and women, mean age 69 + 5.8 years	Mobility and balance	60 minutes	Moderate intensity	4 to 5 times per week (52 weeks)

The findings from these studies are as follows:

Van de Port conducted a systematic review and meta-analysis of 23 randomised controlled trials with 712 participants (van de Port et al 2007). Results showed that gait-oriented training interventions was effective for improving gait speed and walking distance, but not balance.

In a randomised controlled trial evaluating group physical activity for 278 men and women, Faber randomly assigned participants to a non-exercise control group, a functional walking group, or to a balance group, which consisted of physical activities based on principles of tai chi (Faber et al 2006). Small improvements in mobility assessment and physical performance were found for participants in both physical activity groups.

Taylor-Piliae and colleagues conducted a randomised controlled trial to test the effectiveness of tai chi on physical and cognitive functioning (Taylor-Piliae et al 2010). In this study, tai chi resulted in improvements to the balance component of physical functioning.

Effective mixed or various physical activity interventions

The literature review identified fourteen papers indicating effective mixed or various physical activity interventions for enhancing physical function and mobility amongst people over the age of 65.

Table 6.53

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Luctkar-Flude 2007	N = 19 studies; men and women with cancer, aged 65 years and older	Mixed or various physical activities	Not specified	Not specified	Not specified
Chin A Paw 2008	N = 20 studies; men and women, aged 77–88 years	Mixed or various physical activities	Most 45 to 60 minutes	Not specified	Most 3 times per week (10 weeks to 28 months)
Fransen 2008	N = 32 studies; men and women with osteoarthritis, any age	Mixed or various physical activities	Range: 30 to 90 minutes	Varying intensities	Varying frequencies (range: 1 to 6 months)
Forster 2009	N = 49 studies; men and women, aged 69–89 years	Mixed or various physical activities	Most 30 to 45 minutes	Varying intensities	Most around 3 times per week (most <20 weeks)
Forster 2010	N = 49 studies; men and women, mean age 82 years	Mixed or various physical activities	30 to 60 minutes	Not specified	Generally 3 times per week (generally 12 weeks)

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Binder 2002	N = 115; frail men and women, aged 83 ± 4 years	Mixed or various physical activities (flexibility, balance, resistance, aerobic endurance)	Aerobic endurance was 15 to 30 minutes; other components not specified	Resistance training building from 65% of one-repetition maximum; aerobic endurance building from 65% of aerobic capacity	3 times per week (9 months)
Messier 2004	N = 316; overweight or obese men and women with osteoarthritis and physical disability, aged 60 years and over	Mixed or various physical activities	60 minutes	Aerobic: 50 to 75% of heart rate reserve; resistance: 2 sets of 12 repetitions	3 times per week (18 months)
Pang 2005	N = 63; men and women with chronic stroke, aged 50 years and over	Mixed or various physical activities	60 minutes	Range: 40% to 80% of heart rate reserve	3 times per week (19 weeks)
Pahor 2006	N = 424; men and women, aged 70–89 years	Mixed or various physical activities	40 to 60 minutes	Moderate-intensity	Centre-based sessions: weaning from 3 times per week; home-based sessions building to ≥3 times per week (26 weeks)
Villareal 2006b	N = 27; obese men and women, aged 65 years and over	Mixed or various physical activities (aerobic endurance and resistance training, balance work)	90 minutes	About 70% of aerobic capacity; about 80% of 1 repetition maximum	3 times per week (6 months)
Dubbert 2008	N = 224; men with physical function limitations, aged 60–85 years	Mixed or various physical activities	20 minutes or more	Not specified	3 to 5 times per week
Guell 2006	N = 40; men and women with severe chronic flow limitation, aged 65 ± 8 years	Mixed or various physical activities	30 minutes	Not specified	Week 1 to 8: 2 times per week; Week 9 to 16: 5 times per week (16 weeks)
Davidson 2009	N = 136; men and women, abdominally obese, aged 60–80 years	Mixed or various physical activities (walking and resistance training)	30 minutes walking; 20 minutes resistance training: 1 set of 9 exercises	Walking at 60–75% of aerobic capacity; resistance training to volitional fatigue	Walking 3 times per week and resistance training 3 times per week (24 weeks)

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Manty 2009	N = 632; men and women, aged 75–81 years	Mixed or various physical activities	Not specified	Not specified	Not specified

Luctkar-Flude's systematic review of nine experimental studies and 10 observational studies of physical activity and fatigue in cancer patients found support for the use of physical activity during treatment of cancer (Luctkar-Flude et al 2007). According to these authors, physical activity offers the strongest available evidence among interventions to maintain functional status during cancer treatment (Luctkar-Flude et al 2007).

Chin A Paw's systematic review of 20 randomised controlled trials assessed various physical activity interventions to improve functional performance (Chin A Paw et al 2008). This review included a heterogeneous collection of studies assessing 23 different programmes including resistance training, tai chi training, or multi-component physical activity, and most were facility-based group physical activity programmes. The majority of reviewed interventions were effective for improving at least one measure of functional performance.

Fransen's 2008 systematic review (Fransen et al 2008) analysed the literature on randomised controlled trials for pain and physical function in older people with osteoarthritis of the knee. It included 32 trials with data for over 3600 individuals. The population included adults under the age of 65 years. According to the authors, there is strong evidence in favour of physical activity, such that a physical activity programme is effective for reducing knee pain and improving physical function for people with knee osteoarthritis. In this study, the effect size was comparable to that obtained by non-steroidal anti-inflammatory drugs.

A systematic review of 49 randomised trials was conducted by Forster and colleagues to evaluate rehabilitative physical activity interventions designed to improve physical functioning among older people in long-term care (Forster et al 2009). Most of the reviewed trials reported improvement in physical condition. This study's authors concluded that physical activity rehabilitative interventions were likely to improve physical condition and reduce disability without adverse events.

Forster and colleagues conducted a systematic review of 49 physically active rehabilitation interventions for older people in long-term care (Forster et al 2010). Results showed that thirty-three trials, including the nine trials that recruited over 100 subjects, reported positive findings, mostly improvement in mobility but also strength, flexibility and balance. This study's authors concluded that physical rehabilitation for older people in long-term care is acceptable and potentially effective.

Binder and colleagues randomly assigned 115 older American frail men and women to a supervised centre-based physical activity intervention, or to a home-based intervention over nine months of study (Binder et al 2002). The supervised mixed physical activity intervention involved resistance training, aerobic endurance training, flexibility exercises, and balance training, while the alternative intervention consisted of low intensity flexibility physical activity at home. This study found supervised physical activity training programme was superior to the home physical activity programme in measures of aerobic capacity, functional status, and physical performance.

Messier reported on a randomised controlled trial of overweight and obese older people with knee osteoarthritis and physical disability to evaluate a long-term physical activity and weight loss programme in relation to physical function, mobility, and pain (Messier et al 2004). In this study, 316 older people (over the age of 60 years) were randomised to a healthy lifestyle (control), diet only, physical activity only, or diet plus physical activity group. Results showed statistically significant improvements in physical function, walking and stair-climbing performance, and knee pain occurred in the diet plus physical activity group. In the physical activity-only group, walking performance improved.

Pang and colleagues conducted a randomised controlled trial to determine the impact of a physical activity intervention designed to improve mobility in participants recovering from stroke (Pang et al 2005). Results showed that compared to control participants, the mixed physical activity intervention group had greater gains in mobility.

Physical activity has been used as part of pulmonary rehabilitation, and Guell's small randomised controlled trial evaluated its effectiveness for providing health benefits in participants with chronic obstructive pulmonary disease (Guell et al 2006). Participants were randomly assigned to pulmonary rehabilitation or a control group. This study found that pulmonary rehabilitation was effective for increased functional capacity.

Villareal's randomised controlled trial was published with two sets of outcomes, with both articles assessing a lifestyle intervention (including a physical activity component) versus control condition in 27 obese older men and women from the US (Villareal et al 2006a). The lifestyle intervention consisted of weekly weight loss behaviour therapy plus sessions of mixed physical activity. Results showed that intervention participants improved in physical performance, functional status, and walking speed.

Pahor and colleagues conducted a randomised controlled trial with 424 sedentary older people from the US, who were randomly assigned to either a mixed physical activity counselling intervention or a successful ageing education programme (Pahor et al 2006). Instead of conducting a carefully supervised centre-based physical activity efficacy study, this randomised trial sought to evaluate the intervention under real-world conditions in a home-based effectiveness model. The physical activity intervention programme consisted of components for strength, flexibility, balance, and moderate intensity aerobic endurance (aiming for 150 minutes of walking per week). In this trial, the participants in the physical activity group had superior physical performance outcomes and a lower incidence of disability at follow-up, compared to controls.

Dubbert and colleagues conducted a randomised controlled trial to test the effectiveness of a relatively brief home-based physical activity intervention in a sample of 224 older American male veterans with functional limitations (Dubbert et al 2008). Rather than using a carefully supervised centre-based physical activity efficacy model, this study evaluated the intervention under more real-world conditions in a home-based effectiveness model. Results showed that intervention group veterans, who were instructed to increase walking and strength training physical activity levels, obtained better physical performance scores, as compared to controls.

Davidson and colleagues studied older sedentary men and women with abdominal adiposity (aged between 60 years and 80 years) (Davidson et al 2009). In this trial, participants were randomised to resistance training, aerobic endurance training, resistance and aerobic endurance training (combined), or a non-exercise control group. The researchers found that functional limitation improved to a statistically significant degree in all physical activity intervention groups compared with the control group.

A population-based randomised controlled trial, conducted by Manty and colleagues, took place in Finland with 632 sedentary men and women (Manty et al 2009). This study evaluated the effectiveness of a mixed physical activity counselling session and two years of telephone support on mobility. As opposed to the typically used supervised centre-based physical activity efficacy approach, this study investigated the intervention in a home-based effectiveness model, which represents a more real-world conditions. Results showed a statistically significant lower loss of mobility amongst the intervention group at the two-year follow-up, and the difference remained statistically significant at 18 months post-intervention.

Conclusions: enhancement of physical function and mobility

The following efficacious physical activity interventions were identified in relation to enhancement of physical function and mobility:

- aerobic endurance interventions, typically consisting of moderate intensity physical activities done about three times per week for 30 to 60 minutes per session, over 4 to 26 weeks
- resistance training interventions, typically consisting of two to three session per week of multiple sets of resistance exercises, done at a wide range of intensities, in programmes lasting two to 78 weeks
- mobility and balance interventions, typically consisting of two to five sessions per week, around 60 minutes but varying from eight to 120 minutes in duration over three to 52 weeks. Intensity level was often not specified in the systematic review, but was moderate in two articles
- mixed or various physical activity interventions, typically consisting of two to five sessions per week , each lasting 30 to 90 minutes at a range of intensities, in programmes lasting one to 28 months.

Three articles addressed effective physical activity interventions in the frail old:

- one article found that supervised high intensity training done with free weights three times per week over 10 weeks was safe and more effective physiologically and functionally than lower-intensity training (Seynnes et al 2004)
- two articles found that a combination of high intensity aerobic endurance and resistance training done three times per week for up to 90 minutes was effective for physical function and mobility.

Enhancement of activities of daily living

Effective resistance training interventions

The literature review identified one paper indicating effective resistance training interventions for enhancing activities of daily living amongst people over the age of 65.

Table 6.54

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Ginis 2006	N = 64; men and women, aged 74.4 ± 3.7 years	Resistance training	Not specified	60% of 1 repetition maximum, building to 80% of 1 repetition maximum	2 times per week (12 weeks)

Ginis and colleagues (Ginis et al 2006) used a randomised controlled trial to test two weight training interventions in a sample of 64 healthy sedentary Canadian men and women. One weight training intervention received an additional educational component and the other condition was weight training alone. Results showed that both weight training conditions resulted in statistically significant improvements to activities of daily living.

Effective mixed or various physical activity interventions

The literature review identified two papers indicating effective mixed or various physical activity interventions for enhancing activities of daily living amongst people over the age of 65.

Table 6.55

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Daniels, 2008	N = 10 studies; frail men and women, aged 65 years and over	Mixed or various physical activities	40 to 90 minutes	Low- to moderate-intensity	1 to 3 times per week (10 to 78 weeks)
Forster 2010	N = 49 studies; men and women, mean age 82 years	Mixed or various physical activities	30 to 60 minutes	Not specified	Generally 3 times per week (generally 12 weeks)

Daniels' systematic review of eight clinical trials evaluated effects of various physical activity interventions on disability and activities of daily living (Daniels et al 2008). Of the eight interventions, the long-lasting and highly intense multi-component interventions appeared to have favourable effects on activities of daily living for community-living frail older people.

Forster and colleagues conducted a systematic review of 49 physically active rehabilitation interventions for older people in long-term care (Forster et al 2010). Results showed that thirty-three trials, including the nine trials recruiting over 100 subjects, reported effectiveness in improving mobility, other activities of daily living, or strength. This study's authors

concluded that residents in long-term care should be dissuaded from adopting a sedentary lifestyle and reassured that physical activity is likely to promote mobility and daily living activities.

Conclusions: enhancement of activities of daily living

The following efficacious physical activity interventions were identified in relation to enhancement of activities of daily living:

- a resistance training intervention, typically consisting of two sessions per week of resistance exercises performed at 60% to 80% of one repetition maximum, done over 12 weeks
- mixed or various physical activity interventions, typically consisting of one to three sessions per week, lasting 30 to 90 minutes per session at various intensities
- effective physical activity interventions for the frail old (Daniels et al 2008). This article described various physical activities performed at a low to moderate intensity one to three times per week for 40 to 90 minutes over 10 to 78 weeks.

Enhancement of balance

Effective aerobic endurance interventions

The literature review identified one paper indicating effective aerobic endurance interventions for enhancing balance amongst people over the age of 65.

Table 6.56

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Howe 2007	N = 34 studies; men and women, 60 years and over	Aerobic endurance	Typically 60 minutes	Not specified	Typically 3 times per week (range: 4 weeks to 12 months)

The findings from this study are as follows:

In a systematic review, Howe and colleagues included 34 randomised controlled trials and quasi-randomised trials involving a total of 2883 participants (Howe et al 2007). This systematic review of physical activity interventions included studies that evaluated the effects of aerobic endurance exercise on balance in older people. Among the results, statistically significant improvements in balance ability were seen in the physical activity interventions, compared to control groups. In this systematic review, walking aerobic endurance physical activity interventions were among those that appeared to have a large beneficial effect on balance.

Effective resistance training interventions

The literature review identified two papers indicating effective resistance training interventions for enhancing balance amongst people over the age of 65.

Table 6.57

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Howe 2007	N = 34 studies; men and women, 60 years and over	Resistance training	Typically 60 minutes	Not specified	Typically 3 times per week (range: 4 weeks to 12 months)
Orr 2008	N = 29 studies; men and women, mean age 60 years or over	Resistance training	35 to 90 minutes	2 to 3 sets at low (<40% one repetition maximum) to high (> 70% one repetition maximum) intensity	2 to 3 days per week (8 to 104 weeks)

In a systematic review, Howe and colleagues included 34 randomised controlled trials and quasi-randomised trials involving a total of 2883 participants (Howe et al 2007). This systematic review of physical activity interventions included studies that evaluated the effectiveness of resistance training on balance in older people. Among the results, statistically significant improvements in balance ability were seen in the physical activity interventions, compared to control groups. According to this systematic review, resistance training interventions were among those that appeared to have a large beneficial effect on balance.

The results, however, showed limited evidence that intervention effects were long-lasting, suggesting a need for more long-term evaluations and possibly extended physical activity programmes.

Orr and colleagues reported on a systematic review of literature that addressed resistance training and balance and included 29 studies, representing work with 2174 total participants (Orr et al 2008). Among the reviewed studies, about 22% reported improvements to balance from resistance training programmes.

Effective mobility and balance interventions

The literature review identified four papers indicating effective mobility and balance interventions for enhancing balance amongst people over the age of 65.

Table 6.58

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Howe 2007	N = 34 studies; men and women, 60 years and over	Mobility and balance	Typically 60 minutes	Not specified	Typically 3 times per week (range: 4 weeks to 12 months)
Li 2005	N = 256; men and Women, aged 70–92 years	Mobility and balance	60 minutes	Not specified	3 times per week (6 months)
Voukelatos 2007	N = 702; women (85%) and men, aged 60 years and over	Mobility and balance	60 minutes	Not specified	1 per week (16 weeks)

Taylor-Piliae 2010	N = 132; men and women, mean age 69 + 5.8 years	Mobility and balance	60 minutes	Moderate-intensity	4 to 5 times per week (52 weeks)

In a systematic review, Howe and colleagues included 34 randomised controlled trials and quasi-randomised trials involving a total of 2883 participants (Howe et al 2007) This systematic review of physical activity interventions included studies that evaluated the effects of mobility and balance exercises on balance in older people. Among the results, statistically significant improvements in balance ability were seen in the physical activity interventions, compared to control groups. Physical activity interventions targeting gait, balance, co-ordination and functional exercises were among those that appeared to be effective for improving balance.

Li and colleagues reported on a randomised trial that showed attending a thrice-weekly tai chi group was effective for improving functional balance for previously inactive people aged 70 years and older, relative to controls (Li et al 2005). Furthermore, improvements were also seen in fall rates for this population.

Another randomised controlled trial by Voukelatos and colleagues studied community-dwelling older people and showed that weekly participation in tai chi may be effective for improving balance (Voukelatos et al 2007). In this study, participation in tai chi class once per week for an hour over 16 weeks resulted in less frequent falls and better balance, relative to controls.

Taylor-Piliae and colleagues conducted a randomised controlled trial to test the effectiveness of tai chi on balance and cognitive functioning (Taylor-Piliae et al 2010). In this study, a one-hour tai chi session, done four to five times per week resulted in improvements to balance.

Effective mixed or various physical activity interventions

The literature review identified three papers indicating effective mixed or various physical activity interventions for enhancing balance amongst people over the age of 65.

Table 6.59

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Baker 2007	N = 15 studies; men and women with mild cognitive impairment, aged 55–85 years	Mixed or various physical activities	Not specified	Not specified	Commonly 3 days per week
Howe 2007	N = 34 studies; men and women, 60 years and over	Mixed or various physical activities	Typically 60 minutes	Not specified	Typically 3 times per week (range: 4 weeks to 12 months)
Forster 2010	N = 49 studies; men and women, mean age 82 years	Mixed or various physical activities	30 to 60 minutes	Not specified	Generally 3 times per week (generally 12 weeks)

Rydwik 2008	N = 96; frail men and women, mean age 83 years	Mixed or various physical activities	60 minutes	Aerobic endurance: not specified; resistance training: “60–80% intensity”	2 times per week (12 weeks)

In a systematic review by Baker and colleagues, researchers examined 15 randomised controlled trials, with a total sample of 2149 participants generally ranging from 67 to 84 years of age (Baker et al 2007). Results showed that among the eleven trials that included balance measurements, six of them described statistically significant improvements to balance from various physical activity interventions, compared to controls.

In a systematic review, Howe and colleagues included 34 randomised controlled trials and quasi-randomised trials involving a total of 2883 participants (Howe et al 2007). This systematic review of physical activity interventions included studies that evaluated the effects of mixed types of exercise on balance in older people. Among the results, statistically significant improvements in balance ability were seen in the physical activity interventions, compared to control groups. Those interventions with multiple types of physical activity showed greatest effectiveness for improving balance.

The results, however, showed limited evidence that intervention effects were long-lasting, suggesting a need for more long-term evaluations and possibly extended physical activity programmes.

Forster and colleagues conducted a systematic review of 49 physically active rehabilitation interventions for older people in long-term care (Forster et al 2010). Results showed that most trials reported various physical activity interventions were effective for improving balance in older people.

Rydwik and colleagues conducted a randomised controlled trial with a sample of 96 community-dwelling frail older men and women (Rydwik et al 2008). Participants were randomised 1) to a physical activity intervention including aerobic, muscle strength, and balance training; 2) to a nutrition intervention; 3) to a combined physical activity and nutrition intervention; or 4) to a control group. Results showed that there were small statistically significant changes for some of the balance measurements in the training group without nutrition treatment.

Conclusions: enhancement of balance

The following efficacious physical activity interventions were identified in relation to enhancement of balance:

- aerobic endurance interventions, typically consisting of three hour-long sessions per week over four to 52 weeks
- resistance training interventions, typically consisting of two to three sessions per week, each lasting 35 to 90 minutes. Multiple sets of exercises at varying intensity levels were typical of these intervention programmes
- mobility and balance interventions, typically consisting of one to five hour-long sessions per week, over four to 52 weeks, at unspecified intensity levels

- mixed or various physical activity interventions, typically consisting of three sessions per week, each lasting 30 to 60 minutes over four to 52 weeks, at unspecified intensity levels
- an effective physical activity intervention for the frail old (Daniels et al 2008). This article featured various physical activities, but the frequency, intensity, and duration of the physical activity were not specified in the article.

Enhancement of aerobic capacity

Effective aerobic endurance interventions

The literature review identified eight papers indicating effective aerobic endurance interventions for enhancing aerobic capacity amongst people over the age of 65.

Table 6.60

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Brosseau 2003	N = 1 study, with 39 participants; men and women, mean age 71 years	Aerobic endurance	1 hour sessions (25 minutes devoted to bicycling)	Low- and high-intensity	3 times per week (10 weeks)
Shekelle 2003	N = 47 studies; men and women, mostly aged 65 years and over	Aerobic endurance	Not specified	Not specified	Not specified
Angevaren 2008	N = 11 studies; men and women, aged 55 years and over	Aerobic endurance	Mostly 30 to 90 minutes	Varying intensity	Range: 1 to 5 times per week (8 to 26 weeks)
Gass 2004	N = 54; men aged 65–75 years	Aerobic endurance	180–200 kilojoules per session	50% of aerobic capacity	Three times a week (12 weeks)
Hung 2004	N = 21; women, aged 60–80 years	Aerobic endurance	30 minutes	70% to 85% of peak heart rate	3 times per week (8 weeks)
Haykowsky 2005	N = 31; women, aged 68 ± 4 years	Aerobic endurance	Building from 15 minutes to 42.5 minutes	60% to 80% of heart rate reserve	3 times per week (12 weeks)
Broman 2006	N = 29; women, aged 69 ± 4 years	Aerobic endurance	Not specified	Target heart rate = 75% of maximum	2 times per week (8 weeks)
Pogliaghi 2006	N = 12; men, aged 67 ± 5 years	Aerobic endurance	30 minutes	High (90% to 110% of heart rate ventilatory threshold)	3 times per week (12 weeks)
Wisloff 2007	N = 27; men and women with heart failure, mean age 75.5 ± 11.1 years	Aerobic endurance	38 minutes (interval group); 47 minutes (continuous group)	95% of peak heart rate (interval group); 70% of peak heart rate (continuous group)	3 times per week (12 weeks)

Brosseau's systematic review included one randomised controlled trial with 39 older participants with mean age of 71 years, who had osteoarthritis of the knee (Brosseau et al 2003). This study found that aerobic endurance physical activity (cycling), of either high intensity or low intensity, led to greater aerobic capacity.

Shekelle reported on a large systematic review and meta analysis with 47 studies, in which effect sizes were calculated for physically active intervention outcomes including strength, aerobic capacity, physical function, and depression (Shekelle et al 2003). For aerobic endurance training interventions, the pooled effect size for aerobic capacity from 17 studies was of small to moderate intensity in size, indicating that these interventions were effective for improving aerobic capacity.

Angevaren and colleagues systematically reviewed 11 randomised controlled trials that evaluated cognitive outcomes from aerobic physical activity interventions in people without impairment (Angevaren et al 2008). Eight of the 11 trials showed that aerobic physical activity interventions led to increased aerobic capacity.

In a randomised controlled trial with Australian older men, Gass and colleagues reported statistically significant improvements in heart functioning measures from 12 weeks of aerobic bicycling physical activity (GASS et al 2004). In those men randomly assigned to either moderate or vigorous intensity physical activity groups, bicycling three times per week resulted in improved aerobic capacity, cardiac stroke volume and heart rate at a given workload.

In a randomised controlled trial with 21 older women (aged 60–80 years) diagnosed with coronary artery disease, Hung sought to compare a programme of aerobic endurance training to a combined strength and aerobic endurance training programme (Hung et al 2004). Results showed that both programmes resulted in similar improvements to aerobic capacity.

Haykowsky and colleagues evaluated the relative effectiveness of resistance training, aerobic endurance training, and resistance plus aerobic endurance training compared to a no-intervention control group (Haykowsky et al 2005). Results indicated that all intervention types, including aerobic endurance training, were effective in increasing aerobic capacity.

Broman and colleagues conducted a randomised controlled trial with 29 healthy older women in Sweden (Broman et al 2006). In this study, women were randomly assigned to a control or physical activity group that did high intensity deep water running with a floatation vest. Results showed that the aquatic exercise training improved aerobic capacity by 10%. Furthermore, the fitness improvements from physical activity in the water successfully transferred to land-based activities in these older women.

In a randomised controlled trial that took place in Italy, Pogliaglhi studied the effects of arm bicycling compared to leg bicycling in 12 older non-smoking men (Pogliaghi et al 2006). Following training, peak heart rate remained unchanged, but higher workload and measures of aerobic capacity that were statistically significant were obtained in both arm and leg training groups.

A randomised controlled trial by Wisloff and colleagues evaluated an aerobic endurance training programme in a sample of 27 older Norwegian men and women with heart failure (Wisloff et al 2007). This study found that higher intensity physical activity was effective in improving aerobic capacity in patients with post-infarction heart failure.

Effective resistance training interventions

The literature review identified two papers indicating effective resistance training interventions for enhancing aerobic capacity amongst people over the age of 65.

Table 6.61

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Haykowsky 2005	N = 31; women, aged 68 ± 4 years	Resistance training	Not specified	50 to 75% of 1 repetition maximum, 2 sets of 10 repetitions	3 times per week (12 weeks)
Wieser 2007	N = 24; men and women, mean age 76.2 ± 3.2 years	Resistance training	60 minutes	Building from 1 set to 2 sets of 8 exercises at 10 to 15 repetitions (maximum)	2 times per week or 3 times per week (12 weeks)

Haykowsky and colleagues evaluated the relative effectiveness of resistance training, aerobic endurance training, and resistance plus aerobic endurance training compared to a no-intervention control group (Haykowsky et al 2005). Results indicated that all three types of physical activity intervention, including resistance training, were able to increase aerobic capacity to a similar degree.

However, the strength training and combined strength and aerobic endurance training conditions improved overall muscle strength more effectively than did aerobic endurance training.

A study by Wieser and colleagues involved 24 men and women in Austria, measured for strength, aerobic capacity, and body composition before and after being randomised to a 12-week strength training group or no-intervention control group (Wieser et al 2007). Results showed that those in the strength training group had statistically significant gains in aerobic capacity. Furthermore, this study showed that twice-per-week resistance training could be as effective as thrice-per-week training, provided the total number of sets performed were equal.

Effective mixed or various physical activity interventions

The literature review identified four papers indicating effective mixed or various physical activity interventions for enhancing aerobic capacity amongst people over the age of 65.

Table 6.62

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Hung 2004	N = 21; women, aged 60–80 years	Mixed or various physical activities	30 minutes aerobic training plus additional strength training	Aerobic 70% to 85% of peak heart rate; strength training at 55% of 1 repetition maximum, increasing by 2.5% every week	3 times per week (8 weeks)
Takeshima 2004	N = 35; men and women mean age 68.3 ± 4.9 years	Mixed or various physical activities	50 minutes	Moderate intensity	3 times per week (12 weeks)
Haykowsky 2005	N = 31; women, aged 68 ± 4 years	Mixed or various physical activities	Aerobic endurance: building from 15 minutes to 42.5 minutes; resistance training not specified	Aerobic endurance: 60% to 80% of heart rate reserve; resistance training: 50% to 75% of 1 repetition maximum, 2 sets of 10 repetitions	3 times per week (12 weeks)
Pang 2005	N = 63; men and women with chronic stroke, aged 50 years and over	Mixed or various physical activities	60 minutes	Range: 40% to 80% of heart rate reserve	3 times per week (19 weeks)
Villareal 2006b	N = 27; obese men and women, aged 65 years and over	Mixed or various physical activities (aerobic endurance and resistance training, balance work)	90 minutes	About 70% of aerobic capacity; about 80% of 1 repetition maximum	3 times per week (6 months)

Hung and colleagues conducted a randomised controlled trial with 21 older women diagnosed with coronary artery disease, that sought to compare a programme of aerobic endurance training to a combined strength and aerobic endurance training programme (Hung et al 2004). Results showed that both physical activity intervention programmes resulted in similar improvements to aerobic capacity.

Takeshima and colleagues studied 35 older men and women in Japan to determine the effectiveness of an intervention including circuit physical activity training (Takeshima et al 2004). This physical activity intervention being evaluated included aerobic endurance and hydraulic resistance training. The findings indicated that combined aerobic endurance and hydraulic resistance training resulted in statistically significant improvements to aerobic capacity in older people.

Haykowsky and colleagues evaluated the relative effectiveness of resistance training, aerobic endurance training, and resistance plus aerobic endurance training compared to a no-intervention control group (Haykowsky et al 2005). Results indicated that all three types of

physical activity intervention, including combined resistance and aerobic endurance training, were able to increase aerobic capacity to a similar degree.

Pang and colleagues conducted a randomised controlled trial to determine the impact of a fitness and mobility physical activity programme designed to improve aerobic capacity, mobility, leg muscle strength, balance, and hip bone mineral density (Pang et al 2005). In the physical activity group, participants performed one hour of mixed physical activity three times per week for 19 weeks. Results indicated that, compared to control participants, the intervention group participants had greater gains in aerobic capacity.

