At least five a week

Evidence on the impact of physical activity and its relationship to health

A report from the Chief Medical Officer

READER INFORMATION

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Description	A high level DH document that presents the evidence on the relationship between physical activity and health. It is particularly aimed at the NHS, specifically public health and PCTs. The report will set out the latest research evidence of the benefits of physical activity for health. The document is aimed at those concerned with formulating and implementing policies or programmes that utilise the promotion of physical activity, sport, exercise and active travel to achieve health gain.
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Call for action

I highlighted, in my report *Health Check: on the state of public health* in 2002,[1] the growing epidemic of obesity – now a major health concern. Since then, the issue has risen up the public agenda, with considerable media attention on the wider health risks of our sedentary lifestyles in the industrialised 21st century. However, the Government must act on the basis of evidence, and that is why I commissioned this analysis of the scientific evidence on the links between physical activity and health.

In his report *Securing good health for the whole population*,[2] Derek Wanless proposed a key role for Government in ensuring that the public has proper information on which to take decisions regarding their health. This report provides the evidence on which health professionals and others can advise the public, and it provides a basis for Government intervention to create greater opportunities for children and adults to be more physically active.

The message in this report is clear. The scientific evidence is compelling. Physical activity not only contributes to well-being, but is also essential for good health. People who are physically active reduce their risk of developing major chronic diseases – such as coronary heart disease, stroke and type 2 diabetes – by up to 50%, and the risk of premature death by about 20-30%. The annual costs of physical inactivity in England are estimated at £8.2 billion – including the rising costs of treating chronic diseases such as coronary heart disease and diabetes. This does not include the contribution of inactivity to obesity – an estimated further £2.5 billion cost to the economy each year.

This report must be the wake-up call that changes attitudes to active lifestyles in every household. Being active is no longer simply an option – it is essential if we are to live healthy and fulfilling lives into old age.

The recommendations for physical activity are supported by the scientific evidence. For general health, a total of at least 30 minutes a day of at least moderate intensity physical activity on five or more days of the week reduces the risk of premature death from cardiovascular disease and some cancers, significantly reduces the risk of type 2 diabetes, and it can also improve psychological well-being.

The research demonstrates that the 30 minutes of physical activity necessary for health benefit can be built up in bouts of 10 minutes or more. For example, it can be made up of three 10-minute brisk walks rather than catching the bus for short journeys.

The recommendation for adults of at least 30 minutes of activity a day is for general health. However, it is likely that, for many people, 45-60 minutes of moderate intensity physical activity a day will be needed to prevent obesity.

For children and young people, a total of at least 60 minutes of at least moderate intensity physical activity each day is needed, and at least twice a week this should include activities to improve bone health (activities that produce high physical stresses on the bones), muscle strength and flexibility.

The evidence also clearly demonstrates that achieving the weekly recommendation is not the preserve of the sports enthusiast. We all can and should be more active.

A shift in society's attitudes and behaviour

The evidence of the potential health gains from active lifestyles is clear. We now need a culture shift to achieve these goals. Changing inactive lifestyles and levels of inactivity presents a tremendous public health challenge – a challenge we must rise to if we are to improve health. The solution does not lie in any single innovation. Nor does it lie in advances in medical science. Current levels of physical activity are a reflection of personal attitudes about time use and of cultural and societal values. They also reflect how conducive our homes, neighbourhoods and environments have become for more inactive living.

A mass shift in current activity levels is needed. This will only be achieved if people see and want the