Villareal and colleagues conducted a randomised controlled trial that evaluated a lifestyle intervention that included aerobic endurance, balance, and resistance training physical activity, versus a control condition in 27 obese older men and women from the US (Villareal et al 2006a). Results showed that the intervention participants improved in aerobic capacity.

Conclusions: enhancement of aerobic capacity

The following efficacious physical activity interventions were identified in relation to enhancement of aerobic capacity:

- aerobic endurance interventions, typically consisting of sessions held two to three times per week of 30 to 60 minutes at moderate to vigorous intensity, in programmes lasting eight to 12 weeks
- resistance training interventions, typically consisting of two to three sessions per week, over 12 weeks. Intensity level was 50% to 75% of one repetition maximum, and multiple sets were performed
- mixed or various physical activity interventions, typically consisting of 50 to 90-minute sessions of moderate to high intensity activities performed three times per week for eight to 19 weeks.

Enhancement of strength

Effective aerobic endurance interventions

The literature review identified one paper indicating effective aerobic endurance interventions for enhancing strength amongst people over the age of 65.

Table 6.63

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Hung 2004	N = 21; women, aged 60–80 years	Aerobic endurance	30 minutes	70% to 85% of peak heart rate	3 times per week (8 weeks)

Hung and colleagues conducted a randomised controlled trial with 21 older women diagnosed with coronary artery disease, that sought to compare a programme of aerobic endurance training to a combined strength and aerobic endurance training programme (Hung

et al 2004). Results showed that both programmes resulted in similar improvements to lower-body strength.

Effective resistance training interventions

The literature review identified fourteen papers indicating effective resistance training interventions for enhancing strength amongst people over the age of 65.

Table 6.64

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Shekelle 2003	N = 47 studies; men and women, mostly aged 65 years and over	Resistance training	Not specified	Not specified	Not specified
Latham 2004	N = 62 studies; men and women, mean age 60 years or over	Resistance training	Varying durations	Low- to moderate-intensity	Mostly 2 to 3 times per week (2 to 78 weeks)
Liu 2009	N = 121 studies; men and women, mean age 60 years or over	Resistance training	Not specified	Most at high-intensity	Most 2 to 3 times per week, 2 trials daily (2 to 104 weeks)
Suetta, 2004	N = 36; men and women with osteoarthritis, aged 60–86 years	Resistance training	Time to complete exercises (not specified)	3 to 5 sets of 8 to 10 repetitions (at 8 repetition maximum intensity)	Daily to 3 times per week (8 weeks)
Fatouros 2005	N = 50; Overweight men, aged 65–78 years	Resistance training	About 60 minutes	Low, moderate and high intensity	3 times per week (6 months)
Galvão 2005	N = 28; men and women, aged 65–78 years	Resistance training	Not specified	8RM intensity	2 times per week (20 weeks)
Haykowsky 2005	N = 31; women, aged 68 ± 4 years	Resistance training	Not specified	50 to 75% of 1 repetition maximum, 2 sets of 10 repetitions	3 times per week (12 weeks)
Symons 2005	N = 37; men, aged 73 ± 5 years; and women, aged 73 ± 7 years	Resistance training	Not specified	3 sets of 10 maximal voluntary contractions	3 times per week (12 weeks)
Ginis 2006	N = 64; men and women, aged 74.4 ± 3.7 years	Resistance training	Not specified	60% of 1 repetition maximum, building to 80% of 1 repetition maximum	2 times per week (12 weeks)

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Mikesky 2006	N = 221; men and women with osteoarthritis, mean age 69 years	Resistance training	Time taken to complete exercises (not specified)	3 sets of 8 to 10 repetitions for 4 exercises	3 times per week (52 weeks)
Sullivan 2007	N = 29; men and women with functional decline, mean age 79.4 ± 7.4 years	Resistance training	Not specified	Building from 20% to 80% of 1 repetition maximum	Not specified (12 weeks)
Wieser 2007	N = 24; men and women, mean age 76.2 ± 3.2 years	Resistance training	60 minutes	Building from 1 set to 2 sets of 8 exercises at 10 to 15 repetitions (maximum)	2 times per week or 3 times per week (12 weeks)
Petterson 2009	N = 149; men and women with total knee arthroplasty, aged 50–85 years	Resistance training	Not specified	2 to 3 sets of 10 repetitions at 10 repetition maximum intensity	2 to 3 times per week (6 weeks)
Verdijk 2009	N = 26; men, mean age 72 ± 2 years	Resistance training	Not specified	4 sets of 10 to 15 repetitions at 60% of 1 repetition maximum (4 weeks) then 4 sets of 8 repetitions at 80% of 1 repetition maximum	3 times per week (12 weeks)

Shekelle reported on a large systematic review and meta analysis with 47 studies, in which effect sizes were calculated for physically active intervention outcomes including strength, cardiovascular fitness, physical function, and depression (Shekelle et al 2003). For strength, 32 studies were included, and the effect size was equivalent to an increase of seven kilograms in knee extension force. Thus, this review showed that resistance training was effective for increasing strength in older people.

Latham's systematic review of 62 randomised controlled trials with a total of 3674 participants assessed the impact of resistance training in older people (Latham et al 2004). This review indicated that resistance training was effective in improving muscle strength.

Liu conducted a large systematic review that assessed findings from 121 randomised trials with a total of 6700 participants (Liu et al 2009). Results of this review showed that resistance training resulted in large effects on muscle strength among older people.

In a sample of 36 Danish older men and women with hip osteoarthritis, Suetta and colleagues tested the effectiveness of strength training during recovery from long-term muscle disuse and hip surgery in a randomised controlled trial (Suetta et al 2004). Results showed that strength training increased muscle mass, maximal isometric strength, rate of force development, and muscle activation in these older men and women.

The researchers concluded that the improvement in muscle mass and neural function from strength training was likely to have positive functional implications for older individuals.

Fatouros and colleagues conducted a randomised controlled trial to determine the effectiveness of varying intensities of resistance training in a sample of 50 overweight and inactive older men (Fatouros et al 2005). In this study, the older men were randomly assigned to participate in low, moderate, or high intensity resistance training. Results showed intensity-dependent increases in strength after training, such that the higher intensities resulted in greater strength gains.

In a randomised controlled trial by Galvão and colleagues, researchers tested the effectiveness of one set of resistance training exercises compared to three sets (Galvão et al 2005). Results showed that both resistance training intervention conditions led to increases in muscular strength, though outcomes typically favoured the higher volume condition. Conclusions from this study were that a single-set of eight repetition maximum resistance exercises, performed twice per week, was sufficient to enhance muscular strength.

Haykowsky and colleagues evaluated the relative effectiveness of strength training, aerobic endurance training, and strength plus aerobic endurance training compared to a no-intervention control group (Haykowsky et al 2005). Results indicated that the strength training and combined strength and aerobic training conditions improved overall muscle strength more effectively than did aerobic training.

Symons reported on a group of 37 healthy older men and women from Canada who participated in a randomised controlled trial that evaluated the effects of three types of resistance exercises (Symons et al 2005). In this study, participants were randomly assigned to one of three trial arms: isometric, concentric, or eccentric resistance training. Results of this study showed that all three types of resistance training were efficacious for increasing strength and concentric power and work.

Ginis and colleagues (Ginis et al 2006) used a randomised controlled trial to test two resistance training interventions in a sample of 64 healthy sedentary Canadian men and women. One resistance training intervention received an additional educational component and the second intervention was resistance training alone. Both intervention programmes included exercises targeting eight major muscle groups. Results showed that both weight training conditions resulted in statistically significant improvements to strength.

Mikesky and colleagues conducted a randomised controlled trial to evaluate the effectiveness of strength training compared to range of motion training in a sample of men and women with osteoarthritis of the knee (Mikesky et al 2006). Results indicated that both strength training and range-of motion groups decreased in leg strength over the course of 30 months, but this rate of strength loss was faster in the range-of-motion group. Thus, the strength training intervention was effective as that group lost less strength, compared to the range of motion group.

In a randomised controlled trial from the United States, Sullivan and colleagues randomly assigned 29 men and women with functional decline to either low resistance training or high intensity progressive resistance muscle strength training, combined with megestrol acetate or placebo (Sullivan et al 2007). This study showed that the participants who received high

intensity progressive resistance training without megestrol acetate experienced the greatest strength gains.

A study by Wieser and colleagues involved 24 men and women in Austria, measured for strength, aerobic capacity, and body composition before and after being randomised to a 12-week strength training group or no-intervention control group (Wieser et al 2007). Results showed that those in the resistance training physical activity groups had statistically significant gains in maximum strength. Furthermore, this study showed that twice-per-week resistance training could be as effective as thrice-per-week training, provided the total number of sets performed were equal.

In a randomised controlled trial, Petterson and colleagues investigated the effectiveness of strength training programmes with and without neuromuscular electrical stimulation in 149 men and women with total knee arthroplasty (Petterson et al 2009). This study showed that the resistance training intervention programme was effective for strengthening of the quadriceps muscles in this population.

Verdijk and colleagues conducted a randomised controlled trial in the Netherlands with 26 healthy older men (Verdijk et al 2009). In this study, participants were randomly assigned to a strength training programme with or without protein supplementation. After completion of the programme, strength increased by about 25–35% in both groups.

Effective mixed or various physical activity interventions

The literature review identified six papers indicating effective mixed or various physical activity interventions for enhancing strength amongst people over the age of 65.

Table 6.65

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Hung 2004	N = 21; women, aged 60–80 years	Mixed or various physical activities	30 minutes aerobic training plus additional strength training	Aerobic 70% to 85% of peak heart rate; strength training at 55% of 1 repetition maximum, increasing by 2.5% every week	3 times per week (8 weeks)
Mador 2004	N = 24; men and women with COPD aged 68 ± 2 years (aerobic); and 74 ± 2 years (combined)	Mixed or various physical activities	Not specified	Resistance training: 50% of maximal load and 1 set of 60% 1 repetition maximum, increasing to 3 sets	3 times per week (8 weeks)
Takeshima 2004	N = 35; men and women mean age 68.3 ± 4.9 years	Mixed or various physical activities	50 minutes	Moderate intensity	3 times per week (12 weeks)
Pang 2005	N = 63; men and women with chronic stroke, aged 50 years and over	Mixed or various physical activities	60 minutes	Range: 40% to 80% of heart rate reserve	3 times per week (19 weeks)

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Villareal 2006b	N = 27; obese men and women, aged 65 years and over	Mixed or various physical activities (aerobic endurance and resistance training, balance work)	90 minutes	About 70% of aerobic capacity; about 80% of 1 repetition maximum	3 times per week (6 months)
Goodpaster 2008	N = 42; men and women with functional limitations, aged 70–89 years	Mixed or various physical activities	40 to 60 minutes	Not specified	3 to 5 times per week (52 weeks)
Rydwik 2008	N = 96; frail men and women, mean age 83 years	Mixed or various physical activities	60 minutes	Aerobic endurance: not specified; resistance training: “60–80% intensity”	2 times per week (12 weeks)
Rydwik 2010	N = 96; frail men and women, mean age 83 years	Mixed or various physical activities	60 minutes	Aerobic endurance: not specified; resistance training: “60–80% intensity”	2 times per week (12 weeks)

Hung and colleagues conducted a randomised controlled trial with 21 older women diagnosed with coronary artery disease, that sought to compare a programme of aerobic endurance training to a combined strength and aerobic endurance training programme (Hung et al 2004). Results showed that both physical activity interventions resulted in similar improvements to lower-body strength.

In a randomised controlled trial, Mador and colleagues compared the effectiveness of an aerobic endurance bicycling programme to a programme of strength training plus aerobic endurance bicycling training by participants who had chronic obstructive pulmonary disease (COPD) (Mador 2004). This trial found that participants in the combined physical activity intervention experienced improvements in muscle strength.

Such improvement in muscle strength did not translate into additive quality of life improvements or improvements in exercise performance beyond that provided by aerobic endurance physical activity alone.

Takeshima and colleagues studied 35 older men and women in Japan to determine the effectiveness of interventions that included circuit physical activity training (Takeshima et al 2004). The findings indicated that combined aerobic endurance and hydraulic resistance training resulted in statistically significant improvements to muscular strength in older people.

Pang and colleagues conducted a randomised controlled trial to determine the impact of a fitness and mobility physical activity programme designed to improve cardio-respiratory fitness, mobility, leg muscle strength, balance, and hip bone mineral density (Pang et al 2005). Compared to control participants, the intervention group had greater gains in paretic leg muscle strength.

Villareal and colleagues conducted a randomised controlled trial that evaluated a lifestyle intervention with resistance training, balance, and aerobic endurance training versus an inactive control condition in 27 obese older men and women from the US (Villareal et al 2006a). Results showed that intervention participants improved in strength, relative to controls.

Goodpaster and colleagues conducted a randomised controlled trial with 42 older men and women with moderate functional limitations to evaluate whether a mixed physical activity intervention could attenuate the loss of strength over time (Goodpaster et al 2008). Results showed that the loss of strength was completely prevented in the mixed physical activity group. Based on this study's findings, it appears that mixed physical activity prevents the age-associated loss of muscle strength in older people with moderate functional limitations.

Rydwik and colleagues conducted a randomised controlled trial with a sample of 96 community-dwelling frail older men and women (Rydwik et al 2008). Participants were randomised to a physical activity intervention including aerobic endurance, muscle strength, and balance training, to a nutrition intervention, to a combined physical activity and nutrition intervention, or to a control group. Results showed that there were statistically significant improvements in lower extremity muscle strength in both physical activity intervention groups compared with the nutrition group at first follow-up. This study shows the positive effect on lower extremity muscle strength directly after the intervention.

Rydwik and colleagues later reported again on their randomised controlled trial with a sample of 96 community-dwelling frail older men and women (Rydwik et al 2010). Participants were randomised to a physical activity intervention including aerobic, muscle strength, and balance training, to a nutrition intervention, to a combined physical activity and nutrition intervention, or to a control group. Results showed that there was a statistically significant increase in lower extremity muscle strength in the physical activity groups, compared with nutrition alone.

Conclusions: enhancement of strength

The following efficacious physical activity interventions were identified in relation to enhancement of strength:

- an aerobic endurance intervention, consisting of three sessions of 30 minutes each at a moderate to vigorous intensity, over eight weeks
- resistance training interventions, typically consisting of two to three sessions per week of multiple sets of resistance exercises done at a wide range of intensities over two to 104 weeks
- mixed or various physical activity interventions, typically consisting of 3 to 5 sessions per week, each lasting 50 to 90 minutes at moderate to vigorous intensity, in programmes lasting eight to 52 weeks
- an efficacious physical activity intervention for the frail old (Rydwik et al 2010; Rydwik et al 2008). This study featured a 12-week physical activity intervention that included aerobic endurance, resistance training and balance, done twice per week for an hour, over 12 weeks. The resistance training was performed at an intensity of 60 to 80%.

Enhancement of quality of life

Effective aerobic endurance interventions

The literature review identified four papers indicating effective aerobic endurance interventions for enhancing quality of life amongst people over the age of 65.

Table 6.66

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Netz 2005	N = 36 studies; men and women, aged 65 years and over	Aerobic endurance	Shorter duration (inconclusive)	Moderate	Not specified
Hung 2004	N = 21; women, aged 60–80 years	Aerobic endurance	Aerobic training: 30 minutes	Aerobic training: 70% to 85% of peak heart rate	3 times per week (8 weeks)
Wisloff 2007	N = 27; men and women with heart failure, mean age 75.5 ± 11.1 years	Aerobic endurance	38 minutes (interval group); 47 minutes (continuous group)	95% of peak heart rate (interval group); 70% of peak heart rate (continuous group)	3 times per week (12 weeks)
McDermott 2009	N = 156; men and women with peripheral arterial disease, aged 60 years and over	Aerobic endurance (treadmill)	15 minutes, gradually increasing to 40 minutes	Not specified	3 times per week (24 weeks)

Netz and colleagues conducted a systematic review and meta-analysis of 36 studies addressing physical activity and wellbeing (Netz et al 2005). Results of the meta-analysis showed that physical activity intervention groups experienced greater levels of wellbeing than that seen in control groups. Among the findings, aerobic training was most effective for wellbeing, and moderate intensity activity was the most effective activity level.

Hung and colleagues conducted a randomised controlled trial with 21 older women diagnosed with coronary artery disease, that sought to compare a programme of aerobic endurance training to a combined strength and aerobic endurance training programme (Hung et al 2004). Results showed that both programmes resulted in similar improvements to emotional and global measures of quality of life.

Wisloff and colleagues conducted a randomised controlled trial of 27 older Norwegian men and women with heart failure to evaluate the effects of aerobic endurance interval training compared to moderate intensity continuous aerobic endurance training (Wisloff et al 2007). In this study, participants who were randomly assigned to aerobic interval training experienced greater improvement in quality of life compared to moderate intensity continuous trainers.

McDermott's randomised controlled trial evaluated the effect of two physical activity intervention programmes amongst 156 US men and women with peripheral arterial disease (McDermott et al 2009). The researchers found that both treadmill exercise and resistance training had positive effects on health, and treadmill exercise improved quality of life for this population.

Effective resistance training interventions

The literature review identified two papers indicating effective resistance training interventions for enhancing quality of life amongst people over the age of 65.

Table 6.67

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Singh 2005	N = 60; men and women with depression, mean age 70 ± 6 years	Resistance training	About 60 minutes (plus 5 minutes of stretching)	80% of 1 repetition maximum	3 times per week (8 weeks)
McDermott 2009	N = 156; men and women with peripheral arterial disease, aged 60 years and over	Resistance training	15 minutes, gradually increasing to 40 minutes	Resistance: 50% of 1 repetition maximum, gradually increasing to 80% of 1 repetition maximum	3 times per week (24 weeks)

In a randomised controlled trial by Singh and colleagues, participants with depression were randomised to a supervised high intensity resistance training group, low intensity resistance training group, or non-physically active usual care (Singh et al 2005). Results showed a marked improvement in depression and quality of life for the high intensity group.

McDermott's randomised controlled trial evaluated the effect of two physical activity programmes amongst 156 US men and women with peripheral arterial disease (McDermott et al 2009). In this study, researchers found that resistance training had positive effects on quality of life.

Effective mixed or various physical activity interventions

The literature review identified 12 papers indicating effective mixed or various physical activity interventions for enhancing quality of life amongst people over the age of 65.

Table 6.68

Study	Population (number, sex and age)	Type of intervention	Duration	Intensity	Frequency
Baker 2007	N = 15 studies; men and women with mild cognitive impairment, aged 55–85 years	Mixed or various physical activities	Not specified	Not specified	Commonly 3 days per week
Luctkar-Flude 2007	N = 19 studies; men and women with cancer, aged 65 years and older	Mixed or various physical activities	Not specified	Not specified	Not specified
Holland 2008	N = 5 studies; men and women interstitial lung disease, aged 52–70 years	Mixed or various physical activities	Not specified	Varying intensities	Range: 2 to 5 times per week (5 to 12 weeks for outpatients, 6 months for home-based)
Davies 2010	N = 19 studies; men and women with heart failure, any age	Mixed or various physical activities	Range: 15 to 120 minutes	Varying intensities	Range: 2 to 7 times per week (24 to 52 weeks)
Windle 2010	N = 13 studies; men and women, aged 65 years and older	Mixed or various physical activities	45 to 60 minutes	Not specified	1 to 3 times per week
Hung 2004	N = 21; women, aged 60–80 years	Mixed or various physical activities	30 minutes aerobic training plus additional strength training	Aerobic 70% to 85% of peak heart rate; strength training at 55% of 1 repetition maximum, increasing by 2.5% every week	3 times per week (8 weeks)
Guell 2006	N = 40; men and women with severe chronic flow limitation, aged 65 ± 8 years	Mixed or various physical activities	30 minutes	Not specified	Week 1 to 8: 2 times per week; week 9 to 16: 5 times per week (16 weeks)
Dubbert 2008	N = 224; men with physical function limitations, aged 60–85 years	Mixed or various physical activities	20 minutes or more	Not specified	3 to 5 times per week
Courtney 2009	N = 128; men and women, aged 78.8 ± 6.9 years	Mixed or various physical activities	Not specified	Not specified	Not specified (24 weeks)
Morey 2009	N = 398; overweight cancer-surviving men and women, aged 65 years and over	Mixed or various physical activities	Not specified	Not specified	Not specified (52 weeks)

In a systematic review by Baker and colleagues, researchers examined 15 randomised controlled trials, with a total sample of 2149 participants generally ranging from 67 to 84 years of age (Baker et al 2007). Although the available evidence was limited, this study found that along with a positive effect on falls prevention, multi-modal physical activity has a small effect on quality of life outcomes.

Luctkar-Flude's systematic review of nine experimental studies and 10 observational studies of physical activity and fatigue in cancer patients found support for the notion of using various types of physical activity during treatment of cancer (Luctkar-Flude et al 2007). According to this review, physical activity offers the strongest available evidence among interventions to combat cancer fatigue and maintain quality of life (Luctkar-Flude et al 2007).

Holland's systematic review of five randomised or quasi-randomised trials relevant to physical activity for interstitial lung disease found short-term improvements in quality of life for people completing physical activity interventions (Holland et al 2008).

Longer-term effects of the interventions were unclear. Although longer programmes and more frequent sessions appear to be more effective in people with other chronic lung diseases, the amount and frequency of physical activity needed to obtain beneficial health outcomes in those with interstitial lung disease is uncertain.

Davies and colleagues analysed physical activity training interventions from 19 randomised controlled trials that included 3647 participants with heart failure (Davies 2010). This review of literature found that various physical activity intervention programmes improved health-related quality of life, both in the short term and for long-term assessments.

Windle and colleagues conducted a systematic review of literature pertaining to physical activity and wellbeing (a key part of quality of life) (Windle et al 2010). The included interventions were designed for older people, targeted those who were sedentary, and were delivered in a community setting, primarily through a group-based approach that was led by trained leaders. Meta-analyses found a small effect from physical activity on wellbeing. This systematic review also showed that there is some indication, from two previous studies that physical activity interventions can improve the wellbeing of frail older people, aged 75 years and up.

Hung and colleagues conducted a randomised controlled trial with 21 older women diagnosed with coronary artery disease, that sought to compare a programme of aerobic endurance training to a combined strength and aerobic endurance training programme (Hung et al 2004). Results showed that both programmes resulted in similar improvements to emotional and global measures of quality of life.

Physical activity has been used as part of pulmonary rehabilitation, and a small randomised controlled trial by Guell and colleagues evaluated its effectiveness in participants with chronic obstructive pulmonary disease (Guell et al 2006). Guell's study found that pulmonary rehabilitation resulted in decreased psychological morbidity and increased health-related quality of life.

Dubbert and colleagues conducted a randomised controlled trial to test the effectiveness of a relatively brief physical activity counselling intervention in a sample of 224 older American male veterans with functional limitations (Dubbert et al 2008). Rather than using a carefully supervised centre-based physical activity efficacy model, this study sought to evaluate the intervention under more real-world conditions in a home-based effectiveness model. Results showed that veterans who were part of the intervention group that was counselled to increase walking and strength training obtained better quality of life scores, as compared to controls.

In a randomised controlled trial in Australia, Courtney and colleagues evaluated an individualised programme of mixed physical activity strategies and nurse-conducted home visits and telephone follow-ups, compared to a no-intervention control group (Courtney et al 2009). This study found that the intervention group reported more improvement in quality of life, relative to controls. Thus, this study showed that a physical activity programme with home visits and telephone follow-up may improve quality of life in older people with health problems.

Morey and colleagues reported on a recent randomised controlled trial that took place in the UK, US, and Canada with survivors of colorectal, breast, or prostate cancer (Morey et al 2009). In this study, participants who took part in a tailored diet and physical activity intervention programme that focused on strength training and aerobic endurance physical activities experienced better improvements in overall quality of life than those in the control group.

Conclusions: enhancement of quality of life

The following efficacious physical activity interventions were identified in relation to enhancement of quality of life:

- aerobic endurance interventions, typically consisting of moderate intensity physical activity done three times per week for 15 to 47 minutes per session, over eight to 24 weeks
- resistance training interventions, typically consisting of three sessions per week of moderate to high intensity resistance exercises, lasting 15 to 60 minutes per session, over eight to 24 weeks
- mixed or various physical activity interventions, typically consisting of 2 to 7 sessions per week of 15 to 120 minutes of mostly moderate to vigorous intensity physical activity per session over eight to 52 weeks
- efficacious physical activity interventions for frail elders (Windle et al 2010). The mixed or various physical activity interventions typically consisted of one to three sessions per week for 45 to 60 minutes per session, at an unspecified intensity.

Overall conclusions

Prevention

Table 6.69

Type of intervention	Number of paper (studies)	Prevented conditions/outcomes	Duration	Intensity	Frequency (length)	Caveats
Aerobic endurance	8 (114 studies total)	Hospitalisation Osteoporosis Disability Hypertension Insulin resistance and type 2 diabetes	Average about 50 minutes; range 15 to 120 minutes	Moderate to vigorous intensity	Average about 3 times per week; range 2 to 7 times per week (10 to 52 weeks)	Three articles were based on female-only samples. Three articles were based on samples with a substantial portion of participants under age 65. Also see evidence from mixed or various physical activity interventions that usually included aerobic endurance training.
Resistance training	2 (84 studies total)	Osteoporosis Physical disability	Average about 40 minutes; range 25 to 60 minutes	Moderate to high intensity	Average about 3 times per week (6 to 52 weeks)	Only two articles were identified that focused on effective prevention physical activity interventions with resistance training alone, but these were systematic reviews of many high-quality studies. The osteoporosis article was based on a female-only sample. The osteoporosis article was based on a sample with a substantial portion of participants under age 65. Also see evidence from mixed or various physical activity interventions that sometimes included resistance training.
Mobility and balance	4 (114 studies total)	Falls	Average about 60 minutes	Typically not specified	Average about 2 times per week; range 1 to 3 times per week (6 to 52 weeks)	One article was based on female-only sample.

Type of intervention	Number of paper (studies)	Prevented conditions/outcomes	Duration	Intensity	Frequency (length)	Caveats
Mixed or various	15 (394 studies total)	Falls Physical disability Osteoporosis Hospitalisation Hypertension Insulin resistance and type 2 diabetes	Average about 50 minutes; range 30 to 90 minutes	Moderate to vigorous (when specified)	Average about 3 times per week; range 1 to 5 times per week (4 to 104 weeks)	One article on osteoporosis was based on a female-only sample. Six articles were based on samples with a substantial portion of participants under age 65.

Management

Table 6.70

Type of intervention	Number of paper (studies)	Prevented conditions/outcomes	Duration	Intensity	Frequency (length)	Caveats
Aerobic endurance	13 (77 studies total)	Vascular disease Heart disease Stroke Cancers Osteoarthritis Neurological disorders Depression Hip injury	Average about 45 minutes; range 15 to 120 minutes	Moderate to vigorous intensity	Average about 3 times per week; range 1 to 7 times per week (4 to 52 weeks)	One article was based on a female-only sample. One article was based on a men-only sample. Four articles were based on samples with a substantial portion of participants under age 65. Also see evidence from mixed or various physical activity interventions that usually included aerobic endurance training.

Type of intervention	Number of paper (studies)	Prevented conditions/outcomes	Duration	Intensity	Frequency (length)	Caveats
Resistance training	11 (23 studies total)	Vascular disease Stroke Osteoarthritis Frailty Obesity and overweight Depression Hip injury Sleep problems	Average about 50 minutes; range 35 to 60 minutes	Low to high intensity	Average about 3 times per week; range 2 to 5 times per week (4 to 52 weeks)	Stroke article was based on a sample with a portion of participants under age 65. Also see evidence from mixed or various physical activity interventions that sometimes included resistance training.
Mobility and balance	5 (27 studies total)	Stroke Osteoarthritis Frailty Sleep problems	Average about 55 minutes; range 8 to 120 minutes	Typically not specified	Average about 3 times per week; range 2 to 5 times per week (10 to 48 weeks)	Frailty article was based on female-only sample. One article on stroke was based on a sample with a portion of participants under age 65.
Mixed or various	37 (268 studies total)	Vascular disease Heart disease Stroke Cancer Osteoarthritis Frailty Obesity and overweight Type 2 diabetes Pulmonary disease Neurological disorders Depression Sleep problems	Average about 50 minutes; range 15 to 120 minutes	Range from low to high intensity	Average about 3 times per week; range 1 to 7 times per week (2 to 357 weeks)	One article was based on a female-only sample. Ten articles were based on samples with a substantial portion of participants under age 65.

Enhancement

Table 6.71

Type of intervention	Number of paper (studies)	Prevented conditions/ outcomes	Duration	Intensity	Frequency (length)	Caveats
Aerobic endurance	23 (372 studies total)	Cognitive function Physical function and mobility Balance Aerobic capacity Strength	Average about 45 minutes; range 15 to 90 minutes	Moderate to vigorous intensity	Average about 3 times per week; range 1 to 5 times per week (4 to 52 weeks)	One article was based on a female-only sample. One article was based on a men-only sample. Five articles were based on samples with a substantial portion of participants under age 65. Also see evidence from mixed or various physical activity interventions that usually included aerobic endurance training.
Resistance training	34 (533 studies total)	Cognitive function Physical function and mobility Activities of daily living Balance Aerobic capacity Strength	Average about 55 minutes when specified; range 40 to 60 minutes when specified	Low to high intensity	Average 2 to 3 times per week; range 1 to 7 times per week (4 to 104 weeks)	Three articles were based on a female-only sample. One article was based on a men-only sample. Also see evidence from mixed or various physical activity interventions that sometimes included resistance training.
Mobility and balance	8 (63 studies total)	Cognitive function Physical function and mobility Balance	Average about 60 minutes; range 8 to 120 minutes	Moderate intensity, when specified	Average about 3 times per week; range 1 to 5 times per week (3 to 52 weeks)	One article was based on female-only sample. One article on stroke was based on a sample with a portion of participants under age 65.
Mixed or various	43 (434 studies total)	Physical function and mobility Activities of daily living Balance Aerobic capacity Strength Quality of life	Average about 50 minutes; range 15 to 120 minutes	Moderate to vigorous or moderate to high intensity	Average about 3 times per week; range 1 to 7 times per week (10 to 121 weeks)	One article was based on a female-only sample. One article was based on a sample with a substantial portion of participants under age 65.

Conclusions: aerobic endurance interventions

The reviewed literature indicates that there are numerous effective aerobic endurance interventions. In the reviewed literature, there were articles describing effective aerobic endurance interventions for the prevention of:

- hospitalisation
- osteoporosis
- disability
- hypertension
- insulin resistance and type 2 diabetes.

The identified effective prevention interventions are characterised by an average of three sessions per week of brisk walking or bicycling for an average of 50 minutes per session, at a moderate to vigorous intensity. Although effective interventions vary widely in characteristics, the average total is about 150 minutes per week of moderate to vigorous intensity aerobic endurance physical activity.

In the reviewed literature, there were also articles describing effective aerobic endurance interventions for the management of:

- vascular disease
- heart disease
- stroke
- cancers
- osteoarthritis
- neurological disorders
- depression
- hip injury.

The identified effective interventions for management are characterised by an average of three sessions per week of brisk walking or bicycling for an average of 45 minutes per session, at a moderate to vigorous intensity. Although effective interventions vary widely in characteristics, the average total is about 135 minutes per week of moderate to vigorous intensity aerobic endurance physical activity.

In the reviewed literature, there were also articles describing effective aerobic endurance interventions for the enhancement of:

- cognitive function
- physical function and mobility
- balance
- aerobic capacity
- strength.

The identified effective interventions for enhancement are characterised by an average of three sessions per week of brisk walking or bicycling for an average of 45 minutes per session, at a moderate to vigorous intensity. Although effective interventions vary widely in characteristics, the average total is about 135 minutes per week of moderate to vigorous intensity aerobic endurance physical activity.

Conclusions: resistance training interventions

The reviewed literature indicates that there are some effective resistance training interventions. In the reviewed literature, there were articles describing effective resistance training interventions for the prevention of:

- osteoporosis
- physical disability.

The identified effective prevention interventions are characterised by an average of three sessions per week of resistance training for an average of 40 minutes per session, at a moderate to high intensity. Although effective interventions are heterogeneous, the average total is about 120 minutes per week of moderate to high intensity resistance training physical activity.

The reviewed literature also indicates that there are numerous effective resistance training interventions for the management of:

- vascular disease
- stroke
- osteoarthritis
- frailty
- obesity and overweight
- depression
- hip injury
- sleep problems.

The identified effective management interventions are characterised by an average of three sessions per week of resistance training for an average of 50 minutes per session, at a low to high intensity. Although effective interventions are heterogeneous, the average total is about 150 minutes per week of low to high intensity resistance training physical activity.

The reviewed literature also indicates that there are numerous effective resistance training interventions for the enhancement of:

- vascular disease
- cognitive function
- physical function and mobility
- activities of daily living
- balance
- aerobic capacity
- strength.

The identified effective enhancement interventions are characterised by an average of three sessions per week of resistance training for an average of 50 minutes per session, at a low to high intensity. Although effective interventions are heterogeneous, the average total is about 150 minutes per week of low to high intensity resistance training physical activity.

Conclusions: mobility and balance interventions

The reviewed literature indicates that there are some effective mobility and balance interventions. In the reviewed literature, there were articles describing effective mobility and balance training interventions for the prevention of falls.

The identified effective prevention interventions are characterised by an average of two sessions per week of tai chi or a similar physical activity programme for an average of 60 minutes per session. Although effective interventions are reported in as little as 60 minutes per week, the average total is about 120 minutes per week of mobility and balance physical activity.

The reviewed literature also indicates that there are numerous effective mobility and balance training interventions for the management of:

- vascular disease
- stroke
- osteoarthritis
- frailty
- sleep problems.

The identified effective management interventions are characterised by an average of three sessions per week of resistance training for an average of 55 minutes per session. Although effective interventions vary widely, the average total is about 165 minutes per week of low to high intensity mobility and balance physical activity.

The reviewed literature also indicates that there are numerous effective mobility and balance training interventions for the enhancement of:

- cognitive function
- physical function and mobility
- balance.

The identified effective enhancement interventions are characterised by an average of three sessions per week of resistance training for an average of 60 minutes per session, at a moderate intensity. Although effective interventions are heterogeneous, the average total is about 180 minutes per week of moderate intensity mobility and balance physical activity.

Conclusions: mixed or various physical activity interventions

The reviewed literature indicates that there are numerous effective mixed or various physical activity interventions. In the reviewed literature, there were articles describing effective mixed or various physical activity interventions for the prevention of:

- falls
- physical disability
- osteoporosis
- hospitalisation
- hypertension
- insulin resistance and type 2 diabetes.

The identified effective prevention interventions are characterised by an average of three sessions per week of physical activity, such as a combination of brisk walking and resistance training with exercise machines for an average of 50 minutes per session at a moderate to vigorous intensity. Although effective interventions are reported in as little as 90 minutes per week, the average total is about 150 minutes per week of mixed or various physical activities.

The reviewed literature also indicates that there are numerous effective mixed or various physical activity interventions for the management of:

- vascular disease
- heart disease
- stroke
- cancer
- osteoarthritis
- frailty
- obesity and overweight
- type 2 diabetes
- pulmonary disease
- neurological disorders
- depression
- sleep problems.

The identified effective prevention interventions are characterised by an average of three sessions per week of physical activity, such as a combination of bicycling and resistance training with body weight exercises for an average of 50 minutes per session at a moderate to vigorous intensity. Although effective interventions are reported in as little as 90 minutes per week, the average total is about 150 minutes per week of mixed or various physical activities.

The reviewed literature also indicates that there are numerous effective mixed or various physical activity interventions for the enhancement of:

- physical function and mobility
- activities of daily living
- balance
- aerobic capacity
- strength
- quality of life.

The identified effective prevention interventions are characterised by an average of three sessions per week of physical activity, such as a combination of treadmill walking and resistance training with free weights for an average of 50 minutes per session at a moderate to vigorous or moderate to high intensity. Although effective interventions are reported in as little as 90 minutes per week, the average total is about 150 minutes per week of mixed or various physical activities.

As presented in this chapter, there is ample evidence that a wide variety of physical activity intervention programmes are effective in preventing disease, injury and other undesirable health conditions. In addition, there is ample evidence that physical activity intervention programmes can assist in the management of many diseases and conditions, and further ample evidence that physical activity can enhance numerous meaningful health-related factors for the older person. Despite that, there are some areas within the reviewed literature that will require further research to bolster the evidence of effectiveness of physical activity interventions.

It is important to note that we limited our review of effective interventions to high-level evidence that included only randomised controlled trials, the gold standard of effectiveness research, as well as systematic literature reviews that typically included numerous randomised controlled trials. Although limiting the reviewed literature to high-level evidence resulted in smaller amounts of evidence for certain health topics or intervention types under review, the reader can be confident that the studies presented here offer quality information at low risk of bias. With further regard to the issue of bias, the reader should not assume that all physical activity interventions are effective. Based on the research question of this chapter, we have presented only the characteristics of physical activity interventions that showed some form of effectiveness for a relevant health outcome. This approach naturally results in selection bias, but this allows the reader to focus on what ‘works’ rather than what has been shown ineffective. Chapter 4 presents evidence that overlaps with this chapter, and provides a more complete picture of outcomes associated with physical activity, a picture less prone to selection bias. The complete picture shows that physical activity is not always beneficial or effective.

As detailed in this chapter, differing types of physical activity interventions appear to lead to differing health outcomes. Physical activity may vary by type, intensity, and duration, as well as frequency. Although physical activity in general will likely have an impact on numerous health outcomes, there is clear evidence presented within the present chapter that different interventions confer differing effects. Older people with a given health condition or health-related outcome goal could likely benefit from an evidence-based physical activity intervention programme tailored to their unique characteristics. The evidence presented within this chapter may assist with the creation or selection of such a programme. There are numerous examples of physical activity interventions that have been evaluated with frail older people. Carefully planned physical activity programmes have frequently been shown to be effective for the management of the condition of frailty itself, and also for various health-related outcomes in frail older people.

Despite tremendous variation in health conditions under study, and heterogeneity in the types, amounts, and intensity of physical activity interventions employed in research studies, the evidence seems to find a common centre point with regard to the overall average 'dose' of physical activity required to be effective. Most physical activity intervention evidence suggests that physical activity interventions can be effective when based around three sessions of 40 to 60 minutes of moderate to vigorous intensity physical activity per week, or a total of 120 to 180 minutes per week. Thus, the centre point appears to be around 150 minutes of moderate to vigorous intensity physical activity per week.

Given that there are ample types of effective physical activity interventions, what are the factors related to older people's participation in physical activity? The literature on this question is looked at in chapter 7.

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7 What are the enablers and barriers to physical activity participation in older people?

Background

In 2003, SPARC and the New Zealand Cancer Society surveyed more than 8000 New Zealand adults on motivators and barriers to physical activity and other health-related issues (Sullivan et al 2003). The results of this study revealed the following key barriers to physical activity: lack of time and/or energy, lack of encouragement or support from others, and health problems. The study also revealed key motivators, facilitators, or enablers (hereafter termed 'enablers') for physical activity: awareness and belief that physical activity is good for health, desire to keep in shape, encouragement from others, and wanting to model physically active behaviours.

This chapter reviews the New Zealand-specific and international evidence since 2004 for enablers and barriers to participation in physical activity for older people.

Definitions

In the literature, barriers to physical activity are factors that prevent or hinder participation in physical activity, or require modification of physical activity (Belza et al 2004; Rasinaho et al 2007).

Enablers of physical activity for older people are factors that enhance, support, facilitate, or motivate participation in physical activity (Belza et al 2004; Rasinaho et al 2007).

Barriers and enablers to participation in physical activity can be broadly classified into personal barriers, social barriers, and environmental barriers (Kolt et al 2006; Wilcox et al 2005). The reviewed papers did not necessarily use this three-level classification system, and the authors have applied it to the reviewed papers for the purposes of this literature review.

While this chapter reports only on what each individual paper described as barriers and enablers, it should be noted that barriers and enablers often have an inverse relationship; the absence of an enabler could be considered a barrier and vice versa (Wilcox et al 2005).

Although barriers and enablers could be either ascertained subjectively ('perceived' barriers and enablers) or more objectively ('real' barriers and enablers; eg, Berke et al 2007), our present review focuses primarily on the perceived barriers and enablers of physical activity in older people. Such perceived barriers and enablers may be modifiable or manageable via creative physical activity promotion efforts within communities.

Body of evidence

Twenty-two peer-reviewed journal articles or abstracts were identified that met the inclusion criteria for enablers or barriers to physical activity in international samples of older people, and were appraised or reviewed. This evidence was supplemented by two published reports (Bowers et al 2009; Pringle 2008). Amongst the peer-reviewed literature, there were 10 quantitative studies (Berke et al 2007; Crombie et al 2004; Forkan et al 2006; Grant et al 2007; Morris et al 2008; Rasinaho et al 2007; Shores et al 2009; Talkowski et al 2008; Zizzi et al 2006) primarily consisting of cross-sectional surveys; nine qualitative studies, primarily from focus group interviews (Belza et al 2004; Buman et al 2010; Chen 2010; Grossman et al 2003; Kalavar et al 2005; Lawton et al 2006; Mathews et al 2010; Wilcox et al 2005) and four narrative review articles (Brawley et al 2003; Lee et al 2008; Schutzer et al 2004; Stumbo et al 2007). The NHMRC level of evidence was either level IV or uncategorised for all studies, ie, primarily observational studies or qualitative work (refer to methods for further details).

Seven studies were identified that met the inclusion criteria for enablers or barriers to physical activity in New Zealand populations, including Māori, Pacific, and Asian older people, and were appraised or reviewed (Bowers et al 2009; Grant et al 2007; Hutton et al 2009; Kolt et al 2004; Kolt et al 2006; Kolt et al 2007; Pringle 2008). Five studies presented qualitative data, using focus group interviews to obtain information about physical activity barriers and enablers (Bowers et al 2009; Hutton et al 2009; Kolt et al 2004; Kolt et al 2006; Pringle 2008). Two studies presented cross-sectional data from questionnaires and other methods (Grant et al 2007; Kolt et al 2007). The NHMRC level of evidence was either level IV or uncategorised for all studies (refer to methods for further details).

Summary of findings

Barriers summary

The international and New Zealand literature supports and expands on the findings of the SPARC and New Zealand Cancer Society survey.

The most frequently cited barriers in the literature are problems in health (Belza et al 2004; Chen 2010; Crombie et al 2004; Forkan et al 2006; Grant et al 2007; Grossman et al 2003; Hutton et al 2009; Kalavar et al 2005; Kolt et al 2004; Kolt et al 2006; Lawton et al 2006; Lee et al 2008; Mathews et al 2010; Pringle 2008; Rasinaho et al 2007; Schutzer et al 2004; Stumbo et al 2007), functional ability (Brawley et al 2003; Chen 2010; Forkan et al 2006; Lee et al 2008; Morris et al 2008; Pringle 2008), and fears about falling or injury (Belza et al 2004; Chen 2010; Forkan et al 2006; Kalavar et al 2005; Lee et al 2008; Mathews et al 2010; Stumbo et al 2007).

Commonly cited (those reported in at least three studies) personal barriers include psychological concerns such as low self efficacy (Lee et al 2008; Morris et al 2008; Pringle 2008; Stumbo et al 2007; Wilcox et al 2005; Zizzi et al 2006), lack of time (Buman et al 2010; Grant et al 2007; Grossman et al 2003; Hutton et al 2009; Lawton et al 2006; Lee et al 2008; Mathews et al 2010; Pringle 2008; Stumbo et al 2007; Zizzi et al 2006), financial constraints (Buman et al 2010; Grant et al 2007; Mathews et al 2010; Stumbo et al 2007), and lifestyles

in conflict with or not conducive to physical activity (Buman et al 2010; Chen 2010; Kalavar et al 2005; Lee et al 2008; Stumbo et al 2007).

Commonly cited social barriers include family or work obligations (Belza et al 2004; Grant et al 2007; Stumbo et al 2007; Wilcox et al 2005), cultural or social norms (Bowers et al 2009; Brawley et al 2003; Kolt et al 2004; Kolt et al 2006; Lawton et al 2006; Stumbo et al 2007) and lack of support to be active (Grant et al 2007; Kolt et al 2004; Stumbo et al 2007; Wilcox et al 2005). Social barriers are an area of particular consequence for Māori, Pacific, or Asian older people in New Zealand where the literature indicates the influence of cultural barriers to physical activity. These include cultural norms and expectations or familial constraints that conflict with physical activity, such as not wanting to be seen by other people when physically active, or needing to attend to the domestic needs of other family members (Bowers et al 2009; Kolt et al 2004; Kolt et al 2006).

Commonly cited environmental barriers include inclement weather (Belza et al 2004; Forkan et al 2006; Kolt et al 2004; Kolt et al 2006; Mathews et al 2010; Pringle, 2008; Stumbo et al 2007), lack of public transportation and lack of close and convenient facilities for physical activity (Belza et al 2004; Grant et al 2007; Mathews et al 2010; Wilcox et al 2005).

Given these barriers, any guidance to primary care and public health practitioners should ensure that they have a broad understanding of the barriers that are most likely to impact on older people taking up physical activity. They should also be provided with guidance on the specific questions that should be asked of individuals, so that they can understand the extent to which the barriers are real or perceived, and whether or not they will be able to develop creative solutions to overcome the barriers. Finally, they should be given specific advice about how best to work with their local ethnic communities to develop solutions that can overcome the cultural barriers.

Barriers identified internationally

Table 7.1 summarises the barriers to physical activity identified in the international literature.

Table 7.1: Barriers to physical activity at the personal, social, and environmental levels, identified in the international literature

Level	Barriers to physical activity (in order of frequency of citation within studies)
Personal level	Most frequently cited barriers (five or more studies): • health problems/concerns (Belza et al 2004; Chen 2010; Crombie et al 2004; Forkan et al 2006; Grossman et al 2003; Kalavar et al 2005; Lawton et al 2006; Lee et al 2008; Mathews et al 2010; Rasinaho et al 2007; Schutzer et al 2004; Stumbo et al 2007) • time management/lack of time (Buman et al 2010; Grossman et al 2003; Lawton et al 2006; Lee et al 2008; Mathews et al 2010; Stumbo et al 2007; Zizzi et al 2006) • fear of falling/injury (Belza et al 2004; Chen 2010; Forkan et al 2006; Kalavar et al 2005; Lee et al 2008; Mathews et al 2010; Stumbo et al 2007) • lack of motivation/interest (Crombie et al 2004; Forkan et al 2006; Lee et al 2008; Stumbo et al 2007; Wilcox et al 2005) • functional limitations/frailty (Brawley et al 2003; Chen 2010; Forkan et al 2006; Lee et al 2008; Morris et al 2008) • low confidence/self-efficacy (Lee et al 2008; Morris et al 2008; Stumbo et al 2007; Wilcox et al 2005; Zizzi et al 2006). Less frequently cited barriers (fewer than five studies): • old age/ageing (Grossman et al 2003; Mathews et al 2010; Stumbo et al 2007; Wilcox et al 2005) • lack of knowledge/education (Chen 2010; Mathews et al 2010; Schutzer et al 2004; Stumbo et al 2007) • personal safety concerns (Belza et al 2004; Crombie et al 2004; Rasinaho et al 2007; Zizzi et al 2006) • doubt about benefits/outcome expectations (Crombie et al 2004; Forkan et al 2006; Lee et al 2008) • lack of fitness/energy (Crombie et al 2004; Stumbo et al 2007; Wilcox et al 2005) • past sedentary lifestyle (Chen 2010; Lee et al 2008; Stumbo et al 2007) • financial cost (Buman et al 2010; Mathews et al 2010; Stumbo et al 2007) • depression (Forkan et al 2006; Stumbo et al 2007) • history of traumatic experiences with physical activity (Buman et al 2010) • change in lifestyle (Kalavar et al 2005) • misconceptions about ageing process (Lee et al 2008) • lack of personal transportation (Crombie et al 2004) • self consciousness/embarrassment (Mathews et al 2010) • weight problems (Buman et al 2010).

Level	Barriers to physical activity (in order of frequency of citation within studies)
Social level	Cited barriers (all are cited in three or fewer studies): • family/work obligations (Belza et al 2004; Stumbo et al 2007; Wilcox et al 2005) • cultural/social norms/expectations (Brawley et al 2003; Lawton et al 2006; Stumbo et al 2007) • isolation/far from friends (Belza et al 2004; Stumbo et al 2007) • lack of group or partners (Crombie et al 2004; Rasinaho et al 2007) • lack of support/encouragement (Stumbo et al 2007; Wilcox et al 2005) • caregiving roles (Brawley et al 2003) • lack of role models (Wilcox et al 2005) .
Environmental level	Most frequently cited barriers (five or more studies): • lack of close facilities/environment not conducive to PA (Grossman et al 2003; Mathews et al 2010; Morris et al 2008; Rasinaho et al 2007; Schutzer et al 2004; Stumbo et al 2007; Wilcox et al 2005). Less frequently cited barriers (fewer than five studies): • poor weather (Belza et al 2004; Forkan et al 2006; Mathews et al 2010; Stumbo et al 2007) • lack of public transportation (Belza et al 2004; Mathews et al 2010; Wilcox et al 2005) • lack of sidewalks/footpaths (Schutzer et al 2004; Wilcox et al 2005) • crime/hazards (Schutzer et al 2004; Wilcox et al 2005).

Barriers specific to New Zealand

Table 7.2 summarises the barriers to physical activity identified in the New Zealand literature.

Cultural, societal, and familial constraints were identified as barriers to participation in physical activity in four studies (Bowers et al 2009; Grant et al 2007; Kolt et al 2004; Kolt et al 2006). Cultural barriers include such factors such as inhibitions among older people about being seen doing physical activity. Familial constraints include older peoples' role in looking after domestic needs of younger family members. One study reported that a lack of encouragement among females for physical activity earlier in life hindered current levels of physical activity (Kolt et al 2004).

Table 7.2: Barriers to physical activity at the personal, social, and environmental levels, identified in New Zealand-specific literature

Level	Barriers to physical activity
Personal level	Most frequently cited barriers (four or more studies): • health problems/concerns (Grant et al 2007; Hutton et al 2009; Kolt et al 2004; Kolt et al 2006; Kolt et al 2007; Pringle 2008). Less frequently cited barriers (one to three studies): • self consciousness/embarrassment (Hutton et al 2009; Pringle 2008) • lack of motivation/interest (Kolt et al 2004; Pringle 2008) • lack of knowledge/education (Kolt et al 2006) • time management/lack of time (Grant et al 2007; Hutton et al 2009; Pringle 2008) • old age/ageing (Grant et al 2007; Hutton et al 2009) • lack of energy, too tired (Grant et al 2007) • hard to stick to a routine (Grant et al 2007) • physical activity is uncomfortable (Grant et al 2007) • lack of confidence/self efficacy (Pringle 2008) • lack of enjoyment (Pringle 2008) • pain associated with exercise (Pringle 2008).
Social level	Cited barriers (all are cited one to three studies): • lack of support/encouragement (Grant et al 2007; Kolt et al 2004; Kolt et al 2006) • cultural/social norms/expectations (Bowers et al 2009; Kolt et al 2004; Kolt et al 2006) • programmes not responsive to ethnic realities (Bowers et al 2009) • caregiving roles (Grant et al 2007; Kolt et al 2004) • lack of group or partners (Grant et al 2007).
Environmental level	Cited barriers (all are cited in one or two studies): • poor weather (Kolt et al 2004; Pringle 2008) • lack of close facilities/environment not conducive to physical activity (Grant et al 2007; Kolt et al 2004) • competitive exercise environments (Hutton et al 2009) • lack of footpaths, cycle lanes/paths, street lighting (Grant et al 2007) • poor scenery (Grant et al 2007).

Enablers summary

The international and New Zealand literature supports and expands on the findings of the SPARC and New Zealand Cancer Society survey.

The most frequently cited enablers in the literature are positive experiences/outcome expectations (Belza et al 2004; Buman et al 2010; Kalavar et al 2005; Mathews et al 2010; Pringle 2008; Rasinaho et al 2007; Wilcox et al 2005), promotion of health/feeling healthy (Grant et al 2007; Grossman et al 2003; Kalavar et al 2005; Mathews et al 2010; Pringle 2008; Rasinaho et al 2007; Schutzer et al 2004; Wilcox et al 2005), social support for physical activity (Belza et al 2004; Grant et al 2007; Kalavar et al 2005; Mathews et al 2010;

Schutzer et al 2004; Shores et al 2009; Wilcox et al 2005), and easy access to parks/facilities and low-cost or no-cost programmes (Belza et al 2004; Mathews et al 2010; Schutzer et al 2004; Shores et al 2009; Wilcox et al 2005).

Commonly cited (in three or more papers) personal enablers include the enjoyment of being active, having positive experiences with physical activity, or expecting to obtain benefits (including positive health outcomes from physical activity) (Belza et al 2004; Buman et al 2010; Grant et al 2007; Grossman et al 2003; Kalavar et al 2005; Mathews et al 2010; Pringle 2008; Rasinaho et al 2007; Schutzer et al 2004; Wilcox et al 2005). Older people who have knowledge about benefits of physical activity, know how to be physically active (Mathews et al 2010; Schutzer et al 2004; Wilcox et al 2005) and are confident they can be active (Morris et al 2008; Pringle 2008; Schutzer et al 2004) also have higher levels of physical activity.

Commonly cited social enablers include having support and encouragement for physical activity (Belza et al 2004; Grant et al 2007; Kalavar et al 2005; Mathews et al 2010; Schutzer et al 2004; Shores et al 2009; Wilcox et al 2005), and getting a recommendation from a health professional (Grant et al 2007; Hutton et al 2009; Kolt et al 2004; Kolt et al 2006; Schutzer et al 2004; Wilcox et al 2005). This enabler was supported in the New Zealand context by two studies that emphasised the importance of leadership from community leaders (Bowers et al 2009; Kolt et al 2006).

Environmental enablers (identified as being applicable in New Zealand by one study) include having ready access to community-based programmes and public transportation (Belza et al 2004; Hutton et al 2009; Mathews et al 2010; Schutzer et al 2004; Shores et al 2009; Wilcox et al 2005), along with utilising local facilities for physical activity (Belza et al 2004; Hutton et al 2009).

Given these enablers, any guidance to primary care practitioners should ensure that they have a broad understanding of the enablers that will encourage uptake of physical activity in older people. They should also be provided with guidance on the specific questions that should be asked of individuals, so that they can understand the relative importance of the enablers, and so that they can tailor creative solutions to take advantage of the enablers. This includes working with other community organisations so that older people feel supported in accessing and using appropriate facilities and programmes.

Enablers identified internationally

Table 7.3 summarises the enablers to physical activity identified in the international literature.

Table 7.3: Enablers to physical activity at the personal, social, and environmental levels, identified in the international literature

Level	Enablers for physical activity
Personal level	Most frequently cited enablers (five or more studies): • positive experiences/outcome expectations (Belza et al 2004; Buman et al 2010; Kalavar et al 2005; Mathews et al 2010; Rasinaho et al 2007; Wilcox et al 2005) • promotion of health/feeling healthy (Grossman et al 2003; Kalavar et al 2005; Mathews et al 2010; Rasinaho et al 2007; Schutzer et al 2004; Wilcox et al 2005). Less frequently cited enablers (fewer than five studies): • enjoyment of physical activity (Buman et al 2010; Schutzer et al 2004; Wilcox et al 2005) • knowledge of benefits/how to be active (Mathews et al 2010; Schutzer et al 2004; Wilcox et al 2005) • management of disease/condition (Belza et al 2004; Kalavar et al 2005; Rasinaho et al 2007) • perception of safety (Schutzer et al 2004; Shores et al 2009) • high self efficacy (Morris et al 2008; Schutzer et al 2004) • ability to do multiple short increments of physical activity (Belza et al 2004) • being able to tailor activities to weather (Belza et al 2004) • having a daily physical activity routine (Belza et al 2004) • having medically assistive devices (Mathews et al 2010) • having more time (Schutzer et al 2004) • perception of having good balance (Talkowski et al 2008) • perception of having good health (Talkowski et al 2008) • perception of access to transportation (Shores et al 2009).
Social level	Most frequently cited enablers (five or more studies): • social support for physical activity (Belza et al 2004; Kalavar et al 2005; Mathews et al 2010; Schutzer et al 2004; Shores et al 2009; Wilcox et al 2005). Less frequently cited enablers (fewer than five studies): • guidance/encouragement from health professional (Schutzer et al 2004; Wilcox et al 2005) • institutional encouragement (Wilcox et al 2005) • seeing others being active (Mathews et al 2010) • culture-specific physical activities (Belza et al 2004) • educating families about importance of physical activity (Belza et al 2004) • involving older people in programme development (Belza et al 2004).

Level	Enablers for physical activity
Environmental level	Most frequently cited enablers (five or more studies): • easy access to parks/facilities and low-cost or no-cost programmes (Belza et al 2004; Mathews et al 2010; Schutzer et al 2004; Shores et al 2009; Wilcox et al 2005). Less frequently cited enablers (fewer than five studies): • good street connectivity/walkability (Berke et al 2007; Morris et al 2008) • access to community-based programmes using local facilities (Belza et al 2004) • access to age-appropriate programmes (Wilcox et al 2005) • access to public transportation (Wilcox et al 2005) • programmes using complementary music (Schutzer et al 2004).

Enablers specific to New Zealand

Table 7.4 summarises the enablers to physical activity identified in the New Zealand-specific literature.

Two studies reported on personal enablers, wherein study participants identified enjoyment and perceived benefits in psychological, cognitive, and health outcomes as factors that enhanced their participation in physical activity (Grant et al 2007; Kolt et al 2006; Pringle 2008). Enjoying physical activity, feeling joyful or happy, being able to breathe well, and having a sense of self control are examples of these personal enablers.

Older people in New Zealand have identified the social influence of church leaders, and medical and health practitioners as being important for encouraging physical activity participation (Hutton et al 2009; Kolt et al 2004; Kolt et al 2006).

Bowers and colleagues (Bowers et al 2009) focused on cultural factors as enablers within physical activity programmes. To be in a better position to help Māori older people, it is important that programmes: 1) are based on the principles of the Treaty of Waitangi; 2) are culturally appropriate; 3) include facilitators trained on marae; 4) have elements based on an understanding of tikanga or other Māori philosophies.

Environmental enablers identified in the New Zealand specific literature pertained to issues of access. Access to public transportation (Hutton et al 2009), community-based programmes that use local facilities (Hutton et al 2009), as well as easy access to parks or facilities and low-cost programmes (Hutton et al 2009) were identified as enablers of physical activity.

Table 7.4: Enablers to physical activity at the personal, social, and environmental levels, identified in the New Zealand literature

Level	Enablers for physical activity
Personal level	Cited enablers (all are cited in three or fewer studies): • positive experiences/outcome expectations (Grant et al 2007; Kolt et al 2006; Pringle 2008) • enjoyment of physical activity (Grant et al 2007; Pringle 2008) • promotion of health/feeling healthy (Grant et al 2007; Pringle 2008) • high self efficacy (Pringle 2008).
Social level	Cited enablers (all are cited in three or fewer studies): • guidance/encouragement from health professional (Grant et al 2007; Hutton et al 2009; Kolt et al 2006) • institutional encouragement (Kolt et al 2006) • social support for physical activity (Grant et al 2007) • want to be a good role model (Grant et al 2007) • culturally appropriate programmes, including a 'by Māori – for Māori' or Pacific for Pacific delivery approach (Bowers et al 2009) • physical activity programmes, policies, or interventions informed by the principles of the Treaty of Waitangi; be based on understanding of tikanga and traditional Māori philosophies; and include facilitators trained on marae (Bowers et al 2009).
Environmental level	Cited enablers (all are cited in one study): • access to community-based programmes using local facilities (Hutton et al 2009) • easy access to parks/facilities and low-cost or no-cost programmes (Hutton et al 2009) • access to public transportation (Hutton et al 2009).

Detailed findings

Refer to appendix 3 for details of each of the studies outlined in this chapter. Many of the included studies examined physical activity barriers and enablers simultaneously, so the tabular presentation of these studies in the appendix includes both barriers and enablers. For better clarity, we separately consider barriers and enablers in the text of this chapter.

Barriers: New Zealand specific literature

Although few studies were found for this topic, those identified offer insight on the barriers to physical activity, that are relevant to older people. Although some barriers are possibly unique to Māori, Pacific, or Asian older people, many are the same as those found in other populations.

Personal barriers

Six studies identified personal concerns as a barrier to increased physical activity (Grant et al 2007; Hutton et al 2009; Kolt et al 2004; Kolt et al 2006; Kolt et al 2007; Pringle 2008).

Kolt examined a population of older Asian immigrants who participated in a study of objective physical activity patterns using pedometers (Kolt et al 2007). About a third of participants were considered low active, and nearly half were considered sedentary, and nearly 75% of the participants reported one or more diagnosed chronic health conditions, with the most prevalent being diabetes, arthritis, and heart disease.

In a study of 70 older inactive Tongan, Samoan, Asian Indian, and Pakeha men and women in New Zealand, Kolt and colleagues (Kolt et al 2004) used focus group interviews to investigate barriers to physical activity. This study revealed that lack of motivation or interest and perceived health or physical function limitations and concerns served as personal barriers to physical activity.

In a similar study of inactive older Tongan adults in New Zealand, Kolt and colleagues (Kolt et al 2006) investigated barriers to physical activity through focus group interviews. This study showed that lack of education, lack of motivation, poor physical function, and deteriorating health were barriers at the personal level.

Hutton and colleagues (Hutton et al 2009) conducted a qualitative study to determine barriers and enablers of physical activity in 18 older women and two men from European ancestry. This study's older adults from New Zealand ranged in age from 68 to 81 years. From the interviews, reported barriers to physical activity included health concerns and ageing, a lack of time and being busy, being self conscious, or embarrassment about participation in certain types of physical activity.

Pringle (2008) conducted a qualitative study of Māori, Pacific, and European New Zealanders to investigate the effect of receiving a Green Prescription for physical activity during visits with a general practice physician. This study of 42 people included 12 older people. Among the older participants, the following barriers were described: illness, physical decline, pain upon exercise, no intentions, lack of caring, lack of time, lack of confidence, embarrassment, and poor weather.

Grant and colleagues (Grant et al 2007) reported data from the Obstacles to Action survey with 1285 older men and women and women in New Zealand (805 in the 65–74 age group and 480 in the 75 and up age group). In this study, health problems and lack of energy or being two tired were the most frequently identified personal barriers in both age groups. Feeling too old, finding it hard to stick to a routine, lack of time, and finding physical activity to be expensive or uncomfortable were also reported frequently as personal barriers for both age groups.

Social barriers

Four of the studies identified social barriers to increased physical activity (Bowers et al 2009; Grant et al 2007; Kolt et al 2004; Kolt et al 2006).

Kolt and colleagues (Kolt et al 2004) reported that Asian Indians, Tongans, and Samoans were more likely than Pakeha (New Zealand European) to report that cultural, societal, and familial constraints were barriers to them participating in physical activity. Examples of cultural barriers included older people not wanting others to see them exercise. Examples of familial constraints included older people's role in looking after domestic needs of younger

family members. Of special concern for older women was the cultural barrier that women from all groups indicated that a lack of encouragement for physical activity earlier in life still influenced their current levels of physical activity.

Kolt and colleagues (Kolt et al 2006) reported that both the family environment and cultural expectations both had an impact on participation in physical activity. Needing to care for grandchildren and attend to household activities at times when the children's parents were at work was viewed as a major barrier to physical activity. On the other hand, being looked after and worried about by their adult children posed a barrier to physical activity, due to fears about injury.

Grant and colleagues (Grant et al 2007) found that some older New Zealanders identified family responsibilities and getting too little encouragement. Also, many indicated that not having someone to be active with was a social barrier to physical activity.

Bowers and colleagues (Bowers et al 2009) conducted interviews with four key informants (three Māori, one Pacific) health practitioners to investigate social barriers to participation in physical activity programmes. Informants noted that many programmes were not responsive to the diverse realities of Māori people, or to the cultural shyness of Pacific people. A lack of culturally appropriate physical activity programmes was seen as a barrier to participation.

Environmental barriers

Four studies identified environmental barriers to increased physical activity (Grant et al 2007; Hutton et al 2009; Kolt et al 2004; Kolt et al 2006).

Kolt and colleagues(Kolt et al 2004) reported that environmental barriers to physical activity included inclement weather and inadequate or inconvenient facilities.

Kolt and colleagues (Kolt et al 2006) reported the physical environment presented potential barriers for physical activity in these people.

Hutton and colleagues (Hutton et al 2009) reported that physical activity programmes with a competitive focus was a barrier.

Grant and colleagues (Grant et al 2007) found that lack of footpaths, cycle lanes or paths, and street lighting were environmental barriers to physical activity. Also, poorly maintained footpaths, heavy traffic, and lack of good scenery presented environmental barriers to physical activity in older people.

Enablers: New Zealand specific literature

The same studies that looked at barriers also examined enablers. As with the barriers, many of the enablers are similar to those that exist in other populations.

Personal enablers

Three studies described personal enablers to participation in physical activity.

Kolt and colleagues (Kolt et al 2006) found that having positive experiences and positive outcome expectations about physical activity motivated older people to be more physically active.

In their survey of older people, Grant and colleagues (Grant et al 2007) reported that a majority of participants believed physical activity to be important for a healthy life and a good thing for health, and most believed not being physically active put their health at risk. Most of these participants also reported enjoying physical activity, and caring about keeping in shape.

Pringle (2008) used a qualitative study design to investigate the effect of receiving a Green Prescription for physical activity among Māori, Pacific, and European New Zealanders. This study of 42 people included 12 older people. Among the older participants, the following enablers were described: gaining intrinsic pleasure from physical activity, being motivated by a concern for health, being motivated by potential benefits from physical activity, and having high self efficacy.

Social enablers

Four of the studies identified social enablers (Bowers et al 2009; Grant et al 2007; Kolt et al 2006, Hutton 2009).

Kolt and colleagues (Kolt et al 2006) reported that the focus group participants identified that they believed that there were social, psychological, cognitive and health benefits to be gained from undertaking physical activity. With regard to enablers, it was suggested that governmental efforts, medical and health professionals and leaders from the church could be influential to encourage physical activity participation in older Tongan people.

Hutton (Hutton et al 2009) reported that guidance from a health professional was a vital enabler for physical activity.

Grant and colleagues (Grant et al 2007) found that most older people wanted to be a good role model for their children. A minority of the older people in this study also reported that a health professional had advised them to be more active and believed others would be upset with them if they were not physically active.

Bowers and colleagues (Bowers et al 2009) interviewed key informants (three Māori, one Pacific) to investigate social enablers to participation in physical activity programmes. Bowers and colleagues found that to be in a better position to help Māori older people, it is important that programmes: 1) are based on the principles of the Treaty of Waitangi; 2) are culturally appropriate, which could include being by Māori for Māori (or in the case of Pacific peoples, by the appropriate Pacific ethnic group for that group (eg, Tongan for Tongan); 3) include facilitators trained on marae; 4) have elements based on an understanding of tikanga or other Māori philosophies.

Environmental enablers

One study identified environmental enablers.

Hutton (Hutton et al 2009) reported that older adults stated that accessible public transportation, community based programmes and local facilities for physical activity served as enablers to being active.

Barriers: international literature

Personal barriers

Eighteen articles identified personal barriers (Belza et al 2004; Brawley et al 2003; Buman et al 2010; Chen 2010; Crombie et al 2004; Forkan et al 2006; Grossman et al 2003; Kalavar et al 2005; Lawton et al 2006; Lee et al 2008; Mathews et al 2010; Morris et al 2008; Rasinaho et al 2007; Schutzer et al 2004; Stumbo et al 2007; Talkowski et al 2008; Wilcox et al 2005; Zizzi et al 2006).

Lee's narrative review focused on psychological barriers to physical activity in older people (Lee et al 2008). This review discussed how health status, disability, and physical functioning were related to levels of physical activity, as older people with lower levels of physical functioning and health or higher levels of disability were less likely to be physically active. Also, certain attitudes and misconceptions about ageing and physical activity were likely to result in lower likelihood of being active. In particular, those who were unaware of the benefits of physical activity, those who believed physical activity had to be very vigorous to be beneficial, those who believed physical decline was inevitable and irreversible, and those who believed that exercise was irrelevant to their lifestyles were all less likely to be active. Other barriers to physical activity that were reported in this review included having low self efficacy to be active, having a fear of falling, and having difficulty with time management or scheduling.

Schutzer's narrative review (Schutzer et al 2004) also indicated that a lack of knowledge that moderate exercise could be beneficial was a relevant barrier for older people. Other personal barriers discussed in this article included poor health, pain, injury and illness.

Brawley's narrative review (Brawley et al 2003) indicated that disability and intermittent illness can present problems for older people with regard to physical activity.

Stumbo and colleagues (Stumbo et al 2007) identified deteriorating health, lack of knowledge about benefits of physical activity, lack of perceived control as personal barriers in their narrative review. Furthermore, older people with a lack of energy or time or motivation, and a presence of depression or fear of injury were less likely to be physically active.

Forkan (2006) presented the findings from two cross-sectional studies. In a sample of 409 older people living independently in Scotland, researchers found that personal barriers included lack of interest, lack of fitness, lack of energy, shortness of breath, joint pain and having doubts about the physical and social benefits of physical activity. Among these, the lack of interest in physical activity was the most powerful barrier. In another study of 556 men and women with impaired balance who were recently discharged from physical therapy,

similar findings emerged with regard to lack of interest, low outcomes expectations, and shortness of breath as barriers to physical activity (Forkan et al 2006). Additionally, this study found that change in health status, poor health, depression, weakness, and fear of falling presented barriers to being active, and that barriers were stronger predictors of exercise than were motivators.

A cross-sectional study by Morris and colleagues (Morris et al 2008) assessed the barriers to physical activity in 136 older women from the United States. In this study, low self-efficacy and functional limitation were personal barriers to physical activity.

Zizzi's cross-sectional study of rural American men and women (n = 1,239) found that most participants did not engage in sufficient levels of physical activity, and that all of the barriers were at the personal level: lack of time, lack of self efficacy, and concerns about safety or injury were prominent barriers to being active (Zizzi et al 2006).

A cross-sectional American study of 2269 community-dwelling men and women from the Cardiovascular Health Study examined influences on walking activity in older people (Talkowski et al 2008). This study revealed that after controlling for potential confounding factors, participants who walked at a normal speed and perceived both their health and their balance to be good walked more blocks per week than those who reported slow gait or poorer health or balance. Also, these influences on walking were more important than fall history or balance performance.

A cross-sectional study of 645 community dwelling men and women in Finland by Rasinaho and colleagues (Rasinaho et al 2007) found that participants with poor mobility indicated that poor health and fear of negative experiences were barriers to physical activity.

Belza and colleagues found in a diverse group of 71 older people participating in focus-group discussions on physical activity and exercise, that health could serve as a barrier to physical activity (Belza et al 2004). Older people cited that deteriorating health could interfere with efforts to become more physically active. Concern about personal safety was also a barrier.

Lawton and colleagues (Lawton et al 2006) examined the barriers to physical activity in a group of people living in Scotland with type 2 diabetes who were originally from Pakistani and Indian origin. From the qualitative interviews, researchers found that barriers to physical activity were a lack of time for exercise, their health concerns, and their understanding and perception of diabetes, which could help or hinder the likelihood of being physically active.

Buman and colleagues, in a smaller collection of insufficiently active older adults from the United States, found that early life experiences and beliefs had a lasting influence on the physical activity behaviours of older people (Buman et al 2010). Participants in this study indicated having a history of bad experiences with physical activity, exercise, or sport posed a barrier for these participants, along with fear of injury, financial cost, weight gain, and time management issues.

Grossman used qualitative interviews to provide information from a group of 33 previously inactive older adults on physical activity perceptions, motivations, and barriers (Grossman et al 2003). These participants indicated poor health, lack of time and ageing as personal barriers to physical activity.

Matthews and colleagues (Mathews et al 2010) investigated perceptions of barriers in a diverse group of older adults. The participants identified physical health problems, fear of falling, lack of know-how, perceiving oneself as too old, lack of time, lack of money, negative effects of overdoing physical activity as personal barriers.

Wilcox and colleagues used focus groups to identify relevant barriers to exercise with a sample of African American and Caucasian older women living in the US (Wilcox et al 2005). Personal barriers included low energy, lack of self-efficacy, lack of enjoyment or motivation, having a health issue, reservations about overdoing it or being too old.

Chen's qualitative study of perceived barriers to physical activity with a group of older nursing home residents in Taiwan found personal barriers included physical health and limitation issues, fear of falling and injury, past sedentary lifestyle, and a lack of knowledge about how to be active (Chen 2010).

Kalavar and colleagues presented the findings of a focus group of 10 older sedentary Asians from the United States (Kalavar et al 2005). In this study, authors identified that the barriers to physical activity were health problems and concerns over risk of injury.

Goodrich and colleagues studied the barriers for 274 overweight male veterans taking part in a home-based walking program in the United States (Goodrich et al 2007). All participants reported one or more risk factors for cardiovascular disease. Researchers found that medical problems, such as musculoskeletal injury and cardiovascular disease events presented obstacles to participation in the walking programme.

Social barriers

Six articles identified social barriers (Brawley et al 2003; Forkan et al 2006; Lawton et al 2006; Rasinaho et al 2007; Stumbo et al 2007; Wilcox et al 2005).

Brawley's narrative review indicated that cultural expectations and the demands of being a caregiver could interfere with physical activity for some older people (Brawley et al 2003).

The narrative review by Stumbo and colleagues identified social norms, family obligations, social isolation, and a lack of social support as all being detrimental to physical activity (Stumbo et al 2007).

Forkan's paper on the cross-sectional study of 409 older people living independently in Scotland described not belonging to a group as a social barrier to being active (Forkan et al 2006).

A cross-sectional study of 645 community dwelling men and women in Finland by Rasinaho and colleagues (Rasinaho et al 2007) found that participants with poor mobility indicated that lack of companions was a social barrier to physical activity.

Lawton and colleagues (Lawton et al 2006) examined the barriers to physical activity in a group of people living in Scotland with type 2 diabetes who were originally from Pakistani and Indian origin. From the qualitative interviews, researchers found that cultural norms and social expectations combined with the personal barriers to hinder the likelihood of being physically active.

Wilcox and colleagues used focus groups to identify relevant barriers to exercise with a sample of African American and Caucasian older women living in the US (Wilcox et al 2005). Social barriers included competing responsibilities, lack of time, lack of social support, and a lack or role models growing up.

Environmental barriers

Twelve articles identified environmental barriers (Belza et al 2004; Berke et al 2007; Chen 2010; Forkan et al 2006; Grossman et al 2003; Kalavar et al 2005; Mathews et al 2010; Morris et al 2008; Rasinaho et al 2007; Schutzer et al 2004; Stumbo et al 2007; Wilcox et al 2005).

Schutzer's narrative review (Schutzer et al 2004) reported that living in places with high crime or without good options for physical activity are barriers.

Stumbo and colleagues,(Stumbo et al 2007) identified limited access to activity programmes, weather conditions, poor walking surfaces, and lack of places to sit for breaks in activity as barriers.

Forkan's paper on the cross-sectional studies of 409 older people living independently in Scotland and of 556 men and women with impaired balance who were recently discharged from physical therapy described lack of access to a car and poor weather presented barriers to being active (Forkan et al 2006).

The cross-sectional study by Morris and colleagues (Morris et al 2008) described poor street connectivity as a barrier to physical activity.

The cross-sectional study by Berke and colleagues assessed the influence of built environment and neighbourhood walkability on the physical activity levels of 936 older Americans, and found that older adults did more walking for exercise in walkable neighbourhoods (Berke et al 2007).

A cross-sectional study of 645 community dwelling men and women in Finland by Rasinaho and colleagues(Rasinaho et al 2007) found that participants with poor mobility indicated that unsuitable environments was an environmental barrier to physical activity.

Belza and colleagues found in a diverse group of 71 older people participating in focus-group discussions on physical activity and exercise, that weather conditions and transportation issues emerged as environmental influences on physical activity (Belza et al 2004).

Grossman used qualitative interviews to provide information from a group of 33 previously inactive older adults on physical activity perceptions, motivations, and barriers (Grossman et al 2003). These participants indicated that unconducive environments was a barrier to physical activity.

Matthews and colleagues (Mathews et al 2010) investigated perceptions of barriers in a diverse group of older adults. The participants identified a lack of convenience, lack of transportation and unfavourable weather conditions as barriers.

Wilcox and colleagues used focus groups to identify relevant barriers to exercise with a sample of African American and Caucasian older women living in the US (Wilcox et al 2005). Environmental barriers included lack of transportation or facilities for exercise, having no sidewalk or footpath, and lack of safety or stray dogs.

Chen's qualitative study of perceived barriers to physical activity with a group of older nursing home residents in Taiwan found environmental barriers from lack of access to places appropriate for physical activity, or other environmental restrictions related to living in nursing homes (Chen 2010).

Kalavar and colleagues presented the findings of a focus group of 10 older sedentary Asians from the United States (Kalavar et al 2005). They identified difficulties related to new lifestyles associated with living in a new country as a barrier to physical activity.

Enablers: international literature

Personal enablers

Nine papers identified personal enablers (Buman et al 2010; Grossman et al 2003; Kalavar et al 2005; Mathews et al 2010; Morris et al 2008; Rasinaho et al 2007 Belza, 2004; Schutzer et al 2004; Wilcox et al 2005).

Schutzer's narrative review found that older people cited enjoying or being satisfied with exercise, having more time, and receiving information or prompts about exercise as enablers for physical activity (Schutzer et al 2004).

Morris and colleagues' cross-sectional study of the enablers of physical activity in 136 older women from the United States found that having high self-efficacy for physical activity and not having a functional limitation were enablers (Morris et al 2008).

A cross-sectional study in Finland by Rasinaho and colleagues (Rasinaho et al 2007) examined motives for physical activity in 645 community dwelling men and women. Those with poor mobility listed the benefits of physical activity on disease management as a motivation for exercise. For those participants with little or no mobility limitations, motivations included positive experiences and the health benefits related to exercise.

Belza and colleagues found that, in a diverse group of 71 older people participating in focus-group discussions on physical activity and exercise, improvements to health was a motivating reason to be more active (Belza et al 2004).

Buman and colleagues found that, in a collection of sedentary older adults from the US, early life experiences and beliefs had a lasting influence on the physical activity behaviours of older people (Buman et al 2010). Participants in this study indicated that health concerns for the future, enjoyment, and stress regulation were motivations for physical activity.

Grossman used qualitative interviews to provide information from a group of 33 previously inactive older adults on physical activity perceptions and motivations. These participants indicated health, independence and appearance as personal motivations for physical activity (Grossman et al 2003).

Matthews and colleagues (Mathews et al 2010) investigated perceptions of enablers in a diverse group of older adults. This group of participants identified personal enablers as the positive outcomes of physical activity, and receiving education about physical activity.

Wilcox and colleagues used focus groups to identify relevant barriers and motivations to exercise with a sample of African American and Caucasian older women living in the US (Wilcox et al 2005). Personal enablers included motivations to improve health, lose weight, feel better, and enjoy exercise. Knowledge about the benefits and proper ways to exercise was also an enabler.

Kalavar and colleagues presented the analysis of data from a sample of 100 older Asian men and women living in the United States that completed a questionnaire (Kalavar et al 2005). This study identified the most important personal reasons for participating in physical activity among the Asian older people as: wanting to keep healthy for medical reasons, to alleviate back pain, and to improve fitness.

Social enablers

Seven papers identified social enablers (Belza et al 2004; Grossman et al 2003; Kalavar et al 2005; Mathews et al 2010; Schutzer et al 2004; Shores et al 2009; Wilcox et al 2005).

Schutzer's narrative review found that older people cited receiving a doctor's recommendation as an enabler (Schutzer et al 2004).

Shores' cross-sectional study of 454 men and women from rural areas of the United States showed that those who had social support, such as a partner with whom to do physical activity, were more likely to engage in physical activity (Shores et al 2009).

Belza and colleagues found in a diverse group of 71 older people participating in focus-group discussions on physical activity and exercise that fostering relationships among participants, providing culture-specific exercises, offering convenient programmes near residences, involving older people in programme development, and combining low-cost opportunities to be active with existing social service programmes could all serve as enablers to physical activity (Belza et al 2004).

Grossman used qualitative interviews to provide information from a group of 33 previously inactive older adults on physical activity perceptions and motivations. These participants indicated family support and doctor recommendation as social motivations for physical activity (Grossman et al 2003).

Matthews and colleagues (Mathews et al 2010) investigated perceptions of enablers in a diverse group of older adults. This group of participants identified social enablers as seeing others being active, and having social support.

Wilcox and colleagues used focus groups to identify relevant barriers and motivations to exercise with a sample of African American and Caucasian older women living in the US (Wilcox et al 2005). Social enablers included having companions with whom to exercise, receiving a doctor's recommendation, and support from church.

Kalavar and colleagues presented the analysis of data from a sample of 100 older Asian men and women living in the United States that completed a questionnaire (Kalavar et al 2005) This study identified the most important social reasons for participating in physical activity as support from family and friends for them to be active.

Environmental enablers

Five papers identified environmental enablers (Mathews et al 2010; Morris et al 2008; Schutzer et al 2004; Shores et al 2009; Wilcox et al 2005).

Schutzer's narrative review found that older people cited having access to good facilities for walking or other activities, having complementary music for exercise, and feeling safe in the neighbourhood as motivations (Schutzer et al 2004).

Morris and colleagues' cross-sectional study of the enablers of physical activity in 136 older women from the United States found that having good street connectivity was an environmental enabler (Morris et al 2008).

Shores' cross-sectional study of 454 men and women from rural areas of the United States showed that those who lived within walking distance to parks or perceived that they had transportation to safe areas for physical activity were more likely to be active (Shores et al 2009).

Matthews and colleagues (Mathews et al 2010) investigated perceptions of enablers in a diverse group of older adults. This group of participants identified environmental enablers as access to good facilities and programmes, conducive environments in which to be active, and having access to medically assistive devices.

Wilcox and colleagues used focus groups to identify relevant motivations to exercise with a sample of African American and Caucasian older women living in the US (Wilcox et al 2005). Environmental enablers were convenient low-cost facilities or age-appropriate programmes.

Conclusions

From a wide range of studies in various populations, some common barriers and enablers emerged that can be categorised at the personal level, social level, and environmental level of influence.

To capitalise on enablers and to overcome barriers at the personal level, efforts are needed to educate and empower older people regarding not only the benefits of finding interesting and enjoyable physical activities, but also the way to achieve a more active lifestyle, in light of each person's unique health and life circumstances, considering also resources available to each person.

To capitalise on enablers and to overcome barriers at the social level, health professionals could not only encourage older people to be physically active, but also strive to overcome social or cultural barriers by helping to develop or identify close and convenient programmes, settings, facilities, and opportunities to include appropriate and achievable physical activities, tailored to suit any competing responsibilities. For Māori or Pacific people, it is important to consider promotion of a culturally appropriate physical activity programme. Public health efforts could be aimed at social marketing efforts to foster social support and promote physical activity, or alter the social norms for older people, especially those for whom physical activity is currently not seen as appropriate.

To capitalise on enablers and to overcome barriers at the environmental level, planning and policy changes may be needed to foster greater access to safe, low-cost, convenient environments, facilities, and programmes that are conducive to physical activity.

To capitalise on enablers and to overcome barriers at all levels, public health efforts could address the development and promotion of readily accessible, safe, culturally appropriate, and enjoyable opportunities for physical activity, education about why and how older people should be active and professional guidance for being physically active for those with health problems or concerns.

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8 What are the safety and risk issues associated with physical activity participation by older people?

Introduction

The literature on safety and risk issues provides insight as to whether the barriers described in chapter 7 are supported by the evidence. Most of the retrieved literature can readily be grouped by two of the most commonly cited personal barriers: health problems/concerns and fear of falling/injury.

This chapter presents the evidence on the reality of these safety concerns under the following headings:

- safety issues associated with non-cardiovascular health problems
- safety issues associated with cardiovascular health problems
- safety issues associated with non-fall injuries
- safety issues associated with falls
- safety issues arising from the amount (and changes in the amount) of physical activity
- managing the risks and safety issues.

While the literature discussed in this chapter provides evidence on a range of safety issues, it should be noted that two of the most important individual level risk factors for injuries and other adverse events during physical activity are previous musculoskeletal injuries (Baker et al 2007; US Department of Health and Human Services 2008) or disease (Department of Health Physical Activity Health Improvement and Prevention 2004) and low levels of physical activity or fitness (US Department of Health and Human Services 2008).

Body of evidence

In total, 37 documents were identified that met the inclusion criteria for safety issues and risks. Details can be found in appendix 4.

Note that safety and risk information stemming from guidelines, systematic reviews, randomised trials and observational studies have been critically appraised and are included in chapter 9 and appendix 5. Similar information from case series, surveys, position or scientific statements have been summarised but were not appraised and is reported in chapter 9 and appendix 5.

Three guidelines were identified: the 2008 Physical Activity Guidelines for Americans (US Department of Health and Human Services 2008) (AGREE tool quality grading: strongly recommended); the 1998 Physical Activity Guidelines for Australians (Egger et al 1999) (AGREE tool quality grading: not recommended); and the 2006 National Physical Activity Recommendations for Older Australians (AGREE tool quality grading: strongly recommended) (Sims et al 2006).

There were eight systematic reviews. Seven of these were considered to be of good quality (Baker et al 2007; Bartels et al 2007; Chien et al 2008; de Morton et al 2007b; Foster et al 2005; Latham et al 2004; Liu et al 2009) and one (Department of Health Physical Activity Health Improvement and Prevention 2004) was considered to be of mixed quality.

There were 10 randomised controlled trials. Three of these was considered to be of good quality (Kerse et al 2009; Lawton et al 2008; Liu-Ambrose et al 2008), six (Callahan et al 2008; Fielding et al 2007; LIFE Study Investigators 2006; Littbrand et al 2006; Villareal et al 2006; Wieser et al 2007) of mixed quality, and one of poor quality (De Vos et al 2005).

There were four cohort studies, one of which (van Stralen et al 2008) was considered to be good quality and three of mixed quality (Barnett et al 2009; Haapasalo et al 2007; Parkkari et al 2004).

Twelve case series studies, surveys, position or scientific statements were identified which were not appraised (Adams et al 2006; Belza et al 2004; Briffa et al 2006; Carlson et al 2006; Gerson et al 2004; Heesch et al 2008; Jones et al 2005; Li et al 2006; Thelander et al 2008; Thompson et al 2007; von Klot et al 2008; Wijlhuizen et al 2007).

Data has also been obtained from the Accident Compensation Corporation (ACC) and from the National Injury Query System (NIQS).

One study reported information specific to the frail older person (Kerse et al 2009).

Summary of findings

Refer to appendix 4 for details of individual studies.

Safety issues associated with non- cardiovascular health problems

Seven papers were reviewed.

De Vos reported on a randomised controlled trial that evaluated resistance training, in which there were minimal adverse events for strength testing and power training (0.34% and 0.25%, respectively). The adverse events were primarily musculoskeletal (minor strains 50%, tendonitis, 30%, exacerbation of osteoarthritis 15%, other 5%). All reported adverse events were resolved with alterations in training regimens or anti-inflammatory and/or analgesic medication. The author concluded that the intervention appeared to be reasonably safe in a supervised setting with participants aged 60 years and over (De Vos et al 2005).

Bartels' systematic review of older people with chronic osteoarthritis (Bartels et al 2007), found that aquatic exercise programmes for older patients appeared to be safer when compared with land based exercise (Bartels et al 2007).

Callahan reported no adverse events in an eight week randomised control trial of a land based, community based programme of arthritis self-management through exercise (Callahan et al 2008) in older people (mean age of 70 years) who had been primarily sedentary.

Van Stralen reported from a cohort study that the risk of venous thromboembolism was increased in high intensity exercise, the incidence rate being 4.04/1000 person years compared with 2.5/1000 person years in mild exercise. For those with no exercise, the incidence rate was 4.17/1000 person years. For older people the incidence rate was similar to that of no exercise when engaging in vigorous exercise for venous thromboembolism (van Stralen et al 2008). The evidence still suggested that the benefits of physical activity outweighed any potential harm.

In Foster's systematic review of randomised controlled trials comparing different strategies to encourage sedentary, community dwelling adults to become more physically active, less than half of the included trials (six out of 19) reported on adverse events. In those trials that did report on adverse events, no significant difference in rates of illness between groups were found (Foster et al 2005).

From a case series study of institutionalised older adults with dementia, Thelander found that there were a number of safety concerns about being left alone and fear of not being able to find their way or a fear of falling. Physical activity should be tailored to the individual and to their mental as well as their physical capabilities (Thelander et al 2008).

De Morton reported in a systematic review on an inpatient exercise programme for those with an acute exacerbation of a medical condition and found that the programme did not have any effect on the specific outcomes of mortality compared with control groups (de Morton et al 2007b).

Safety issues associated with cardiovascular health problems

Nine papers were reviewed.

The US Department of Health and Human Services' 2008 Physical Activity Guidelines for Americans contains a number of findings relevant to safety and risk issues associated with cardiovascular health problems (US Department of Health and Human Services 2008):

- the risk of sudden adverse cardiac events (eg, sudden death, myocardial infarction) are higher during periods of vigorous physical activity than during periods of less intense activity or while at rest for all individuals
- active people are at less risk than inactive people
- the risks of sudden adverse cardiac events are greater for those who remain sedentary than for those who increase their regular level of physical activity, especially if the increase is gradual
- the risks of sudden cardiac adverse events are lower for light- and moderate-intensity activities, and likely depend on relative intensity as much or more than absolute intensity.

The National Heart Foundation of Australia (Briffa et al 2006) noted that the estimated risks of a cardiovascular event occurring in those individuals with coronary heart disease, attending supervised exercise rehabilitation, was one for every 117,000 hours of activity for a major event and one per 750,000 hours of activity for a fatal event.

The National Physical Activity Recommendations for Older Australians included a systematic review of 81 studies (n = 2387 participants, more than 60,000 person hours of physical activity). The review concluded that there was no significant difference in the likelihood of deaths or adverse events for people with chronic heart failure, whether they participated in an exercise intervention or were randomised to the control group (OR 0.71) (Sims et al 2006).

Chien conducted a systematic review of home based aerobic exercise programmes (with or without resistance exercise) for older people with chronic heart failure (this study included adults 50 years or older). Within the 10 randomised controlled trials (n = 648 participants), two trials reported hospitalisations due to cardiac events and there was no effect of harm identified. The primary authors noted that there may still be a risk of those considered to be of 'high risk' (not defined) (Chien et al 2008).

Thompson found, in a scientific statement from the American Heart Association, that vigorous exercise has been shown to transiently increased the risk of acute myocardial infarction and sudden cardiac death, even in exercise-conditioned individuals (Thompson et al 2007). Despite this, the actual occurrence of these events was rare and was probably outweighed by the benefits (Thompson et al 2007). The absolute risk of an exercise related cardiac event varies with the prevalence of diagnosed or occult cardiac disease but appeared to be low in 'healthy' individuals (Thompson et al 2007). Thompson's recommendation was that individuals who appear to be at increased risk of coronary artery disease should consider exercise testing prior to engaging in a vigorous physical activity programme (Thompson et al 2007).

Von Klot found a graded exposure relationship was identified between the intensity of physical activity and the triggering of acute myocardial infarction (AMI) (von Klot et al 2008). In a case series study of survivors of acute myocardial infarction (37% > 65 years of age) men were more likely than women to report strenuous and physical exertion during the four days before AMI symptom onset (20.5% versus 8.9%, $p < 0.001$). The risk of AMI symptom onset was about five times higher either during or within two hours of engaging in strenuous exertion than during times of very light or no exertion (RR 5.7, 95% CI 3.6–9.0). Even moderate exertion was associated with a higher risk compared to very light or no exertion (RR 1.6, 95% CI 1.2–2.1). The effect of strenuous exertion, but not moderate exertion, was stronger among older compared with younger subjects. The relative risk of AMI symptom onset was significantly higher when strenuous exertion was performed outdoors compared to when the same level of exertion was performed indoors ($P = 0.008$), while there was no interaction with moderate exertion (von Klot et al 2008). The case series covered a participant age range of 25–74 years.

Adams reported from an observational study that there were no adverse events reported during a high intensity supervised exercise session (including flexibility and treadmill walking programmes) in a group of patients with chronic peripheral arterial vascular disease (age range between 57 and 70 years, mean of 68 years). There was careful monitoring of these individuals, in particular of those with atrial fibrillation. The author concluded that such an intervention was safe with individuals in this rehabilitation exercise programme (Adams et al 2006).

In Foster's systematic review of randomised controlled trials comparing different strategies to encourage sedentary, community dwelling adults to become more physically active, less than half of the included trials (six out of 19) reported on adverse events. In those trials that did report on adverse events, no significant difference in rates of potential cardiovascular events between groups was found (Foster et al 2005).

Littbrand reported on a randomised controlled trial of participants (Littbrand et al 2006) in a 'High Intensity Functional Exercise Programme' aimed to improve lower-limb strength, balance, and gait ability. Sixty-three percent of participants reported adverse events. There were 179 adverse events reported in 166 (9%) of the attended exercise sessions. All except two adverse events were categorised as 'minor and temporary'. Two events were considered to be 'serious symptoms', with one session stopped because of chest pain. No data were reported for the control group.

Safety concerns associated with non-fall injuries

Twenty papers were reviewed and data was also extracted from the National Injury Query System.

According to the National Injury Query System (accessed 18/05/2011) the crude rate of non-fall unintentional injuries (including 'cut/piercing', 'drowning', and 'struck by' or 'against' categories) in 2009 in New Zealand was:

65–69 years	377.5/100,000 persons
70–74 years	413.2/100,000 persons
75–79 years	517.2/100,000 persons
80–84 years	633.1/100,000 persons
85+ years	797.2/100,000 persons.

Activities with fewer and less forceful contacts with objects or other people have appreciably lower injury rates than collision or contact sports. Aerobic exercise, such as walking for exercise, gardening, bicycling or exercise cycling, dancing, swimming, and golf were identified as activities with the lowest injury rates in the 2008 Physical Activity Guidelines for Americans (US Department of Health and Human Services 2008).

The Department of Health Physical Activity Health Improvement and Prevention reports that (Department of Health Physical Activity Health Improvement and Prevention 2004):

- high risks occur predominantly among those exercising at high intensity levels and those participating in contact sports and high volume fitness training
- individuals with pre-existing musculoskeletal disease are at a higher risk of injury as a result of physical activity
- risks associated with participation in physical activity levels that promote health are low.

De Vos reported on a randomised controlled trial that evaluated resistance training, in which there were minimal adverse events for strength testing and power training (0.34% and 0.25%, respectively). Most adverse events were musculoskeletal, eg, minor strains (50%), tendonitis (30%), all of which resolved with alterations in training regimens or anti-inflammatory and/or analgesic medication. The author concluded that the intervention

appeared to be reasonably safe in a supervised setting with participants aged 60 years and over (De Vos et al 2005).

Baker reported no serious adverse events in a systematic review (Baker et al 2007) that evaluated multimodal exercise interventions (including strength/resistance training, aerobic/ cardiovascular endurance training, and balance/stability training, and may or may not have included flexibility exercises) in the home or fitness centre (mean cohort age ranged from 67 ± 8 years to 84 ± 3 years). Four of the nine randomised controlled trials included in the review reported no adverse events. In the remaining trials the type of adverse events included minor falls (0.5%), pain, or shoulder injuries which resulted in discontinuation of the intervention (0.5%) (Baker et al 2007).

De Morton reported, in a systematic review, on an inpatient exercise programme for those with an acute exacerbation of a medical condition and found that the programme did not have any effect on the specific outcomes of musculoskeletal injury compared with control groups (de Morton et al 2007b).

In Foster's systematic review of randomised controlled trials comparing different strategies to encourage sedentary, community dwelling adults to become more physically active, less than half of the included trials (six out of 19) reported on adverse events. In those trials that did report on adverse events, no significant difference in rates of musculoskeletal injury (fractures and sprains), falls between groups was found (Foster et al 2005).

Liu's systematic review of progressive resistance training which included 121 trials noted that the associated risks were poorly monitored and poorly reported in the majority of the trials, making it difficult to assess the risk of injury or other events associated with resistance training. As a consequence, adverse events may have been under-reported. The mean or median age of participants ranged between 60 and 80 years an older across the studies (Liu et al 2009). Neither Latham (2004) nor Liu (2009) reported any serious adverse events (ie, death or illness resulting in hospitalisation) associated with progressive resistance training (Latham et al 2004; Liu et al 2009).

Wieser reported on a randomised controlled trial that evaluated resistance training, in which no adverse events occurred during a 12-week maximal resistance training programme for participants aged 70 years and over (Wieser et al 2007).

Barnet reported on a walking team ball game called 'Lifeball', which was developed for community dwelling 'seniors' (mean age of participants was 67 years; age range of 40–94 years) who wish for a slower pace than traditional basketball or netball. The injury rate was 10.3 per 100 participants over a 12-month period in a cohort study which noted the most common injuries reported were knee injuries, minor abrasions, and joint fractures (Barnett et al 2009). The cohort study provides no control group data.

The LIFE-P intervention (Fielding et al 2007; LIFE Study Investigators 2006) consisted of walking, strength, flexibility, and balance training supplemented with behavioural skills training modules. With the exception of consultations for abnormal heart rhythm ($p = 0.02$), which were more frequent in the intervention group there were no significant differences between the groups for serious and non-serious adverse events. Serious events were defined as death, life threatening events, inpatient hospitalisations or abnormal clinical

investigations. Non-serious events included seeking medical advice for back injury, fainting, sprain, abnormal heart rhythm or having experienced muscle sprain, foot pain, fatigue, dizziness or other illness restricting activity.

A randomised controlled trial conducted in New Zealand using ‘green prescriptions’ in a primary care setting reported that despite the increase in physical activity the physiological parameters did not change and there were increased injuries (increase of 12% from baseline in the intervention group and 0% in the control group; $P < 0.001$) and falls (increase of 5% from baseline in the intervention group and decrease of 5% in the control group; $P = 0.03$) in the intervention group (Lawton et al 2008). The population was women aged 40 to 74 years.

Liu-Ambrose, using data from the Otago Exercise Programme (OEP), reported two adverse events (low back pain) that were directly related to the exercise and for which one participant discontinued the programme (Liu-Ambrose et al 2008).

De Morton reported on an inpatient exercise programme for those with an acute exacerbation of a medical condition and found that the programme did not have any effect on the specific outcomes of musculoskeletal injury compared with control groups (de Morton et al 2007b).

Five studies reported on epidemiological data for injuries sustained through participation in physical activity (Carlson et al 2006; Haapasalo et al 2007; Parkkari et al 2004; Gerson et al 2004; Jones et al 2005).

- Parkkari and Haapasalo separately reported from a cohort study that the individual risk exposure per hour of participation was found to be relatively low in commuting, walking, and cycling when compared with recreational and competitive sports (Haapasalo et al 2007; Parkkari et al 2004). They found that, for 65 to 74 year olds, the injury rate was 1.0 and 1.2 per 1000 hours participation for recreational and competitive sports respectively (Haapasalo et al 2007; Parkkari et al 2004).
- Carlson reported on case series data on injuries associated with leisure time physical activity from the 2000 to 2002 National Health Interview Survey in America (Carlson et al 2006). The overall incidence rate was 68.1/1000 (95%CI 59.8–76.4) for respondents aged 65 years or over. There were no differences observed between different intensities of physical activity. The percentage of injuries was minimal and those who were active had a lower incidence of non-sport or non-leisure time injury than those who were inactive. However, those who were active reported higher rates of sports related injuries (Carlson et al 2006).
- Gerson reported on case series data from the American National Electronic Injury Surveillance System for those aged 64 years and over (Gerson et al 2004). The overall injury rate was 177.3/100,000 population with 60% more men than women reporting an injury. Forty percent of the injuries occurred in a sports venue, 13% at home and 11% in the street. Seventy percent of the injuries were associated with bicycling, exercising, fishing, golfing or snow skiing. Just over a quarter (27%) of the injuries sustained were fractures. Recreational activities were associated with a risk of injury, although in many cases this was potentially avoidable through the application of injury prevention strategies. However, the study failed to include non-hospitalised or fatal injuries and there is no information on participation to enable an estimate of injuries per 1000 hours participation (Gerson et al 2004).

- Jones also used case series data from the American National Electronic Injury Surveillance System to report on non-equipment exercise related injury among women aged over 65 years. The overall prevalence rate for injury was 26.8 per 100,000 population (95%CI 21.0–32.6) (Jones et al 2005). Sixty percent of the injuries were sustained by women between the ages of 65 and 74 years and the most common injuries were sprains and strains (36.4%) and fractures (31%). The most common location for occurrence was the street or road (25.2%). The exercise activities being engaged in at the time of injury were walking or hiking (58%) followed by exercise or callisthenics (23%), aerobics (9%), and jogging (4%). The authors recommended that older women should be aware of the potential risks of participating in physical activity in particular if they are at risk of osteoporosis and that appropriate information should be supplied to these groups (Jones et al 2005).

Safety issues associated with falls

Ten papers were reviewed. Information was also extracted from the National Injury Query System and the Accident Compensation Corporation (ACC).

According to the National Injury Query System (accessed 18/05/2011) the crude rate of unintentional, non-fatal falls in 2009 in New Zealand was:

65–69 years	512.6/100,000 persons
70–74 years	747.1/100,000 persons
75–79 years	1467.7/100,000 persons
80–84 years	2831.6/100,000 persons
85+ years	5686.8/100,000 persons

The ACC noted that falls, in particular in those aged 80 years or more were most frequently attributable to poor balance, weak muscles, low blood pressure, poor vision and/or comorbidities. It was noted that falls can be reduced through participation in regular exercise to improve muscle strength, balance and fitness such as tai chi and participation in the Green Prescription Programme. A comprehensive list of studies relating to falls prevention are found on the ACC website (http://www.acc.co.nz/preventing-injuries/at-home/older-people accessed 14.10.2010).

Kerse reported on a randomised control trial that the rate of falls do not appear to be increased through the participation in physical activity, even in those more frail older people who are residents of nursing homes (Kerse et al 2009).

Liu-Ambrose, using data from the Otago Exercise Programme (OEP), reported a reduction in the reporting of at least one fall in the OEP group (43%) compared with the control group (67%) (Liu-Ambrose et al 2008).

Falling and fear of falling was a safety issue identified in a case series study of community dwelling older adults published by Wijlhuizen (Wijlhuizen et al 2007). Individuals appeared to adjust their behaviour to reduce the risk of falling. The risk of falling may therefore be underestimated as those individuals at higher risk may avoid engagement in physical activity. Older adults with a high fear of falling should build up their physical abilities in a safe environment before being encouraged to move outdoors (Wijlhuizen et al 2007).

Li reported on a case series study of falls in middle and older aged adults (Li et al 2006) in which outdoor falls accounted for 54% of all falls among older adults. For those aged over 80 years outdoor falls accounted for 48% of the most recent falls. These incidents occurred most frequently on the footpaths, curbs and streets. Almost 40% occurred in gardens, patios, yards, decks or porches. The most common activity being undertaken was walking (46.7%). Outdoor recreation areas and parks were also a common location reported by those aged over 65 years (Li et al 2006).

The likelihood of falls occurring whilst walking is confirmed by the Active NZ Survey (SPARC 2008) that reported walking as the most popular physical activity of participants aged 65 years or more of any ethnicity (73.3%).

Within the Australian Longitudinal Study of Women's Health, a prospective observational survey of 8188 healthy community dwelling women age 70–75 in 1996 reported no significant association between physical activity and injury from falling. Daily moderate to vigorous physical activity was considered necessary for primary prevention of falls and fractured bones in women aged 70–75 years (Heesch et al 2008).

Villareal reported minor adverse events from a randomised trial of diet and exercise therapy (including flexibility, endurance, strength and balance) in obese participants aged 65 years and older. One fall was reported which did not prevent continued participation in physical activity (Villareal et al 2006).

In Foster's systematic review of randomised controlled trials comparing different strategies to encourage sedentary, community dwelling adults to become more physically active, less than half of the included trials (six out of 19) reported on adverse events. In those trials that did report on adverse events, no significant difference in rates of falls between groups was found (Foster et al 2005). The age range of participants across the trials was between 35 years and 92 years with 14 of the 19 trials including older adults.

Barnet reported on a walking team ball game called 'Lifeball', which was developed for community dwelling 'seniors' (mean age of participants was 67 years; age range of 40–94 years) who wish for a slower pace than traditional basketball or netball. The fall rate was 8.7 per 100 participants over a 12-month period (Barnett et al 2009). The cohort study provides no control group data and there is no comparison with average fall data from a similar population.

Littbrand reported on a randomised controlled trial of participants aged 65 years and over, (Littbrand et al 2006) in a 'High Intensity Functional Exercise Programme' aimed to improve lower-limb strength, balance, and gait ability. Sixty-three percent of participants reported adverse events. There were 179 adverse events reported in 166 (9%) of the attended exercise sessions. All except two adverse events were categorised as 'minor and temporary'. Two events were considered to be 'serious symptoms', with physiotherapists preventing a fall by lowering the subject to the floor in one session. No data were reported for the control group.

De Morton reported on an inpatient exercise programme for those with an acute exacerbation of a medical condition and found that the programme did not have any effect on the specific outcomes of falls injury compared with control groups (de Morton et al 2007b).

Safety issues arising from the amount (and changes in the amount) of physical activity

Three papers were reviewed.

The Physical Activity Guidelines for Australians (1999) (Egger et al 1999), which are for the general population and not specifically targeted at older people, noted that with the possible exception of unexpected injury the risks were mainly associated with excessive exercise (Egger et al 1999).

Barnet reported on a walking team ball game called 'Lifeball', which was developed for community dwelling 'seniors' (refer to the summary of findings on non-fall injuries and fall injuries above). In general, falls and injuries were low for the number of hours of participation (Barnett et al 2009). For those with attendance data (n = 257) this equated to 2.8 falls per 1000 hours participation and 3.3 injuries per 1000 hours participation (Barnett et al 2009).

The 2008 Physical Activity Guideline for Americans noted that (US Department of Health and Human Services 2008):

- the amount of physical activity was directly related to the risk of musculoskeletal injury. Injury rates at the level of activity commonly recommended (150 minutes per week of moderate intensity activity) appeared to be rare
- risk of injury is directly related to size of increase in the amount of physical activity performed
- incremental increases in activity followed by a period of adaptation would be expected to cause fewer injuries than larger increases
- the addition of a small amount of walking, such as 5 to 15 minutes 2 to 3 times per week, to one's usual daily activities has a low risk of musculoskeletal injury and no known risk of sudden severe cardiac events.

Managing the safety and risk issues

Eleven papers were reviewed.

General advice on managing safety issues

The Physical Activity Guidelines for Americans (2008) noted that taking appropriate precautions is important to managing safety issues, and involves the use of proper equipment, choosing safe environments and making sensible choices about when and where to be active. The guidelines noted that (US Department of Health and Human Services 2008):

- the use of personal protective equipment such as helmets, goggles and shin pads can reduce the frequency of injuries
- neighbourhood characteristics that limit vehicular speed and keep pedestrians and bicyclists separated from motor vehicles also reduce the risk of activity-associated injuries (neighbourhood safety was an issue identified also identified in the focus group reported by Belza) (Belza et al 2004)

- making sensible choices may involve being active in the morning rather than in the heat of the day, and participating in indoor rather than outside activities.

The Physical Activity Readiness Questionnaire (PAR-Q) was developed in Canada and is a simple seven-item questionnaire that provides a cost effective alternative to physician clearance for participation and is usually administered by 'fitness professionals' (Jamnik et al 2007). It is designed to screen individuals who are planning to undergo a fitness assessment or to become much more physically active (Jamnik et al 2007). The questionnaire is used internationally (Canada, USA, UK) as a standardised pre-screening tool for participation in an exercise or physical activity programme (Jamnik et al 2007) and is also widely used within New Zealand. If there is a positive response to any of the questions the individual is directed to undergo clearance with a physician using the Physical Activity Readiness Medical Examination (PARmed-X), the original questionnaire designed for individuals aged 15 to 69 years. This tool is currently undergoing revision by the Canadian Society for Exercise Physiology (CSEP) and the Canadian Academy of Sports Medicine to include older people (http://www.csep.ca/english/view.asp?x=802 accessed 12.10.2010).

Managing safety issues associated with non-cardiovascular health problems

Jones, in his report on a case series, recommended that older women should be aware of the potential risks of participating in physical activity in particular if they are at risk of osteoporosis and that appropriate information should be supplied to these groups (Jones et al 2005).

Managing safety issues associated with cardiovascular health problems

The 2008 Physical Activity Guidelines for Americans notes that asymptomatic men and women who plan prudent increases to their daily physical activities do not need to consult a health care provider before doing so. Evidence that persons who consult with a health care provider before increasing their physical activity receive more benefits or suffer fewer adverse events than persons who do not is not available. Symptomatic persons or those with cardiovascular disease, diabetes, or other active chronic conditions who want to begin engaging in vigorous physical activity and who have not already developed a physical activity plan with their health care provider may wish to do so (US Department of Health and Human Services 2008).

Thompson, in his scientific statement, recommended that individuals who appear to be at increased risk of coronary artery disease should consider exercise testing prior to engaging in a vigorous physical activity programme (Thompson et al 2007).

The National Heart Foundation of Australia recommended that those with peripheral vascular disease and stroke survivors, unless contra-indicated, should progress over time to the recommended level of physical activity (Briffa et al 2006).

The National Heart Foundation of Australia noted that for patients with known cardiovascular disease (including myocardial infarction, unstable angina, coronary artery bypass grafting, or percutaneous coronary interventions), for whom physical activity is not contra-indicated, supervised exercise rehabilitation should be offered. Those with implantable cardiac devices

(pacemakers) and congenital and valvular heart disease should progress over time to the recommended physical activity levels (Briffa et al 2006).

Managing safety issues associated with falls

Li reported on a case series study of falls in middle and older aged adults (Li et al 2006) in which outdoor falls accounted for 54% of all falls among older adults. Li found that many of the incidents could have been avoided through appropriate maintenance of the physical environment.

Within the Australian Longitudinal Study of Women's Health, a prospective survey of 8188 healthy community dwelling women age 70–75 in 1996 reported no significant association between physical activity and injury from falling. Daily moderate to vigorous physical activity was considered necessary for primary prevention of falls and fractured bones in women aged 70–75 years (Heesch et al 2008).

Thelander, reporting on case series data, found that there were a number of safety concerns for institutionalised older adults with dementia, primarily about being left alone, fear of not being able to find their way or a fear of falling. Thelander recommended that physical activity should be tailored to the individual and to their mental as well as their physical capabilities (Thelander et al 2008).

Managing safety issues arising from the amount (and changes in the amount) of physical activity

The 2008 Physical Activity Guideline for Americans noted that (US Department of Health and Human Services 2008):

- frequency and duration of aerobic activity should be increased before intensity. Increases in activity level may be made as often as weekly among youth, whereas monthly is more appropriate for older or unfit adults
- attainment of the desired level of activity may require a year or more, especially for elderly, obese, or habitually sedentary individuals.

Incremental increases in physical activity are recommended for everyone by the UK Chief Medical Officer, regardless of health, fitness or activity level. This recommendation was particularly emphasised for those with low levels of habitual physical activity who are unfit or have existing comorbidities (Department of Health Physical Activity Health Improvement and Prevention 2004).

Incremental increases are also recommended in the National Physical Activity Recommendations for Older Australians (Sims et al 2006).

Conclusion

Those studies which evaluated the role of physical activity in older people were often powered to detect benefits and not harms, which were rarely reported. As a consequence, the evidence pertaining to the risk and safety of physical activity in the older adult may be underestimated. Although the systematic reviews identified were mainly considered to be of 'good quality', not all of the included studies reported on adverse events or risks and thus the systematic reviews are subject to bias. None of the trials examined reported at either an individual or a government level on the cost implications of injuries resulting from participation in physical activity.

With these caveats in mind, the evidence supports the finding in The National Physical Activities Recommendations for Older Australians that there was minimal risk (adverse events, including death) in participating in physical activity for the older adult (Sims et al 2006). Much of the evidence suggests that the adverse events associated with physical activity in the older adult are generally innocuous (Baker et al 2007; Barnett et al 2009; Bartels et al 2007; Carlson et al 2006; Chien et al 2008; de Morton et al 2007b; Egger et al 1999; Fielding et al 2007; Foster et al 2005; Haapasalo et al 2007; Jones et al 2005; LIFE Study Investigators 2006; Parkkari et al 2004; US Department of Health and Human Services 2008) although risks do appear to increase with the intensity of physical activity (Department of Health Physical Activity Health Improvement and Prevention 2004; Egger et al 1999; US Department of Health and Human Services 2008).

The risk of non-cardiovascular adverse events was minimal (Callahan et al 2008; de Morton et al 2007b; De Vos et al 2005; Foster et al 2005). With frail elderly, or those with neurodegenerative disease, a more tailored approach to participation in physical activity should be considered to reduce the risk of injury and increase self-confidence (Thelander et al 2008).

The risk of sudden cardiac events is associated with periods of vigorous activity (Thompson et al 2007; US Department of Health and Human Services 2008; von Klot et al 2008). For adults with coronary artery disease, there is an increased risk of a cardiac event (Chien et al 2008) and medical advice or supervision should probably be recommended for this sub-population prior to engaging in physical activity.

The risk of falling does not appear to be increased whilst participating in physical activity (de Morton et al 2007a; Foster et al 2005; Heesch et al 2008; Kerse et al 2009; Liu-Ambrose et al 2008). Some of the issues are around the fear of falling as a barrier to participation in physical activity (Wijlhuizen et al 2007). The majority of falls occur outdoors (Li et al 2006) and this is probably associated with walking being one of the most common recreational activities for those aged 65 years or more (SPARC 2008).

The risk of sustaining an injury whilst engaging in physical activity can be reduced through a number of simple processes which include incremental increases in the amount of physical activity (Department of Health Physical Activity Health Improvement and Prevention 2004; US Department of Health and Human Services 2008) and the provision of appropriate information and advice (Jones et al 2005) for individuals wishing to engage in physical activity. Some types of physical activity programme may be better suited to older adults with chronic medical conditions and be less likely to place additional strain on joints, but even in

adults with chronic medical conditions the frequency of severe, life threatening adverse events is minimal.

The risk of an injury whilst participating in physical activity remains a possibility and for some may be a barrier to further participation (chapter 7 refers). Selection of low risk activities and prudent behaviour while doing any activity can minimise the frequency and severity of adverse events and maximise the benefits of regular physical activity (US Department of Health and Human Services 2008). Many of the risks associated with participation can potentially be avoided (Department of Health Physical Activity Health Improvement and Prevention 2004; Gerson et al 2004; Li et al 2006; US Department of Health and Human Services 2008). This can potentially be achieved through provision of appropriate information (Jones et al 2005) or through the provision of safe physical activity environments through local council and national initiatives (Belza et al 2004; US Department of Health and Human Services 2008).

In conclusion, the evidence suggests that the benefits of regular physical activity outweigh the inherent risk of adverse events (Department of Health Physical Activity Health Improvement and Prevention 2004; Egger et al 1999; US Department of Health and Human Services 2008; van Stralen et al 2008). A simple pre-screening questionnaire for 'healthy' individuals is available (PAR-Q) that can be supplemented by a medical examination if required (Jamnik et al 2007). For those with coronary disease a medical examination, including stress testing, is recommended by the National Heart Foundation of Australia (Briffa et al 2006).

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9 International guidelines, policies and principles

Introduction

The previous chapters document the evidence from published literature as to the benefits, safety and risk issues associated with physical activity by older people. Chapter 6 describes the most effective interventions as described in the published literature.

Published, peer-reviewed literature is the best source of evidence. Other sources include published, but non-peer-reviewed guidelines and policy statements. This chapter examines a range of these documents as they have been published in English since 2004. In doing so, it extracts a common set of principles about physical activity in older people.

The search for these documents was more complex than the previous searches of the literature using electronic databases (refer to Methods chapter of this report). Policy documents are often located on Government or Department/Ministry of Health websites. The World Health Organization has a comprehensive database of policies relating to physical activity and their website was used a primary resource, alongside the appropriate Ministerial websites from the included countries (refer to Methods chapter). Guidelines were critically appraised using the AGREE tool (refer to Methods chapter); policies were summarised but not critically appraised.

Note that as guidelines and policies are not peer-reviewed literature, they are not considered in the preceding chapters. As a result, this chapter does contain some material on benefits and effectiveness that is not included in chapters 4 and 6.

Definitions

A **guideline** aims to guide decisions regarding prevention, diagnosis, management, and treatment in specific areas of healthcare and is based on an examination of current evidence within the paradigm of evidence-based medicine. Modern clinical guidelines briefly identify, summarise and evaluate the highest quality evidence and most current data about prevention, diagnosis, prognosis and therapy including dosage of medications, risk/benefit and cost-effectiveness. Thus, they integrate the identified decision points and respective courses of action to the clinical judgement and experience of practitioners, and provide an ability to standardise interventions.

Guidelines are usually produced at national or international levels by medical and other professional associations, or governmental bodies, with these often being adapted by local healthcare providers for their specific context (New Zealand Guidelines Group 2001).

A **policy** is a formal statement that should define priorities for action, goals and strategies as well as accountability and allocation of resources (Bull et al 2004). Policy development is a procedure to gain desired outcomes and is initiated by government, non-government or private sector organisations. There is often intersectoral involvement (eg, from transport,

recreation, education, planning, and safety) and there is usually a method of evaluation and feedback (Bull et al 2004).

Sentinal report from the US Surgeon General

In 1996, a sentinel document on physical activity, the US Surgeon General's Report was produced (US Surgeon General 1996). The report was not a clinical guideline nor a policy or scientific statement, however many of the documents subsequently discussed are based on this initial report (US Surgeon General 1996). The US Surgeon General's report appears to be based on a review of the literature and expert opinion but there is no evidence of a systematic approach to searching the literature.

The report emphasised the significant health benefits to be obtained by including a moderate amount of physical activity (eg, 30 minutes of brisk walking or raking leaves, 15 minutes of running, or 45 minutes of playing volleyball) on most, if not all, days of the week. The report also noted that additional health benefits could be gained through greater amounts of physical activity (US Surgeon General 1996). An incremental approach was recommended to those who had been previously sedentary and consultation with a medical practitioner for those with chronic medical conditions or those seeking to embark on a vigorous programme of activity (US Surgeon General 1996). It was suggested that aerobic exercise be supplemented with strength-developing exercises at least twice a week for adults, in order to improve musculoskeletal health, maintain independence in performing the activities of daily life, and reduce the risk of falling (US Surgeon General 1996).

Guidelines

Body of evidence

Eight guidelines made recommendations on the duration, frequency and intensity of physical activity specifically for older people (aged 65 years or older).

- Global Recommendations on Physical Activity for Health (World Health Organization 2010) (AGREE tool quality grading – strongly recommend). There are specific subsections of this guideline for people aged 65 years and older.
- The National Physical Activity Recommendations for Older Australians (Sims et al 2006) (AGREE tool quality grading – strongly recommend).
- Physical Activity Guidelines for Americans (US Department of Health and Human Services 2008) (AGREE tool quality grading – strongly recommend). There are specific subsections of this guideline for people aged 65 years and older.
- Canadian Physical Activity Guidelines for Older Adults (Kesaniemi et al 2010; Paterson et al 2007; Sharratt et al 2007; Tremblay et al 2010; Tremblay et al 2007) (AGREE tool quality grading – strongly recommend).
- British Heart Foundation Guidelines for the promotion of physical activity with older people (British Heart Foundation 2008) (AGREE tool quality grading – recommend with modifications).

- The National Guidelines on Physical Activity for Ireland (Department of Health and Children Health Service Executive 2009) (AGREE tool quality grading – not recommended). There are specific subsections of this guideline for people aged 65 years and older.
- The Australian Physical Activity Guidelines (Egger et al 1999) (AGREE tool quality grading – not recommended). This guideline includes specific references to older people.
- The New Zealand Physical Activity Guideline Movement=Health! (Hillary Commission 2001).

The New Zealand Physical Activity Guideline was identified in the literature search. However, documented evidence around guideline development was not obtainable. It was established (personal communication Sport and Recreation New Zealand, Sue Walker, SPARC 13.07.2010) that the guideline was based on the US Surgeon General's report (1996) (US Surgeon General 1996) and that evidence was reviewed by the National Physical Activity Taskforce and the National Health Committee. Due to the lack of other information this guideline was unable to be appraised using the AGREE tool.

Two guidelines examined interventions to increase participation in physical activity and both guidelines included older people.

- National Institute for Health and Clinical Excellence. Four commonly used methods to increase physical activity: brief interventions in primary care, exercise referral schemes, pedometers and community-based exercise programmes for walking and cycling (National Institute for Health and Clinical Excellence 2006) (AGREE tool quality grading – strongly recommend).
- National Institute for Health and Clinical Excellence Occupational therapy interventions and physical activity interventions to promote the mental wellbeing of older people in primary care and residential settings (National Institute for Health and Clinical Excellence, 2008) (AGREE tool quality grading – strongly recommend).

Summary of findings

A brief summary of the Guidelines can be referred to in Table 9.1. Details are reported in appendix 5 (table 1).

Starting physical activity (or increasing it)

Older people who have ceased participation in physical activity, or who are starting a new physical activity (Sims et al 2006; US Department of Health and Human Services 2008) or those whose physical activity levels do not meet current guideline recommendations (British Heart Foundation 2008; US Department of Health and Human Services 2008) should start at a level that is easily manageable and gradually build up the recommended amount, type and frequency of activity (British Heart Foundation 2008; Sims et al 2006; US Department of Health and Human Services 2008; World Health Organization 2010).

Paterson (2007) stated that individuals who are new to physical activity or who are considering more challenging activities may wish to consult a physician before starting that activity (Paterson et al 2007). Those older adults with an associated medical condition may

also wish to consult a medical practitioner (British Heart Foundation 2008; Department of Health and Children Health Service Executive; Hillary Commission 1994, 2001; US Department of Health and Human Services 2008; World Health Organization 2010). When providing physical activity advice, primary care practitioners should take into account the individual's needs, preferences and circumstances (National Institute for Health and Clinical Excellence 2006; Paterson et al 2007). They should agree goals with them and provide written information about the benefits of activity and the local opportunities to be active and should follow them up at appropriate intervals over a three- to six-month period (National Institute for Health and Clinical Excellence 2006).

Examples of how older people can perform physical activity

Physical activity incorporating aerobic exercise for older people can include everyday activities, leisure pursuits, supervised and independent activities (Sims et al 2006), eg, walking, dancing, swimming, water aerobics, jogging, aerobic exercise classes, bicycle riding (stationary or on a path); some activities of gardening, eg, raking and pushing a lawn mower, or sports such as tennis or golf (without a cart) (Egger et al 1999; Hillary Commission 1994, 2001; US Department of Health and Human Services 2008).

Examples of muscle strengthening activities include lifting weights, working with resistance bands, calisthenics using body weight for resistance, climbing stairs, carrying heavy loads, and heavy gardening (US Department of Health and Human Services 2008). Examples of exercises for balance include backward walking, sideways walking, heel walking, toe walking, and standing from a sitting position (US Department of Health and Human Services 2008).

Duration, intensity and frequency

All of the guidelines concur in recommending a minimum of 30 minutes moderate intensity physical activity on most (at least five) if not all days per week (accumulating 150 minutes).

One guideline recommended that in addition to this minimum an extra 75 minutes (minimum) vigorous activity per week should be undertaken (US Department of Health and Human Services 2008) and two other guidelines (Egger et al 1999; Hillary Commission 2001) recommended an additional 20 minutes of vigorous physical activity on three to four days per week. This could also be an equivalent duration of a combination of moderate and vigorous physical activity (US Department of Health and Human Services 2008).

For additional, and more extensive health benefits, two of the guidelines recommended that older adults should increase their aerobic physical activity to 300 minutes (five hours) a week of moderate-intensity, or 150 minutes a week of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity activity (US Department of Health and Human Services 2008; World Health Organization 2010).

Muscle strengthening activities that are moderate or high intensity should involve all major muscle groups and should be undertaken on two or more days a week (Department of Health and Children Health Service Executive; Kesaniemi et al 2010; US Department of Health and Human Services 2008; World Health Organization 2010), with one guideline recommending that these days are non-consecutive (British Heart Foundation 2008).

The British Heart Foundation recommends that flexibility activities should be performed on a minimum of two days a week for at least 10 minutes' duration (British Heart Foundation 2008). The Canadian Physical Activity Guideline recommends flexibility activities on a daily basis (Kesaniemi et al 2010).

It is suggested that to make it easier to attain the recommended duration of physical activity, sessions can be broken down into smaller bouts of 10 to 15 minutes (British Heart Foundation 2008; Department of Health and Children Health Service Executive; Egger et al 1999; Hillary Commission 1994, 2001; Kesaniemi et al 2010; Sims et al 2006; US Department of Health and Human Services 2008; World Health Organization 2010).

Several of the guidelines noted that participation in physical activity at any level was preferential to inactivity (Department of Health and Children Health Service Executive; Egger et al 1999; Sims et al 2006; US Department of Health and Human Services 2008).

Additional components of physical activities for older people

In addition to duration, intensity and frequency, as detailed above, strength (British Heart Foundation 2008; Department of Health and Children Health Service Executive; Kesaniemi et al 2010; Sims et al 2006; US Department of Health and Human Services 2008; World Health Organization 2010), balance (British Heart Foundation 2008; Department of Health and Children Health Service Executive; Kesaniemi et al 2010; Sims et al 2006; US Department of Health and Human Services 2008; World Health Organization 2010), co-ordination (British Heart Foundation 2008) and flexibility (British Heart Foundation 2008; Kesaniemi et al 2010; Sims et al 2006) interventions were recommended as components of physical activity that should be undertaken by older people.

Programmes to increase participation in physical activity

Two guidelines from the National Institute of Health and Clinical Excellence (NICE) (AGREE tool quality grading – strongly recommended) examined specific programmes to promote physical activity (National Institute for Health and Clinical Excellence 2006, 2008).

One guideline examined the effectiveness of four programmes (brief interventions in primary care, exercise referral schemes, pedometers, and community-based exercise interventions for walking and cycling) (National Institute for Health and Clinical Excellence 2006). The guideline recommended that primary care practitioners should take the opportunity, whenever possible, to identify inactive individuals and advise them to try to achieve 30 minutes of moderate intensity physical activity on five days of the week (or more). This advice should be tailored to the individual based on ability and comorbidities.

Evidence from 11 studies (six individual RCTs, two cluster RCTs, and three controlled non-randomised trials) suggested that brief programmes in primary care, such as exercise referral schemes, could be effective in both the short and long term at increasing participation in physical activity (National Institute for Health and Clinical Excellence 2006).

The evidence from two RCTs suggested that exercise referral schemes, involving a referral either from or within primary care, could have positive effects on physical activity levels in the short term but were not effective in the long term (National Institute for Health and Clinical Excellence 2006).

The evidence regarding pedometer (four RCTs) and walking based programmes (four primary studies) was equivocal. There was no evidence about the effectiveness of community-based cycling programmes using a controlled research design. These programmes are popular and well-received by participants; however, there is no substantiating evidence for their benefit (National Institute for Health and Clinical Excellence 2006).

The second guideline focused on the role of occupational therapy and physical activity interventions in older people and included 97 effectiveness and two cost effectiveness studies (National Institute for Health and Clinical Excellence 2008). There was a lack of robust evidence on the effectiveness of interventions and the studies included in the evidence base of the guideline were generally of poor quality. A number of recommendations were made on the amount of physical activity that should be engaged in. Older people should be offered tailored exercise and physical activity programmes in the community, focusing on: a range of mixed exercise programmes of moderate intensity (eg, dancing, walking, swimming) strength and resistance exercise, especially for frail older people. Sessions should be attended at least once or twice a week and should be based on individual preferences (National Institute for Health and Clinical Excellence 2008). A recommendation is made that older people and their carers receive advice about how to exercise safely for 30 minutes a day (which can be broken down into 10-minute bursts) on five days each week or more (National Institute for Health and Clinical Excellence 2008).

Implementation

The guidelines that were reviewed mainly focused on the amount and type of physical activity that should be undertaken by older people. There were, however, a number of strategies for implementation that were proposed.

Encouraging adherence to the recommendations could be brought about through societal influences that included buddy schemes and incentive schemes to make access to physical activity more amenable (British Heart Foundation 2008; Sims et al 2006). Two of the guidelines made particular emphasis to the inclusiveness of groups who often have difficulty in accessing opportunities for physical activity due to financial or social constraints and included indigenous peoples (Sims et al 2006) and for socially disadvantaged and ethnic groups (National Institute for Health and Clinical Excellence 2006).

The use of mass media campaigns to promote physical activity at national, regional and local levels and the use of written material and the internet to promote key physical activity messages were identified as implementation tools in three guidelines (British Heart Foundation 2008; Department of Health and Children Health Service Executive; Sims et al 2006; World Health Organization 2010). Messages need to be both adaptable and culturally sensitive. Training and education in the promotion of physical activity was also reported in one guideline (Department of Health and Children Health Service Executive).

Two guidelines noted that the effectiveness of physical activity could be observed in both home based and community settings (Sims et al 2006) and also in group activities (Department of Health and Children Health Service Executive). It is therefore probably individual preferences that will determine where an individual chooses to undertake physical activity. Options therefore need to be made available for both home based and group setting activities to maximise participation based on personal preferences.

The role of primary care in promoting physical activity has also been identified. Examples include 'Green Prescription' and 'Exercise Referral' schemes (Sims et al 2006) and may include counselling and additional consultation time in primary care (British Heart Foundation 2008). Social networking was identified as a specific area for encouragement in one guideline (World Health Organization 2010).

There was also a concerted focus on the importance of environmental factors which included the built environment (World Health Organization 2010) as demonstrated by the National Heart Foundation's Supportive Environments for Physical Activity (SEPA) Initiative (Sims et al 2006) and the provision of safe physical environments (British Heart Foundation 2008), promotion of active transport (public transport, cycling and public pathways), and open public spaces (British Heart Foundation 2008; Sims et al 2006; World Health Organization 2010).

Four of the guidelines noted the importance of surveillance and monitoring processes (British Heart Foundation 2008; National Institute for Health and Clinical Excellence 2006; Sims et al 2006; World Health Organization 2010) in order to evaluate the effectiveness of the recommendations and the associated media campaigns. The importance of evidence based strategies and interventions was emphasised in one of the guidelines (National Institute for Health and Clinical Excellence 2006).

Table 9.1

Guideline	Amount	Intensity	Frequency	Additional Information	Examples of physical activity
Global Recommendations on Physical Activity for Health (World Health Organisation) (World Health Organization 2010)	150 minutes Or Minimum 75 minutes Or an equivalent combination	Moderate Vigorous	Weekly Weekly	For additional benefits, older adults should increase their aerobic physical activity to 300 minutes (five hours) a week of moderate-intensity or 150 minutes a week of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity activity. Those with poor mobility should perform physical activity to enhance balance and prevent falls at least three days a week. Muscle strengthening using major muscle groups should be performed at least two days a week When older adults cannot meet the recommendations due to health conditions they should be as active as possible.	Can be achieved in bouts of 10 minutes
National physical activity recommendations for older Australians (Sims et al 2006)	30 minutes	Moderate	Most, preferably all days	Activities for older adults should incorporate fitness, strength, balance and flexibility. Can be done in smaller bouts of 10–15 minutes	Can include everyday activities, leisure pursuits; supervised and independent activities
Canadian physical activity guidelines for older adults (Kesaniemi et al 2010; Paterson et al 2007; Sharratt et al 2007; Tremblay et al 2010; Tremblay et al 2007)	Moderate intensity aerobic activity 150 minutes/week Or Vigorous intensity activity for a total of 90 minutes per week	Moderate	Most days of the week	The recommendations apply to apparently healthy individuals and not those with chronic disease. Increase endurance activities 4–7 days a week Increase flexibility activities – daily Increase strength and balance activities – 2–4 days a week	Include brisk walking Additional physical activity to the recommendations may have additional benefits The total physical activity can be accumulated in 10-minute bouts

Guideline	Amount	Intensity	Frequency	Additional Information	Examples of physical activity
National Institute for Health and Clinical Excellence (2006). Four commonly used methods to increase physical activity: brief interventions in primary care, exercise referral schemes, pedometers and community-based exercise programmes for walking and cycling. (National Institute for Health and Clinical Excellence 2006)	30 minutes	Moderate	5 days a week	Tailored programme to include moderate intensity, strength and resistance exercise, especially for the frail elderly. It should be based on individual preferences.	Activity can be broken down into 10-minute bursts
Physical Activity Guidelines for Americans (2008) (US Department of Health and Human Services 2008)	150 minutes (2 hours and 30 minutes) Or 75 minutes (1 hour and 15 minutes)	Moderate Vigorous Or an equivalent combination of moderate and vigorous	Weekly	For additional benefits, older adults should increase their aerobic physical activity to 300 minutes (five hours) a week of moderate-intensity, or 150 minutes a week of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity activity. Muscle-strengthening activities that are moderate or high intensity and involve all major muscle groups on two or more days a week. Exercise that improves and maintains balance.	Aerobic physical activity should be spread throughout the week, on at least three days a week, lasting at least 10 minutes. It can be at moderate or vigorous intensity and can be divided throughout the day or week (eg, a brisk 15-minute walk twice a day on every day of the week). Examples of aerobic exercise: walking, dancing, swimming, water aerobics, jogging, aerobic exercise classes, bicycle riding (stationary or on a path), some activities of gardening, such as raking and pushing a lawn mower, tennis, golf (without a cart). Examples of muscle strengthening exercises include lifting weights, working with resistance bands, doing calisthenics using body weight for resistance (such as push-ups, pull-ups, and sit-ups), climbing stairs, carrying heavy loads, and heavy gardening. Examples of exercises for balance include backward walking, sideways walking, heel walking, toe walking, and standing from a sitting position.

Guideline	Amount	Intensity	Frequency	Additional Information	Examples of physical activity
British Heart Foundation (2008)	30 minutes	Moderate	At least five days a week	Additional activities to increase strength, co-ordination and balance recommended for older adults. Activities could be undertaken in shorter bouts of 10 minutes.	For strength – recommended 8–10 exercises be performed on two or more non-consecutive days per week using the major muscle groups. A resistance should be used that allows 10–15 repetitions for each exercise. The level of effort should be moderate or high. Flexibility – activities on a minimum of two days a week for at least 10 minutes.
The National Guidelines on Physical Activity for Ireland (Department of Health and Children Health Service Executive)	30 minutes Or 150 minutes	Moderate	At least five days a week Weekly	Focus on aerobic activity, muscle-strengthening and balance. Activities could be undertaken in shorter bouts of 10 minutes.	Muscle strengthening exercises at least two to three days per week.
Australian Physical Activity Guidelines (Egger et al 1999)	30 minutes If possible an additional 20 minutes	Moderate Vigorous	Most, preferably all days 3 to 4 days a week	Can be done in smaller bouts of 10–15 minutes.	Include brisk walking or cycling, housework and gardening.
New Zealand Physical Activity Guidelines (Hillary Commission 2001)	30 minutes If possible an additional 20 minutes	Moderate Vigorous	Most, preferably all days 3 to 4 days a week	Can be done in smaller bouts of 10–15 minutes.	Incorporate physical activity into daily activities such as walking, gardening, taking the stairs, throwing a ball.

Policies and scientific statements

Body of evidence

There were two systematic reviews of policies (Bornstein et al 2009; Schoppe et al 2004) which both had minor flaws and were considered to be of mixed quality using the GATE appraisal method (refer to Methods chapter for further details).

There were 22 policy or national strategy documents and seven scientific statements/position stands from professional bodies. The policy and national strategy documents were:

- Canada – The Toronto Charter for physical activity: A global call for action (Global Advocacy Council for Physical Activity 2010)
- United States of America – National physical activity plan (National Physical Activity Plan 2010)
- Australia – Blueprint for an active Australia (National Heart Foundation of Australia 2009)
- England – Be Active Be Healthy – A plan for getting the nation moving (Department of Health 2009)
- Australia – Physical activity (The Royal Australian College of General Practitioners 2008)
- Finland – Government resolution: On development of guidelines for health-enhancing physical activity and nutrition (Ministry of Social Affairs and Health 2008)
- Belgium – Draft action plan on diet and physical activity 2008–2015 (Ministry of Welfare Public Health and Family 2008)
- England – Healthier Communities: Improving health and reducing health inequalities through Sport (Sport England 2008)
- World Health Organization – Steps to health. A European framework to promote physical activity for health (World Health Organization 2007)
- Wales – Climbing Higher – The Welsh Assembly Government Strategy for Sport and Physical Activity (Welsh Assembly Government 2005)
- Norway – The action plan on physical activity 2005–2009 – Working together for physical activity (Norwegian Government 2005)
- New Zealand – Preventing Injury from Falls – The National Strategy 2005–2015 (Accident Compensation Corporation (NZ) 2005b) and the Implementation Plan 2006–2015 (Accident Compensation Corporation (NZ) 2005a)
- Australia – Be Active Australia draft National Physical Activity for Health Action Plan (National Public Health Partnership 2004)
- England – At least five a week- evidence on the impact of physical activity and its relationship to health (Department of Health Physical Activity Health Improvement and Prevention 2004)
- Australia – Getting Australia Active II (Bull et al 2004)
- World Health Organization – Global strategy on diet, physical activity and health (World Health Organization 2004)

- Denmark – Healthy throughout Life – the targets and strategies for public health policy of the Government of Denmark, 2002–2010 (Ministry of the Interior and Health 2003)
- Scotland – Lets make Scotland more active (Physical Activity Task Force 2003)
- World Health Organization – Active Aging, A policy framework (World Health Organization 2002)
- New Zealand – Health of Older People Strategy (Ministry of Health 2002)
- New Zealand – Physical Activity (Ministry of Sport Fitness and Leisure et al 1999a)
- New Zealand – Public Health Association of New Zealand (no date specified on document) (Public Health Association of New Zealand).

Further details of the content of these policies can be referred to in appendix 5 (tables 3 and 4).

The scientific statements/position papers were:

- Canada – Canadian recommendations for the management of hypertension: Therapies (Hypertension Canada 2010)
- United States of America – Physical activity and public health in older adults: recommendations from the American College of Sports Medicine and the American Heart Association. (Chodzko-Zajko et al 2009; Haskell et al 2007; Nelson et al 2007)
- European Union – EU Physical Activity Guidelines Recommended Policy Actions in Support of Health-enhancing Physical Activity (EU Working Group Sport & Health 2008)
- Australia – Physical activity for people with cardiovascular disease: recommendations of the National Heart Foundation of Australia (Briffa et al 2006)
- United States of America – The American College of Sports Medicine Position Stand on Exercise and Hypertension (Pescatello et al 2004)
- United States of America – Physical Activity and Exercise Recommendations for Stroke Survivors (Gordon et al 2004)
- Australia – National Heart Foundation of Australia Position Stand (Shilton 2001).

Further details on these scientific statements can be referred to in appendix 5 (table 2).

The evidence base for these documents was varied and in general of poor quality. One document was based on a systematic literature search and grading of evidence (Hypertension Canada 2010). Three documents indicated that they were based on one or more systematic reviews (Bull et al 2004) and expert peer review (Briffa et al 2006; Department of Health Physical Activity Health Improvement and Prevention 2004).

Some of the policies and statements were developed in consultation with panels of experts but there was no evidence of systematic searches of the literature (Accident Compensation Corporation (NZ) 2005b; EU Working Group Sport & Health 2008; Ministry of Social Affairs and Health 2008; Ministry of Welfare Public Health and Family 2008; National Heart Foundation of Australia 2009; World Health Organization 2002, 2007; World Health Organization 2004). The American College of Sports Medicine recommendations are widely cited. They were developed through an expert panel (public health, behavioural science,

epidemiology, exercise science and medicine and gerontology) and evidence was based on primary research, literature reviews, existing preventative recommendations and therapeutic recommendations. There was no systematic review of the literature (Chodzko-Zajko et al 2009; Haskell et al 2007; Nelson et al 2007).

Three of the documents were based on other strategies or action plans (Ministry of Health 2002; Norwegian Government 2005; Sport England 2008). For the remaining policy documents the evidence base provided no details of a systematic literature search, or the source of the evidence was unclear (Department of Health 2009; Global Advocacy Council for Physical Activity 2010; Gordon et al 2004; Ministry of Sport Fitness and Leisure et al 1999a; Ministry of the Interior and Health 2003; National Physical Activity Plan 2010; National Public Health Partnership 2004; Pescatello et al 2004; Physical Activity Task Force 2003; Public Health Association of New Zealand; Shilton 2001; The Royal Australian College of General Practitioners 2008; Welsh Assembly Government 2005).

Summary of findings

Some of the policy documents made recommendations on the amount and type of physical activity for older adults; however the primary focus was on implementation issues in increasing participation in physical activity.

Recommendations for amount of physical activity for older adults

Twenty documents recommended that all adults, including specific references to older adults, should be advised to participate in 30 minutes of moderate activity on most, preferably all, days of the week (Briffa et al 2006; Chodzko-Zajko et al 2009; Department of Health 2009; Department of Health Physical Activity Health Improvement and Prevention 2004; EU Working Group Sport & Health 2008; Haskell et al 2007; Hypertension Canada 2010; Ministry of Health 2002; Ministry of Sport Fitness and Leisure et al 1999b; Ministry of Welfare Public Health and Family 2008; National Public Health Partnership 2004; Nelson et al 2007; Pescatello et al 2004; Physical Activity Task Force 2003; Public Health Association of New Zealand; Sport England 2008; The Royal Australian College of General Practitioners 2008; Welsh Assembly Government 2005; World Health Organization 2007; World Health Organization 2004). Thus accumulating up to 150 minutes per week (National Public Health Partnership 2004).

Three documents recommended that physical activity be undertaken on every day of the week at either a moderate level (Ministry of the Interior and Health 2003; Norwegian Government 2005) or high levels of intensity (Norwegian Government 2005) for at least 30 minutes. Two documents recommended the inclusion of some high intensity physical activity (National Public Health Partnership 2004; Public Health Association of New Zealand) and four documents specified at least 20 minutes of intense aerobic physical exercise should be undertaken on three days in a week (Chodzko-Zajko et al 2009; Haskell et al 2007; Ministry of Welfare Public Health and Family 2008; Nelson et al 2007) or a minimum of 30 minutes 3–4 times a week (The Royal Australian College of General Practitioners 2008). Further increases above the recommendations may have additional benefit (Haskell et al 2007; Nelson et al 2007; Norwegian Government 2005; Chodzko-Zajko et al 2009).

Combinations of moderate and intense physical activity can be used in addition to levels of daily activities of living (Chodzko-Zajko et al 2009; Haskell et al 2007; Nelson et al 2007). The total duration of physical activity undertaken can be broken down into 10-minute bouts (Briffa et al 2006; Department of Health 2009; Department of Health Physical Activity Health Improvement and Prevention 2004; Gordon et al 2004; Ministry of Sport Fitness and Leisure et al 1999b; Ministry of the Interior and Health 2003; Norwegian Government 2005; World Health Organization 2007). For those who have been previously sedentary incremental increases in physical activity are recommended (Briffa et al 2006; Chodzko-Zajko et al 2009; Haskell et al 2007; Nelson et al 2007; World Health Organization 2007).

With regards to resistance and strength training, four documents recommended 8 to 10 strength exercises for older adults at least twice a week (non-consecutive days) (Chodzko-Zajko et al 2009; Haskell et al 2007; Nelson et al 2007; Sharman et al 2009). This should use a resistance weight that allows 10 to 15 repetitions for each exercise and should be of moderate to high intensity (Chodzko-Zajko et al 2009; Gordon et al 2004; Haskell et al 2007; Nelson et al 2007). Three sessions a week of strength exercises was recommended in one document (Physical Activity Task Force 2003).

The importance of co-ordination and balance exercises in older adults was recorded in four documents (Department of Health Physical Activity Health Improvement and Prevention 2004; National Public Health Partnership 2004; World Health Organization 2007; World Health Organization 2004). The Physical Activity Task Force recommended three sessions of balance exercises a week (Physical Activity Task Force 2003) this recommendation was supported by another document which stated that this type of activity be undertaken 2–3 days per week (Gordon et al 2004).

Four documents recommend that, in order to maintain the flexibility necessary for regular physical activity and daily life, older people should perform activities that maintain or increase flexibility on at least two days each week for at least 10 minutes each day (Chodzko-Zajko et al 2009; Gordon et al 2004; Haskell et al 2007; Nelson et al 2007). Three of these documents also recommend that to reduce the risk of injury from falls, community-dwelling older adults with substantial risk of falls should perform exercises that maintain or improve balance (Chodzko-Zajko et al 2009; Haskell et al 2007; Nelson et al 2007).

Recommendations for implementation strategies arising from the policies

The policy documents made a number of recommendations for implementation at local, regional and national levels. Examples of these are provided below.

National policies and physical activity plans

The recently adopted Toronto Charter for physical activity provided an international call to strive for greater political and social commitment to support health enhancing physical activity for all (Global Advocacy Council for Physical Activity 2010). It calls for countries to formulate a national policy and physical activity plan; to introduce policies that promote physical activity; and to reorient services and funding to promote physical activity for all adults (including older adults) and develop partnerships for action (Global Advocacy Council for Physical Activity 2010).

This process can include regional policy development where a national policy is unavailable; (Department of Health Physical Activity Health Improvement and Prevention 2004; Global Advocacy Council for Physical Activity 2010; World Health Organization 2007) and two documents proposed the appointment of a national physical activity co-ordinator (National Public Health Partnership 2004; Physical Activity Task Force 2003) to facilitate plan development.

Policies and plans should have specific and achievable goals (World Health Organization 2004).

Bornstein's systematic review was based on six single, comprehensive national physical activity plans from Australia, UK, Scotland, Sweden, Northern Ireland and Norway, with an additional 25 supplementary documents from the same six countries. All plans included consultation processes, use of individual and environmental strategies, implementation at different levels (community, state and national), integration with other agendas, special consideration to specific sub-populations, timelines and brand identity (Bornstein et al 2009).

Schoppe's systematic review summarised policies from Australia, New Zealand, Canada, USA, Brazil, Scotland, Switzerland, Netherlands and Finland (Schoppe et al 2004). While definitions of 'policy' were found to vary between countries, it was clear that most countries appear to be adhering to the 1996 US Surgeon General's recommendations (US Surgeon General 1996). Schoppe also found that to bring about effective physical activity policies, frameworks for action need to be based on shared information, shared values, understanding of organisational structures as well as on mutual respect among stakeholders (Schoppe et al 2004).

The American National Physical Activity Plan (2010) (National Physical Activity Plan 2010) aimed to facilitate physical activity. It groups recommendations by societal sectors, including public health; health care; education; transportation, land use, community design; parks, recreation, fitness, sports; business and industry; volunteer and non-profit organisations; and mass media. The Plan does not specify amount of physical activity and is directed at the general population. It draws on other guidelines and has five main strategies:

- grass roots advocacy to activate public support
- a national physical education programme of behavioural strategies for increasing physical activities. The integration of this programme with other national health promotion/disease prevention education campaigns
- best practice physical activity models/programmes/policies disseminated to the widest extent and for Americans to access strategies to meet federal physical activity guidelines
- national resource centre to disseminate effective promotion tools
- centre for physical activity policy development and research over all sections of the National Physical Activity Plan.

Preventing Injury From Falls: The National Strategy 2005 included a focus on older people aged 65 years or older (Accident Compensation Corporation (NZ) 2005b) . The strategy aimed to reduce falls in the home and in residential care settings. The strategy was accompanied by an implementation plan (Accident Compensation Corporation (NZ) 2005a). The implementation plan suggested a process of evaluation and monitoring of falls related

mortality and injury; assessment of resourcing, research, falls preventing activities, education and training in New Zealand; multisectoral collaboration and establishment of central government funding.

Infrastructure

Many of the policies acknowledged the importance of the development of the national infrastructure and therefore of transport and environmental policy to promote physical activity (Bull et al 2004; Global Advocacy Council for Physical Activity 2010; Ministry of Social Affairs and Health 2008; National Physical Activity Plan 2010; Schoppe et al 2004; World Health Organization 2002, 2007). This includes the built environment (Norwegian Government 2005) and the management of cycleways and pathways (Norwegian Government 2005), public transport, green spaces, and safe environments (Bull et al 2004; Department of Health Physical Activity Health Improvement and Prevention 2004; EU Working Group Sport & Health 2008; Ministry of Health 2002; Ministry of Welfare Public Health and Family 2008; National Heart Foundation of Australia 2009; Shilton 2001; World Health Organization 2002; World Health Organization 2004). Other suggested methods have included prompts to use stairways (Bull et al 2004). At a local government level it is important to regulate for the built environment that supports active living (National Heart Foundation of Australia 2009) and also to ensure road safety for pedestrians and cyclists (EU Working Group Sport & Health 2008).

Monitoring and evaluation

In order to ensure that the policy recommendations have been implemented and effective it is necessary to maintain national monitoring and evaluation plans (Bull et al 2004; Department of Health Physical Activity Health Improvement and Prevention 2004; EU Working Group Sport & Health 2008; Global Advocacy Council for Physical Activity 2010; Ministry of Social Affairs and Health 2008; National Heart Foundation of Australia 2009; National Public Health Partnership 2004; Schoppe et al 2004; Sport England 2008; World Health Organization 2007; World Health Organization 2004).

Education and training capacity

The education and training of individuals to promote physical activity is acknowledged (EU Working Group Sport & Health 2008; Global Advocacy Council for Physical Activity 2010; National Heart Foundation of Australia 2009; National Physical Activity Plan 2010; National Public Health Partnership 2004; Shilton 2001; World Health Organization 2002).

Promotion of life long participation

Six of the policies and scientific statements noted that it was never too late to commence physical activity (Global Advocacy Council for Physical Activity 2010; Schoppe et al 2004) and that this formed part of a continuum of life-long benefits in health whatever the age of the individual (Ministry of Health 2002; National Heart Foundation of Australia 2009; Shilton 2001; World Health Organization 2004).

Financial support

Political support is key to ensuring an effective physical activity plan and strategies (World Health Organization 2007) and this involves key stakeholder involvement throughout the process (Bull et al 2004). In order to promote physical activity and to encourage participation and access to facilities there is a need for federal or central government financial support, (Global Advocacy Council for Physical Activity 2010; National Physical Activity Plan 2010; Schoppe et al 2004) similarly financial support at local government and community level is also required (EU Working Group Sport & Health 2008; Physical Activity Task Force 2003).

Media campaigns

In order to get the message to the general public there is a necessity for effective media campaigns (Global Advocacy Council for Physical Activity 2010; National Physical Activity Plan 2010; Schoppe et al 2004) and brand identity (Bornstein et al 2009; Bull et al 2004; Department of Health 2009; EU Working Group Sport & Health 2008; Ministry of the Interior and Health 2003; Ministry of Welfare Public Health and Family 2008; National Heart Foundation of Australia 2009; National Physical Activity Plan 2010; Physical Activity Task Force 2003; Shilton 2001; World Health Organization 2007).

Inter-agency collaboration and partnerships

The issue of physical activity promotion crosses more than just health agencies but also involves transport, education, health and environment. Effective inter-agency collaboration is therefore fundamental (Bornstein et al 2009; Bull et al 2004; Ministry of the Interior and Health 2003; National Public Health Partnership 2004; Physical Activity Task Force 2003; World Health Organization 2007; World Health Organization 2004) and can also be extended to involve community groups (Global Advocacy Council for Physical Activity 2010), voluntary groups and clubs (Physical Activity Task Force 2003; Shilton 2001). There is a need to implement sustainable actions in partnership at national, regional, and local levels and across multiple sectors to achieve greatest impact (Global Advocacy Council for Physical Activity 2010; National Public Health Partnership 2004; World Health Organization 2007; World Health Organization 2004). Local strategic partnerships should aim to meet health goals (eg, exercise referral, pedometer schemes, information on local facilities, and public places) (Department of Health Physical Activity Health Improvement and Prevention 2004; EU Working Group Sport & Health 2008). Intersectoral collaboration between researchers and practitioners was also seen as being relevant (EU Working Group Sport & Health 2008; Shilton 2001). Support is offered through an implementation plan from the World Health Organisation (World Health Organization 2004).

Clear timelines

One of the systematic reviews noted that it was a fundamental prerequisite of policies to involve a time line for implementation (Bornstein et al 2009).

Evidence based strategies

National policies and activity plans need to be established based on evidence (Bull et al 2004; Global Advocacy Council for Physical Activity 2010; National Physical Activity Plan 2010).

Disadvantaged groups

Several of the policies and statements emphasised the need to focus attention on disadvantaged groups which included older adults (Global Advocacy Council for Physical Activity 2010; National Physical Activity Plan 2010; World Health Organization 2004) or those with chronic diseases (National Physical Activity Plan 2010). There was also a call for cultural sensitivity in the development and implementation of strategies (Global Advocacy Council for Physical Activity 2010; National Heart Foundation of Australia 2009; National Physical Activity Plan 2010) or appropriate material (Shilton 2001; World Health Organization 2002; World Health Organization 2004).

Make physical activity the 'easy' choice

In order for individuals, especially older adults, to participate in adequate levels of physical activity it is imperative that such participation is perceived as the 'easy' choice (Global Advocacy Council for Physical Activity 2010; National Public Health Partnership 2004; World Health Organization 2007). This could include financial incentive (EU Working Group Sport & Health 2008; Ministry of Welfare Public Health and Family 2008; National Heart Foundation of Australia 2009; World Health Organization 2002) through the funding of sports amenities (Norwegian Government 2005) and making participation affordable and accessible (EU Working Group Sport & Health 2008; Ministry of Social Affairs and Health 2008; Ministry of the Interior and Health 2003) and improving access to facilities and public spaces (National Physical Activity Plan 2010).

Primary care involvement

The role of primary care was noted to be of high importance (Ministry of Social Affairs and Health 2008). It was suggested that annual assessment in average risk individuals and assessment at every visit for those at high risk of CVD should be undertaken (The Royal Australian College of General Practitioners 2008). Targeted funding to primary care to promote physical activity was suggested in one document (National Heart Foundation of Australia 2009). Older adults should be offered assessments based on physical activity level and appropriate exercise referral made if required (EU Working Group Sport & Health 2008; National Physical Activity Plan 2010; The Royal Australian College of General Practitioners 2008; Bull et al 2004; Ministry of Health 2002; Physical Activity Task Force 2003). The development of individual plans should be evaluated on a regular basis (Haskell et al 2007; Nelson et al 2007; Chodzko-Zajko et al 2009).

Written information and advice

The importance of written information and advice, provided at an appropriate level was noted (Ministry of Welfare Public Health and Family 2008; National Public Health Partnership 2004; The Royal Australian College of General Practitioners 2008).

Principles arising from the guidelines and policies

The following principles are common across the guidelines and policies:

1. Those who are new to physical activity, have a known medical condition or who are frail should seek medical advice prior to starting physical activity.
2. A minimum of 30 minutes, moderate intensity physical activity should be undertaken on most days (at least five) if not all days per week (accumulating 150 minutes).
3. Additional health benefits can be achieved by increasing moderate intensity physical activity to 300 minutes (5 hours) per week, or 150 minutes of high intensity physical activity or an equivalent combination of moderate and high intensity activity.
4. The total duration of physical activity can be broken down into 10 minute bouts.
5. Additional components should include strength, balance and flexibility exercises at least 2 to 3 days per week.
6. Increasing participation can be enhanced with the use of incentive schemes, cultural sensitivity, media campaigns, offering home based or group activities, the use of exercise referral schemes.
7. Increasing participation can be enhanced by improving the physical environment, promoting active transportation, and provision of open public spaces.
8. National surveillance and monitoring of physical activity is required.
9. Any level of activity is preferential to inactivity.

Horizon scanning

The UK Physical Activity Guidelines are currently in their final stages following consultation. One of the specified target groups are older adults. The remit of the Guidelines was not to review the evidence but to establish if, based on recent evidence from America, Canada and the UK, the physical activity guidelines from each of the home countries was still valid and reflected the available evidence. Drafts were circulated at UK consensus meeting in October 2009. There were 10–12 key questions addressed. Potential recommendations are likely to reflect the focus on five sessions of 30 minutes of moderate intensity physical activity per week or 150 minutes of physical activity per week and that there are numerous ways of accumulating this 150 minutes. Higher volumes of activity greater than 150 minutes are likely to incur greater benefits. The recommendations for older adults should reflect the same total amount of activity required as for the adult population. The guideline is also likely to make additional recommendations around activity intensity and that for older adults there should be greater emphasis on moderate intensity rather than vigorous activity. With regards to session duration the guideline is likely to recognise activity can be accumulated in shorter bouts of at least 10 minutes or more. The guideline also addresses the issues of communicating the recommendations to the public and health providers and educators. Consultation closed at the end of 2009 and the Guideline is anticipated in the near future.

Conclusions

The evidence from the guidelines, policies and scientific statements from professional bodies suggests that older adults should participate in a minimum of 30 minutes of moderate intensity physical activity on most if not all days of the week and that this should be supplemented with strength, balance and co-ordination exercises. Additional moderate or vigorous activity is seen to confer additional health benefits. The duration of the exercise can be accumulated in shorter 10 minute bouts. Those with associated medical conditions or those who have been previously sedentary may wish to seek medical advice prior to undertaking a programme of physical activity.

In terms of the implementation of the recommendations there were a number of key areas that were identified for targeting at local, regional and national levels. These were development of public health policy, safe community and physical built environments, supportive social environments, public and professional education, inter-agency collaboration and formation of coalitions and partnerships, financial support, evidence based research, evaluation and monitoring.

Although the guidelines attempted to ground their recommendations in evidence, the policies and scientific statements were often developed through panels of experts. Despite this there was consensus in the recommendations for the amount, duration and intensity of exercise and the implementation strategies.

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10 New Zealand specific issues and cultural considerations

Background

An ageing population usually means increased pressure on health services. Prevalent ailments among older New Zealanders include cardiovascular disease, hypertension, cerebrovascular accidents, cancer, type II diabetes, chronic respiratory disease, osteoporosis, musculoskeletal disease and sensory impairments (Cornwall et al 2004). As the preceding chapters show, there is evidence that physical activity in older people has benefits in the prevention and management of these conditions.

Two-thirds of New Zealand adults aged 65 years or over are not physically active at levels sufficient to benefit their health (SPARC 2008). This chapter takes New Zealand specific information and evidence in relation to physical activity and draws conclusions about what needs to be considered in taking all of the evidence presented in this report and applying it to New Zealand's unique population mix.

Body of evidence

Eighteen documents and articles relevant to New Zealand were identified. Some of these predated 2004 but were felt to be of significance to the New Zealand setting and have therefore been included.

Five randomised controlled trials were identified. Four were considered to be of good quality (Kerse et al 2005; Kerse et al 2010; Kolt et al 2007a; Lawton et al 2008) and one was considered to be of poor quality (Rosie et al 2007).

Evidence from the remaining studies and documents has been summarised but not critically appraised as they are at lower levels of the hierarchy of evidence (refer to the Methods chapter for further details). Lower levels of evidence from the hierarchy, such as case series and qualitative data are useful when no other evidence is available, or as informative and insightful information.

There were six surveys (Annear et al 2009; Croteau et al 2006; Mummery et al 2007; Sinclair et al 2007a; Sinclair et al 2007b; Sullivan et al 2003), one case series study (Kolt et al 2007b), a focus group (Kolt et al 2006) and a thematic analysis (Elley et al 2007).

The remaining five documents were:

- National Pacific Diabetes Initiative. Physical Activity Guide (Ministry of Health nd)
- Changing physical activity behaviour (SPARC 2005)

- a doctoral thesis on the motives, benefits and barriers of the Green Prescription for older adults (Patel et al 2010)
- two policy documents described in chapter 9 (Ministry of Sport Fitness and Leisure et al 1999; Public Health Association of New Zealand, n.d.).

There are also a number of relevant governmental publications which may be considered within the New Zealand policy context but which have not been critically appraised as part of this report:

- 2006/7 New Zealand Health Survey (Gerritsen et al 2008)
- The Positive Ageing Strategy (Ministry of Social Development 2001)
- Positive Ageing Indicators 2007 (Ministry of Social Development 2007)
- The New Zealand Cancer Control Strategy (Ministry of Health et al 2003)
- Clinical Guidelines for Weight Management in New Zealand Adults (Ministry of Health 2009)
- Ala Mo'ui: Pathways to Pacific Health and Wellbeing 2010–2014 (Minister of Health et al 2010).

Of these, the following provide brief of how physical activity is integrated into New Zealand guidance. The New Zealand Cancer Control Strategy (Ministry of Health et al 2003) promoted physical activity as an integral part of primary prevention of cancer. The strategy noted that those participating in more physical activity were less likely to develop cancer of the bowel, breast, prostate, lung and uterus. The Clinical Guidelines for Weight Management in New Zealand Adults (Ministry of Health 2009) recommended that increased exercise should be incorporated into a weight-loss regimen only in combination with other strategies. Good practice points included promoting a healthy lifestyle and use of information resources prepared for Māori, Pacific, and South Asian populations interested in physical activity. The Ala Mo'ui: Pathways to Pacific Health and Wellbeing 2010–2014 (Minister of Health et al 2010) strategy noted the important role of Pacific church initiatives in increasing physical activity in their community.

Some New Zealand specific issues have been discussed elsewhere in this report; reference can be made to enablers and barriers to participation in physical activity for Māori, Pacific and Asian older people in chapter 7 of this report and falls in chapter 8.

Summary of findings

Matters pertaining to all New Zealanders

Epidemiology

Based on the 2006 Census data, the New Zealand population aged over 65 years at the end of 2006 was 519,940 (12% of the total population) (Ministry of Social Development 2007). It has been estimated that the older adult cohort is projected to increase to 25% of the total population by 2051 (Dunstan et al 2006). In 2006, 45% of the older population were men and

those aged 85 years or older comprised 12% of the ‘older’ population (Ministry of Social Development 2007).

Popular physical activity

The most popular physical activities undertaken by adults aged 65 years and over (of any ethnic group) were walking (73.3%), gardening (65.7%), swimming (15.3%), and equipment-based exercise (14%) (SPARC 2008).

The Active NZ survey identified a number of activities that were popular with specific ethnic group (ages not specified). The results for Māori, Pacific people and Asians are provided in separate sections below. Football was the most popular physical activity for other adults (SPARC 2008).

Participation

During any particular week, 79% of adults participated in at least one sport or recreation activity; for those aged 65 years and over this value was 82.1%. The average number of activities participated in over 12 months decreased with increasing age, from 6.5 for 16 to 24 year olds to 2.7 for those aged 65 years and over.

Neither the New Zealand Health Survey(Gerritsen et al 2008) nor the Active NZ Survey (SPARC 2008) reported any changes in the trends for participation in physical activity (Gerritsen et al 2008), sport and recreation participation (SPARC 2008), or membership of club or centre (SPARC 2008) since the previous survey administration.

Sedentary behaviour

The New Zealand Health Survey indicated that one in every 10 adults in New Zealand reported participating in less than 30 minutes of physical activity per week (Gerritsen et al 2008). Both men and women living in NZDep2006 quintile 5 areas were more likely to be sedentary than those living in quintile 1 areas, when adjusted for age (Gerritsen et al 2008).

Leisure time satisfaction

Older people aged 65 years and over reported the highest levels of overall satisfaction with their leisure time (90%) (Ministry of Social Development 2009). Most New Zealanders, regardless of their ethnicity, were satisfied with their leisure time. In 2008, 75% of Māori expressed satisfaction with their leisure time, a level similar to that of Europeans (76%) and Pacific peoples (74%) (Ministry of Social Development 2009).

Barriers and enablers

The literature on New Zealand specific barriers, reported in chapter 7, indicates that the most common barriers are health problems/concerns, lack of support/encouragement, cultural norms/expectations, poor weather and lack of close facilities (an environment not conducive to physical activity).

Pringle's qualitative study of Māori, Pacific, and European New Zealanders on the effect of receiving a Green Prescription for physical activity during visits with a general practice physician described the following barriers: illness, physical decline, pain upon exercise, no intentions, lack of caring, lack of time, lack of confidence, embarrassment, and poor weather (Pringle 2008).

The same study described the following enablers: gaining intrinsic pleasure from physical activity, being motivated by a concern for health, being motivated by potential benefits from physical activity, and having high self-efficacy (Pringle 2008).

Additionally, the search on New Zealand-specific research highlighted two studies that made reference to barriers, although this was not the outcome under study (NB: additional studies, pertaining to Māori, Pacific people and Asians are discussed separately in this chapter).

In a survey conducted through Sport and Recreation New Zealand (SPARC) self-efficacy (the belief that one can achieve a goal) was identified as having a strong relationship with levels of physical activity (Sullivan et al 2003). Intrinsic factors such as enjoyment of physical activity were significantly related to differences in levels of physical activity whereas extrinsic motivations, such as obtaining approval from others, were not related.

In a qualitative analysis of 15 sedentary adults participating in a Green Prescription trial, two themes relating to barriers and enablers emerged (Elley et al 2007). Many of the perceived barriers were beyond the control of the individual such as the weather and lack of footpaths in rural areas. Poor health and medical conditions were also perceived as barriers. Motivators included knowledge of the benefits of physical activity and the risks of inactivity, personal commitment and guilt. The role of significant others such as health professionals and exercise specialists and the importance of social interactions were also identified as being of high importance.

The influence of the neighbourhood was identified as contributory factor in the participation or non-participation in physical activity in a survey of 63 older adults.(Annear et al 2009) Those older adults residing in areas of lower deprivation (more affluent) had a more positive attitude regarding their physical and social environment and were more likely to participate in leisure time physical activity than counterparts in areas of high deprivation (Annear et al 2009). The influence of the physical and social environment were identified as important areas of consideration when encouraging older individuals to participate in physical activity (Annear et al 2009).

The literature on New Zealand specific enablers, reported in chapter 7, indicates that the most common enablers are positive experiences, guidance/encouragement from a health professional or an institution (ie, social support), access to programmes in local facilities and easy access.

Green Prescription

In a 2010 doctoral thesis, Patel (2010) discusses the motives, benefits and barriers of the Green Prescription for older adults in New Zealand (Patel et al 2010). The population investigated was 330 healthy community dwelling adults aged 65 years or older (range 65 to 91 years). The interventions were two versions of the Green prescription, a time based

compared with a step count (using a pedometer) version. Both interventions showed a significant decrease in depression and a significant increase in general mental health functioning. There were no statistical differences between the two versions of the Green Prescription. Both versions of the intervention increased most categories of physical activity after three months. In a subgroup of 80 subjects, the addition of a pedometer did not provide any additional motivational benefit. The highest ranked motivator was enjoyment in the physical activity and the highest ranked benefit was an improvement in health. Weather and pain were the highest ranked barriers to participation (Patel et al 2010).

The 2010 Green Prescription survey results (personal communication Diana O'Neill, 06.10.2010) indicated that the three most common reasons for referral to a Green Prescription in those aged 65 years and older was due to arthritis (38% compared with 24% overall), high blood pressure or risk of stroke (37% compared with 31% overall) and heart problems (23% compared with 14% overall). Falls prevention accounted for 16% of referrals (compared with 7% overall). Sixty-seven percent of the participants aged 65 or over were women. Adherence to the Green Prescription physical activities is 44% (40%) overall. Reasons cited for not continuing were mainly to do with injury or health problems, fatigue or lack of time. Sixty-seven percent of respondents (aged 65 years or more) reported positive changes in their health since getting their Green Prescription. Compared to baseline almost half of those aged 65 years or older reported spending more time being physically active. The four main activities suggested by the Green Prescription were walking (68%); swimming (37%); water or pool exercises (32%) and/or gym exercises (31%).

Two of the identified randomised controlled trials examined the effectiveness of a Green Prescription prescribed through primary care (Kerse et al 2005; Lawton et al 2008). One of the trials randomised 1089 previously sedentary women into a brief, nurse led, physical activity intervention (Green Prescription) compared with usual care. At 12 months follow-up a significantly greater ($P < 0.001$) proportion of women in the intervention group (43%) had reached the recommended target of 150 minutes of moderate intensity physical activity per week compared with the control group (30%). The effect persisted at 24 months follow-up (39% versus 33% respectively). Quality of life also was reported to improve in the intervention group. There were, however, more falls ($P < 0.001$) and injuries ($p = 0.03$) reported in the intervention group over the 24 month follow-up and there were no significant differences in clinical or biochemical variables (Lawton et al 2008).

In another trial of the Green Prescription, 270 sedentary people aged over 65 years were randomised to receive brief counselling from a primary care giver followed by telephone support from exercise specialists compared with usual care. The intervention was found to increase physical activity and energy expenditure, improve health related quality of life and significantly ($P < 0.03$) decrease hospitalisations (Kerse et al 2005).

The nationally-implemented Green Prescription has also been evaluated using a survey method (Croteau et al 2006; Sinclair et al 2007b) and qualitative analysis (Elley et al 2007).

In the first survey, the majority of participants had completed at least 10 months of the intervention prior to the survey which reported that 56% of participants had an increase in physical activity levels under the Green Prescription and 70% were still engaged in some form of physical activity (Sinclair et al 2007b). Sixty-five percent of the participants were aged between 50 and 79 years of age. Increased activity was associated with greater perceived

health benefits, and effective and ongoing support networks were viewed as important factor in change. Eighty percent of those surveyed reported that they ‘felt better’ after participating in the Green Prescription intervention (Sinclair et al 2007b). The response rate of this survey was only 47% and thus the outcomes should be interpreted with some caution.

The second survey reported that 12.5% of respondents aged over 60 years had received advice on physical activity from primary care in the previous 12 months and 3.2% had received a Green Prescription (Croteau et al 2006). Older adults were less likely to receive advice ($P < 0.001$) and more likely to receive a Green Prescription ($P = 0.002$) than younger adults (Croteau et al 2006). The survey also reported that Māori and Pacific peoples were more likely to receive physical activity advice, although this was not stratified by age (Croteau et al 2006).

In the qualitative analysis of 15 sedentary adults participating in a Green Prescription trial, four themes emerged. These were tailoring advice, barriers, motivators and significant others. The latter three themes are discussed above under barriers and enablers. Tailored advice was more acceptable but needs to be realistic and match expectations and capabilities (Elley et al 2007).

Other research findings

New Zealand specific data on falls in older people and the randomised study conducted by Kerse (Kerse et al 2009) is reported in chapter 8 of this report with regard to risks and harms associated with physical activity.

Telephone counselling compared with usual care was reported in a randomised controlled trial of 186 low active adults aged 65 years or older (Kolt et al 2007a). There was also supplementary written material that had been individually tailored to the participant. At 12 months follow-up leisure physical activity was significantly increased ($P < 0.007$) in the intervention group. Significantly more participants in the intervention group reached the recommended 150 minutes of moderate or vigorous leisure physical activity per week after 12 months (42% versus 23%, odds ratio 2.9, 95% confidence interval 1.33–6.32, $P < 0.007$). The trial did not identify any greater risk of falling in the intervention group over the 12-month follow-up (Kolt et al 2007a).

One of the randomised controlled trials found no differences in mood and mental health outcomes in a trial of a home based physical activity intervention (moderate intensity balance retraining, progressive lower limb resistance and walking) compared with social contact with no physical activity in participants aged 75 years and older. There was no inactive control in this trial (Kerse et al 2010) and the findings may be more to do with social contact, which occurred in both groups, having an effect on mental wellbeing in the older adult.

There were no differences in outcomes between intervention and control groups in a six-week trial of a sit-to-stand device compared with low intensity knee extension exercises in 121 volunteers aged 80 years or older (Rosie et al 2007). The intervention group also received additional telephone support. Although several falls were reported, none were attributed to the exercises (Rosie et al 2007). It should be noted that the study population were volunteers and therefore unlikely to be representative of the general population. The study was not considered to be of good quality.

A case series study of 62 ambulatory people aged 65 years and over reported that only 18% of participants accumulated 30 minutes if physical activity on five or more days of the week as measured by continuous heart rate monitoring (Sinclair et al 2007a). The least active were those aged 80 years or over for whom only 10% were able to meet the recommended target (Sinclair et al 2007a).

One of the included surveys (Mummery et al 2007) concluded that physical activity was not the only lifestyle behaviour that needed targeting to improve the health of older New Zealanders. The survey of 1894 adults aged over 60 years identified a negative association between physical activity and smoking or obesity and a positive association with fruit and vegetable consumption. The survey identified that 18.3% of older adults were classified as inactive, 51.4% reported participating in regular physical activity and 30.7% participating in vigorous activity. Those aged over 80 years were more likely to be inactive than those age 60 to 64 years, women were more inactive than men and those living in rural areas were more likely to be physically active than those living in cities (Mummery et al 2007).

SPARC (2005) recognised that strategic planning for physical activity at a regional and district level was key to improving the nation's physical activity levels. The report was not age specific. SPARC acknowledged the uniqueness of the New Zealand population and noted that each geographical area had difference issues, deprivations and opportunities which had to be addressed in order to increase participation in physical activity.

With this in mind SPARC commissioned the New Zealand Recreation Association to support strategic planning for physical activity in all age groups by way of liaison, advice and administration. Pilot studies were initiated in Canterbury, Waikato, Taranaki and Tasman. Other regional strategies were completed in Hawkes Bay, Southland and at District level in Wairarapa, Timaru, Rangitikei, Thames Coromandel, Masterton/Carterton, Nelson/Tasman. The key feedback from the pilot studies above included the need for strategy structure, linking strategies with evidence and identifying issues that could be addressed collaboratively. Strategy content needed to include a demonstration an understanding of the human aspect of physical activity and socio-ecological influences. Physical activity strategies should be linked to existing strategies for health promotion and community outcomes and there should be an audit of current provision. When planning implementation strategies there is a need for realistic programmes and timeframes, clear accountabilities and a monitoring group.

Examples of proven interventions included community wide campaigns such as 'Push-Play', individually tailored programmes such as the Green Prescription, social support interventions in the community that create improved social networks (walking and cycle groups), and improving access to places for physical activity based on location, cost, relevance and accessibility (SPARC 2005).

Specific matters pertaining to Māori

Epidemiology

Based on the 2006 Census data, Māori aged 65 years or older comprised 4.7% of the population, an increase from 3.4% in 2001 (http://www.stats.govt.nz/census.aspx; accessed 14.10.2010). Māori generally already have high levels of physical activity. Data from the 2006/07 New Zealand Health Survey (Gerritsen et al 2008) indicated that 53.5% of all Māori met the national guidelines.

Physical activity provides a unique opportunity to advance Māori interests and to address other poor indicators of health status among Māori (Ministry of Health 2003).

Popular physical activity

The Active NZ survey identified touch rugby and rugby as the most popular physical activities for Māori adults (age not specified).

Participation

One-third (34.5%) of adults over 65 years were a member of a club or centre compared with the total population (34.9%); Māori have a higher percentage membership (37.7%) (SPARC 2008).

Sedentary behaviour

The New Zealand Health Survey indicated that after adjusting for age the overall prevalence of sedentary behaviour for Māori is 8.7% (95%CI 7.4–10) (Gerritsen et al 2008).

Leisure time satisfaction

Older people aged 65 years and over reported the highest levels of overall satisfaction with their leisure time (90%) (Ministry of Social Development 2009). Most New Zealanders, regardless of their ethnicity, were satisfied with their leisure time. In 2008, 75% of Māori expressed satisfaction with their leisure time, a level similar to that of Europeans (76%) and Pacific peoples (74%) (Ministry of Social Development 2009).

Barriers and enablers

Pringle's qualitative study of Māori, Pacific, and European New Zealanders, which reported on barriers and enablers, is reported above and in chapter 7 (Pringle 2008).

Bowers and colleagues (Bowers 2009) key informant interviews (which included three Māori health practitioners) identified that many programmes were not responsive to the diverse realities of Māori people. A lack of culturally appropriate physical activity programmes was seen as a barrier to participation.

The same study found that to be in a better position to help Māori older people, it is important that programmes: 1) are based on the principles of the Treaty of Waitangi; 2) are culturally appropriate (ie, be delivered by Māori for Māori); 3) include facilitators trained on marae; 4) have elements based on an understanding of tikanga or other Māori philosophies. (Bowers 2009).

Specific matters pertaining to Pacific people

Epidemiology

In the 2006 Census there were 10,083 people aged over 65 years of age identified as Pacific peoples (4%). This was an increase from 3% of the population in 1996. Of significance, is that the number of Pacific peoples in New Zealand aged 65 years and over is expected to increase by more than 400% over the next 50 years (approximate increase to 50,415), the greatest increase of any ethnic population (Ministry of Health 2002).

Data from the 2006/07 New Zealand Health Survey (Gerritsen et al 2008) indicated that 52.6% of all Pacific peoples met the national guidelines.

Popular physical activity

The Active NZ survey identified that touch rugby, volleyball, rugby and basketball are popular physical activities for Pacific adults (age not specified).

Participation

Compared with the total population, all ethnic groups achieved a similar percentage estimate for participation in at least one sport or recreation activity, but participation in three or more activities was lower among Pacific adults (SPARC 2008).

Sedentary behaviour

The New Zealand Health Survey indicated that after adjusting for age the overall prevalence of sedentary behaviour in Pacific adults was 13.9% (95%CI 11.7–16.2). Pacific adults were more likely to be sedentary than the whole population (Gerritsen et al 2008).

Leisure time satisfaction

Older people aged 65 years and over reported the highest levels of overall satisfaction with their leisure time (90%) (Ministry of Social Development 2009). Most New Zealanders, regardless of their ethnicity, were satisfied with their leisure time. In 2008, 74% of Pacific people expressed satisfaction with their leisure time, a level similar to that of Europeans (76%) and Māori (75%) (Ministry of Social Development 2009).

Barriers and enablers

The literature on New Zealand specific barriers, reported in chapter 7 indicated the following barriers apply to Pacific older people (as well as to Asian people): lack of motivation or interest and perceived health or physical function limitations and concerns; lack of education; older people not wanting others to see them exercise; older people's role in looking after domestic needs of younger family members; a lack of encouragement for physical activity earlier in life; fear of injury; inclement weather and inadequate or inconvenient facilities.

Pringle's qualitative study of Māori, Pacific, and European New Zealanders, which reported on barriers and enablers, is reported above and in chapter 7 (Pringle 2008).

In a survey conducted through Sport and Recreation New Zealand (SPARC), one subgroup ('other oriented') represented approximately 6% of the population and comprised one third Asian and Pacific peoples. Cultural appropriateness of activities and communication was identified as key for this group who had the highest rate of perceived barriers to participation. They noted a lack of support, knowledge, and financial constraints, and found facilities difficult to get to. Despite this there was an acknowledgement of the importance of physical activity although only one out of six respondents felt they could reach a target of 30 minutes for five days a week (Sullivan et al 2003).

A physical activity guide as part of the National Pacific Diabetes initiative (Ministry of Health nd) provided some useful insight into concepts of physical activity among Pacific peoples in New Zealand. The constructs of health within the Pacific community are very holistic and group activities or recreational activities are viewed within the social context rather than as a form of exercise. The central role of the church, family and community is acknowledged and the extended family unit is the traditional support for the older adult. Trying to promote physical activity without the support of community and church leaders is likely to fail. Culturally specific media to transmit the healthy message should be based around visual media and the use of narrative.

The literature on New Zealand specific enablers, reported in chapter 7, also indicated only that governmental efforts, medical and health professionals and leaders from the church could be influential to encourage physical activity participation in older Tongan people. Many of the enablers from the New Zealand literature were similar to those that applied internationally and so can be assumed to apply to Pacific people as well. This is supported in The Ala Mo'ui: Pathways to Pacific Health and Wellbeing 2010–2014 (Minister of Health et al 2010) strategy. This document emphasises the important role of Pacific church initiatives in increasing physical activity in their community.

Specific matters pertaining to Asian people

Epidemiology

Data from the 2006/07 New Zealand Health Survey indicated that, following age adjustment, Asian men and women were less likely to meet the recommendation of 30 minutes of physical activity on five or more days of the week compared to men and women in the total population (Gerritsen et al 2008; SPARC 2008).

Popular physical activity

The Active NZ survey identified that pilates/yoga, badminton and basketball are popular physical activities for Asian adults (age not specified).

Participation

Compared with the total population, all ethnic groups achieved a similar percentage estimate for participation in at least one sport or recreation activity, but participation in three or more activities was lower among Asian adults (SPARC 2008).

One-third (34.5%) of adults over 65 years were a member of a club or centre compared with the total population (34.9%); Asians have a lower percentage membership (29.2%) (SPARC 2008).

Sedentary behaviour

The New Zealand Health Survey indicated that after adjusting for age the prevalence of sedentary behaviour in Asian adults was 15.5% (95%CI 13.5–17.6). Asian adults were more likely to be sedentary than the whole population (Gerritsen et al 2008).

Leisure time satisfaction

Older people aged 65 years and over reported the highest levels of overall satisfaction with their leisure time (90%) (Ministry of Social Development 2009). Older people aged 65 years and over reported the highest levels of overall satisfaction with their leisure time (90%) (Ministry of Social Development 2009). Most New Zealanders, regardless of their ethnicity, were satisfied with their leisure time. In 2008, 70% of Asians expressed satisfaction with their leisure time, a level slightly lower than that of Europeans (76%) and Māori (75%) and Pacific peoples (74%) (Ministry of Social Development 2009).

Barriers and enablers

The literature on New Zealand specific barriers, reported in chapter 7 indicated the following barriers apply to Asian older people (as well as to Pacific people): lack of motivation or interest and perceived health or physical function limitations and concerns; lack of education; older people not wanting others to see them exercise; older people's role in looking after domestic needs of younger family members; a lack of encouragement for physical activity earlier in life; inclement weather and inadequate or inconvenient facilities.

In a survey conducted through Sport and Recreation New Zealand (SPARC), one subgroup ('other oriented') represented approximately 6% of the population and comprised one third Asian and Pacific peoples. Cultural appropriateness of activities and communication was identified as key for this group who had the highest rate of perceived barriers to participation. They noted a lack of support, knowledge, and financial constraints, and found facilities difficult to get to. Despite this there was an acknowledgement of the importance of physical activity although only one out of six respondents felt they could reach a target of 30 minutes for five days a week (Sullivan et al 2003).

A physical activity guide as part of the National Pacific Diabetes initiative (Ministry of Health nd) provided some useful insight into concepts of physical activity among Pacific peoples in New Zealand. The constructs of health within the Pacific community are very holistic and group activities or recreational activities are viewed within the social context rather than as a form of exercise. The central role of the church, family and community is acknowledged and the extended family unit is the traditional support for the older adult. Trying to promote physical activity without the support of community and church leaders is likely to fail. Culturally specific media to transmit the healthy message should be based around visual media and the use of narrative.

The literature on New Zealand specific enablers, reported in chapter 7, did not specifically deal with Asian people, but many of the barriers and enablers were similar to those that applied internationally and so can be assumed to apply to Asians as well.

Older Asian Indians were also found to have a mismatch between perceived weight and actual weight (Schofield et al 2006). Although 60% of the New Zealand sample were overweight or obese only 17% considered themselves to be so. Almost half (48.7%) of the 112 participants in this cross-sectional study reported that they had engaged in some form of physical activity or exercise with the aim of weight reduction in the previous month (Schofield et al 2006).

Amount of activity

In a study of Asian Indians residing in New Zealand (Kolt et al 2007b) physical activity levels were found to be low as measured by pedometer steps. On average the sample of 112 took a mean of 5977 steps daily (SD 3560). There was a high prevalence of risk factors for lifestyle related diseases identified which included inactivity and body composition (Kolt et al 2007b).

Specific matters pertaining to sex

Data from the 2006/07 New Zealand Health Survey (Gerritsen et al 2008) indicated that half of all adults (50.5%, 95%CI 49.2–51.9) met the definition of being regularly physically active. Men (55.1%, 95%CI 53.4–56.9) were significantly more likely than women (47.9%, 95%CI 46.0–49.8) to do at least 30 minutes of physical activity a day on five or more days of the week, adjusted for age (Gerritsen et al 2008). Similar results were reported in the 2007/2008 Active NZ survey (SPARC 2008) (N = 4443, age ≥ 16 years), 48.2% (women, 44%; men, 52%) of adults achieved New Zealand's national physical activity guideline target (SPARC 2008).

Men remained physically active for longer than women. Men over 75 years of age were more likely to report regular physical activity than women of the same age (40.6% versus 26.3% respectively) (Gerritsen et al 2008). The proportion engaging in physical activity decreased to 30.4% for those aged 65 years or older as reported in the Active NZ Survey (SPARC 2008).

After adjusting for age 11% of women and 7% of men were sedentary. Women were more likely to be sedentary than men with increasing age and the New Zealand Health Survey reported that one-third of women aged over 75 years were classified as sedentary (Gerritsen et al 2008).

Conclusion

New Zealanders over 80 years were found to be the least active (Sinclair et al 2007b; Gerritsen et al 2008; Mummery et al 2007) and women were more likely to be less active than men (Gerritsen et al 2008; Mummery et al 2007; Sinclair et al 2007b). The most common activities engaged in by older people were walking and gardening (SPARC 2008).

Interventions such as the Green Prescription appeared to be effective in increasing the amount of physical activity undertaken by community dwelling older people in New Zealand (Kerse et al 2005; Lawton et al 2008) and was associated with greater perceived health benefits (Sinclair et al 2007a). There may be some concerns over increased incidence of adverse events associated with the intervention as reported in one of the trials (Lawton et al 2008). As described in chapter 8 the incidence of injuries is relatively low compared with the person hours of participation in physical activity and the adverse events are rarely life threatening. Primary care settings appear to provide an important opportunity to promote physical activity advice in older people in New Zealand. Some interventions do not appear to necessitate face to face interaction but can be effective as a telephone intervention (Kerse et al 2005; Kolt et al 2007a).

Although the evidence identified within New Zealand indicated a benefit in a variety of interventions to promote physical activity in older people, the financial implications for this population (for the intervention, cost of harms or decreased costs associated with benefits) are not well discussed in the literature.

Māori are no less active than the overall population, the focus should therefore be to help provide culturally acceptable physical activity to continue the uptake of physical activity. Examples of popular activities were indicated in the Active NZ Survey (SPARC 2008). Some ethnic groups, in particular Asian groups and Pacific people, require specific targeting (due to lower than average uptake of physical activity) either based on risk factors for inactivity or culturally specific targets to promote physical activity. Examples of popular activities specific to these ethnic groups were indicated in the Active NZ Survey (SPARC 2008). The evidence emphasised the importance of culturally specific and appropriate information and messaging presented through culturally appropriate members of the community.

The key barriers identified for older New Zealanders appear to include education, financial constraints, physical/built environment, lack of cultural appropriateness and medical/physical limitations.

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11 Search strategies

Search strategies

The following search strategies were run in PubMed and/or MEDLINE and were adapted to the other electronic databases.

Chapters 4–7

MESH terms and synonyms:

- Motor activity
  - Activities, motor
  - Activity, motor
  - Motor activities
  - Physical activity
  - Activities, physical
  - Activity, physical
  - Physical activities
  - Locomotor activity
  - Activities, locomotor
  - Activity, locomotor
  - Locomotor activities
- Physical activity
  - Activities, motor
  - Activity, motor
  - Motor activities
  - Physical activity
  - Activities, physical
  - Activity, physical
  - Physical activities
  - Locomotor activity
  - Activities, locomotor
  - Activity, locomotor
  - Locomotor activities
- Exercise
  - Exercises
  - Exercise, physical
  - Exercises, physical
  - Physical exercise
  - Physical exercises
  - Exercise, isometric
  - Exercises, isometric
  - Isometric exercises

  - Isometric exercise
  - Warm-up exercise
  - Exercise, warm-up
  - Exercises, warm-up
  - Warm up exercise
  - Warm-up exercises
  - Exercise, aerobic
  - Aerobic exercises
  - Exercises, aerobic
  - Aerobic exercise
- Physical exertion
  - Exertion, physical
  - Exertions, physical
  - Physical exertions
  - Physical effort
  - Effort, physical
  - Efforts, physical
  - Physical efforts
- Sports
  - Sport
  - Athletics
  - Athletic
- Physical fitness
  - Fitness, physical
  - Physical conditioning, human
  - Conditioning, human physical
  - Conditionings, human physical
  - Human physical conditioning
  - Human physical conditionings
  - Physical conditionings, human
- Sedentary lifestyle
  - Lifestyle, sedentary
  - Lifestyles, sedentary
  - Sedentary lifestyles
- Aged
  - Elderly
- Aged, 80 and over
  - Oldest old
  - Nonagenarians
  - Nonagenarian
  - Octogenarians
  - Octogenarian

  - Centenarians
  - Centenarian
- Frail elderly
  - Elderly, frail
  - Frail elders
  - Elder, frail
  - Elders, frail
  - Frail elder
  - Functionally-impaired elderly
  - Elderly, functionally-impaired
  - Functionally impaired elderly
  - Frail older adults
  - Adult, frail older
  - Adults, frail older
  - Frail older adult
  - Older adult, frail
  - Older adults, frail

Database: Ovid MEDLINE(R) <1996 to September Week 4 2010>
Search Strategy:
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1 exp exercise/ (40830)
2 physical exertion/ (8320)
3 exp sports/ (54037)
4 motor activity/ (32969)
5 dancing/ (740)
6 gardening/ (257)
7 physical fitness/ (9753)
8 “Physical Education and Training”/ (3742)
9 dance therapy/ (91)
10 exercise movement techniques/ (202)
11 Tai Ji/ (365)
12 yoga/ (615)
13 exp exercise therapy/ (12214)
14 exercis* or sport* or walk* or jog* or run or running or swim* or golf* or cycl* or bicycl* or gardening).ti. (136673)
15 (physic* adj3 (activit* or fit or fitness or train* or activ* or endur*)).tw. (38290)
16 (aerobic* or weightlift* or weight lift* or resistance train*).tw. (27207)
17 “Aged, 80 and over”/ or Aged/ (1032583)
18 (elder* or senior* or geriatric).mp. [mp=title, original title, abstract, name of substance word, subject heading word, unique identifier] (112176)
19 health services for the aged/ (7053)
20 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 (268218)
21 17 or 18 or 19 (1057059)
22 20 and 21 (35357)
23 exp Heart Diseases/pc [Prevention & Control] (31216)
24 exp Hypertension/pc [Prevention & Control] (4294)
25 Diabetes Mellitus, Type 2/pc [Prevention & Control] (3219)
26 exp Neoplasms/pc [Prevention & Control] (41880)

27 exp Stroke/pc [Prevention & Control] (7091)
28 exp Osteoporosis/pc [Prevention & Control] (5598)
29 exp Osteoarthritis/ (19529)
30 exp Depression/pc [Prevention & Control] (1322)
31 Mobility Limitation/ (1037)
32 Movement Disorders/pc [Prevention & Control] (70)
33 Accidental Falls/pc [Prevention & Control] (3420)
34 Disabled Persons/ (11788)
35 Weight Loss/ (13993)
36 weight gain/ (12968)
37 obesity/pc (6863)
38 Overweight/pc [Prevention & Control] (419)
39 exp Body Composition/ (18889)
40 exp Cardiac Output/ (19497)
41 Blood Pressure/ (78012)
42 exp Insulin Resistance/ (31007)
43 Self Efficacy/ (7907)
44 Sleep/ (12641)
45 exp sleep disorders/pc (973)
46 Stress, Psychological/pc [Prevention & Control] (3257)
47 Interpersonal Relations/ (22184)
48 Social Isolation/ (3698)
49 Muscle Strength/ (3787)
50 exp Physical Endurance/ (13759)
51 exp Psychomotor Performance/ (43810)
52 Reaction Time/ (40153)
53 Postural Balance/ (7298)
54 Gait/ (8221)
55 or/23-54 (429990)
56 22 and 55 (11508)

PubMed initial search:

((“motor activity”[MeSH Terms] OR “exercise”[MeSH Terms]) OR “physical exertion”[MeSH Terms]) OR “sports”[MeSH Terms] AND (“loattrfull text”[sb] AND “loattrfree full text”[sb] AND hasabstract[text] AND “humans”[MeSH Terms] AND (“male”[MeSH Terms] OR “female”[MeSH Terms]) AND (Clinical Trial[ptyp] OR Meta-Analysis[ptyp] OR Randomized Controlled Trial[ptyp] OR Review[ptyp] OR Controlled Clinical Trial[ptyp] OR Journal Article[ptyp]) AND English[lang] AND (jsubsetaim[text] OR jsubsetn[text]) AND (“aged”[MeSH Terms] OR “aged, 80 and over”[MeSH Terms]) AND (“2004”[PDAT] : “2010”[PDAT])) = 517 returns

EBSCOhost initial search (including PsycINFO, CINAHL Plus with full text, PsycARTICLES, SPORTDiscus:

SU older adult OR SU aged
AND SU physical activity OR SU exercise OR SU (sedentary or inactiv*)
AND AB (benefit OR risk OR barrier)
Limiters: full text; references available; published 2004 to 2010; peer reviewed journal; English language; Age groups- Aged (65 years and over), very old (85 years and older); population group- human; Intended audience- professional and research; Document type- journal article; Methodology- empirical study; Exclude dissertations; Abstract available; English Language; Research article; Human: Publication type- Journal article; Language- English. = 483 returns

Chapter 7 used the additional search terms: enabl*, facilitat*, motivat*, barrier*.

Chapters 4 to 7 used additional hand searches from reference lists, especially those in systematic reviews.

Chapter 8

Database: Ovid MEDLINE(R) In-Process, Ovid MEDLINE(R) Search Strategy:

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1 exp exercise/ or physical exertion/ (47165)
2 exp Sports/ (52660)
3 dancing/ or gardening/ (929)
4 Physical Fitness/ (9554)
5 “Physical Education and Training”/ (3694)
6 Dance Therapy/ (81)
7 exercise movement techniques/ or tai ji/ or yoga/ (1103)
8 exp Exercise Therapy/ (11831)
9 (exercis* or sport* or walk* or jog* or run or running or swim* or golf* or cycl* or bicycl* or gardening).ti. (147647)
10 (physic* adj3 (activit* or fit or fitness or train* or activ* or endur*)).tw. (39855)
11 (exercise* adj3 (train* or physic* or activ*)).tw. (14892)
12 (aerobic* or weightlift* or weight lift* or resistance train*).tw. (28398)
13 or/1-12 (258783)
14 limit 13 to english language (241636)
15 aged/ or “aged, 80 and over”/ or (elder$ or senior$ or geriatric).mp. (1051412)
16 adult/ or middle age/ or adolescent/ or child/ or child, preschool/ (2482097)
17 (youth* or adolescen* or teen* or boy* or girl* or child* or juvenil*).mp. (1036276)
18 16 or 17 (2600973)
19 18 not (18 and 15) (1794110)
20 15 not 19 (1051412)
21 14 and 20 (31141)
22 limit 21 to yr=“2004 -Current” (17519)
23 Risk Assessment/ (107319)
24 exp mortality/ (154894) [...new term added]
25 accidental falls/pc (3295)
26 accidents, home/pc (504)
27 exercise induced.tw. (6719)
28 ((expos* or activit* or exercis*) adj2 (harm or hazard or injur* or accident*)).tw. (2593)
29 risk reduction behavior/ (3714)
30 Safety/ (20809)
31 or/23-30 (287978)
32 22 and 31 (2010)
33 (letter or editorial).pt. (574126)
34 32 not 33 (1964)
35 evaluation studies as topic/ or program evaluation/ (53594)
36 “meta-analysis as topic”/ (8320)
37 meta-analysis/ (22577)
38 meta analy*.tw. (27635)
39 (systematic* adj (review* or overview*)).tw. (24193)
40 or/35-39 (109326)
41 22 and 40 (513)

Chapter 9

Database: Ovid MEDLINE(R) In-Process, Ovid MEDLINE(R) Search Strategy:

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1 exp exercise/ or physical exertion/
2 exp Sports/
3 dancing/ or gardening/
4 Physical Fitness/
5 “Physical Education and Training”/
6 Dance Therapy/
7 exercise movement techniques/ or tai ji/ or yoga/
8 exp Exercise Therapy/
9 (exercis* or sport* or walk* or jog* or run or running or swim* or golf* or cycl* or bicycl* or gardening).ti.
10 (physic* adj3 (activit* or fit or fitness or train* or activ* or endur*)).tw.
11 (exercise* adj3 (train* or physic* or activ*)).tw.
12 (aerobic* or weightlift* or weight lift* or resistance train*).tw.
13 or/1-12
14 limit 13 to english language
15 aged/ or “aged, 80 and over”/ or (elder$ or senior$ or geriatric).mp.
16 adult/ or middle age/ or adolescent/ or child/ or child, preschool/
17 (youth* or adolescen* or teen* or boy* or girl* or child* or juvenil*).mp.
18 16 or 17
19 18 not (18 and 15)
20 15 not 19
21 14 and 20
22 limit 21 to yr=“2004 -Current”
23 practice guidelines as topic/
24 guidelines as topic/
25 guideline*.ti.
26 ((position or scientific) adj statement*).tw.
27 working group*.tw.
28 Health Policy/
29 (health adj2 polic*).tw.
30 or/23-29
31 22 and 30

Chapter 10

Database: Ovid MEDLINE(R) In-Process, Ovid MEDLINE(R) Search Strategy:

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1 exp exercise/ or physical exertion/ (100341)
2 exp Sports/ (52660)
3 dancing/ or gardening/ (1596)
4 Physical Fitness/ (17633)
5 “Physical Education and Training”/ (10515)
6 Dance Therapy/ (146)
7 exercise movement techniques/ or tai ji/ or yoga/ (1543)
8 exp Exercise Therapy/ (21376)
9 (exercis* or sport* or walk* or jog* or run or running or swim* or golf* or cycl* or bicycl* or gardening).ti. (293683)
10 (physic* adj3 (activit* or fit or fitness or train* or activ* or endur*)).tw. (55947)
11 (exercise* adj3 (train* or physic* or activ*)).tw. (23168)
12 (aerobic* or weightlift* or weight lift* or resistance train*).tw. (46978)

13 or/1-12 (491051)
14 limit 13 to english language (427987)
15 aged/ or “aged, 80 and over”/ or frail elderly/ (1915523)
16 (elder* or senior* or geriatric*).tw (175526)
17 15 or 16 (1958632)
18 adult/ or middle age/ or adolescent/ or child/ or child, preschool/ (5216441)
19 (youth* or adolescen* or teen* or boy* or girl* or child* or juvenil*).mp. (2345235)
20 18 or 19 (5448680)
21 17 not 20 (432684)
22 14 and 21 (9416)
23 Māori*.af (1661)
24 New Zealand/ (23667)
25 New Zealand.cp,in,tw (96137)
26 or/23-25 (99573)
27 22 and 27(387)

12 Research questions

The following table details those broad questions that the Ministry of Health contracted NZGG and the University of Western Sydney to answer through this literature review.

RESEARCH QUESTIONS **A literature review of evidence on physical activity for older people & a review of existing international physical activity guidelines for older people.**
Evidence since 2004
Physical Activity and Older People
✓ Descriptive data on older peoples participation in physical activity (e.g sport and recreation, active transportation, occupation and incidental activities, patterns and types of activity) ✓ What are the benefits associated with physical activity for older people, for reducing the risk of disease and disability? ✓ What are the effectiveness of different types of physical activity in improving disease and disability outcomes in older people? ✓ What are the recommended modes (aerobic, resistance, balance and flexibility) of physical activity for older people? ✓ What specific levels (ie, duration, intensity, frequency) of physical activity improve health outcomes for older people? ✓ What are the risks associated with physical inactivity and sedentary behaviours for older people? ✓ What are the risks and safety issues for older people participating in physical activity? ✓ What are the barriers and enablers to physically activity in older adults? ✓ Are there any specific New Zealand considerations, including cultural factors that need to be explored (ie, advice for Māori, Pacific and Asian populations, chronic disease management, co-morbidities, health status of Māori and Pacific people through the life course, and possible need for policies/guidance for under 65 years)?
1990 to present
International policies or guidelines – national level Comparable countries to New Zealand, including, but not limited to, Australia, United Kingdom, United States of American, Canada, and some Scandinavian countries (Sweden, Norway, Finland and Denmark)
✓ What are the policies or guidelines on physical activity for older adults? Are there, key population level policies or guidelines for increasing physical activity in older people? ✓ What are the key similarities and differences amongst existing international policies and/or guidelines? ✓ What is the justification or evidence to support the existing international policies and/or guidelines? ✓ What are the key principles identified in these documents for successfully working with older people in a physical activity context? ✓ What measures should be taken to keep older people safe when participating in physical activity?
Note: Definitions of physical activity, older people and relevant terminology ✓ *Physical activity* refers to all movement produced by skeletal muscles that increases energy expenditure, whether it is incidental, occupational, leisure, structured or supervised. ✓ *Older people* refers to people over 65 years of age - Healthy older people - Older people with disease and/or disability that are independent - Frail older people (Older people with disease and/or disability that are dependent)

Glossary

Where possible, the following definitions are based on those outlined in “Physical Activity and Health”, the 1996 report of the United States Surgeon General [US Surgeon General 1996]. Where not defined by the Surgeon General Report, definitions are based on relevant literature in our review.

Aerobic endurance physical activity

This consists of rhythmic, repeated, and continuous movements of the same large muscle groups for at least 10 minutes at a time. Examples include walking, bicycling, jogging, continuous swimming, water aerobics, and many sports. When performed at sufficient intensity and frequency, this type of physical activity increases cardio-respiratory fitness.

Aerobic endurance physical activity intervention

A structured programme involving continuous movement of large muscle groups, sustained for a minimum of 10 minutes.

Barriers

This term refers to factors, either real or perceived, that may interfere with an older person’s ability to partake in physical activity.

Benefits

This refers to positive outcomes derived from participation in physical activities. Benefits may consist of improvements to physical health, mental health, quality of life, or other.

Cardio-respiratory fitness

Also known as cardio-respiratory endurance, aerobic endurance, or aerobic fitness.

The ability of the circulatory and respiratory systems to supply oxygen during sustained physical activity. The gold standard for measurement of cardiorespiratory fitness is a test of maximal oxygen uptake (eg, Vo_{2max}, Vo_{2peak}).

Effectiveness

Demonstrated statistically significant differences in study outcomes between intervention and control groups within randomised controlled trials. For systematic reviews, effectiveness is similarly based on statistically significant differences and/or author conclusions from the review of interventions.

Enablers

This term refers to factors, either real or perceived, that may facilitate an older person's ability to partake in physical activity. Enablers also include motivators or positive motivations for physical activity.

Exercise

A subset of physical activity: planned, structured, and repetitive bodily movement performed to improve or maintain one or more components of physical fitness. In the present review, the terms 'physical activity' and 'exercise' are often used interchangeably, often determined by use of terms in the literature being reviewed. It should be noted, however, that physical activity is a broader and encompassing term.

Flexibility

This term refers to the range of motion available at joints.

Flexibility exercise

This is exercise (typically stretching) aimed at increasing or maintaining range of motion at joints.

Frail old

People over the age of 65 years who are subject to a loss of physical function, combined with a set of linked deteriorations including, but not limited to, the musculoskeletal, cardiovascular, metabolic, and immunologic systems (frailty).

Health outcome

Health outcomes may include markers of physiological change, disease, death, health, functioning, disability, or physical condition.

Intensity of aerobic endurance physical activity

This will be described as 'moderate' when it is at 40–60% of Vo_{2max} (~50–70% of maximum heart rate) and 'vigorous; when it is at >60% of Vo_{2max} (>70% of maximum heart rate).

Intensity of resistance training

This is frequently described as 'high' if the resistance is 75–80% of the maximum that can be lifted a single time (75–80% of 1RM, the 1 repetition maximum) and 'moderate' if resistance is 50–74% of 1RM. Low intensity resistance training is frequently performed at or around 20% of one-repetition maximum.

MET (metabolic equivalent)

A MET is a unit of intensity equal to energy expenditure at rest. Physical activity at 3 METs uses three times more energy than stationary sitting. MET-hours are units of physical activity volume in which intensity in METs is multiplied by duration of the activity in hours.

Mixed physical activity intervention

A structured programme involving one or more types of physical activity intervention: aerobic endurance, resistance training, and mobility and balance.

Mobility and balance physical activity intervention

A structured programme involving multiple intermittent movements that focus on: maintaining control of the body to avoid falling; improving gait or function; and building co-ordination, flexibility, and muscular strength and endurance.

Muscular fitness

This refers to strength (the amount of force a muscle can exert) and muscular endurance (the ability of the muscle to continue to perform without fatigue).

Older adults or older people

Throughout this report, we refer to older people as those who are 65 years of age and over.

Physical activity

Bodily movement produced by the contraction of skeletal muscle that requires energy expenditure in excess of resting energy expenditure. Physical activity can be categorised according to frequency, intensity, type, and duration. Physical activity can also be classified into occupational, household, leisure-time, and transport-related.

Physical fitness

This includes cardio-respiratory fitness, muscular fitness, and flexibility.

Physical inactivity

This term represents a lifestyle pattern in the older person that does not include regular physical activity. Also referred to as inactive, low active or sometimes called sedentary lifestyle.

Quality of life

A subjective overall feeling of wellbeing or satisfaction with life, and includes the facets of physical, emotional, social, functional, and spiritual wellbeing.

Resistance training

Activities that use muscular strength to move a weight or work against a resistive load. Examples include weight lifting and exercises using weight machines or body weight. When performed with regularity and moderate to high intensity, resistance training increases muscular fitness.

Resistance training physical activity intervention

A structured programme involving multiple intermittent movements of large or small muscle groups, performed repetitively and with resistance to movement.

Sedentary behaviour

The amount of time spent sitting or in low levels of energy expenditure, within a specified timeframe.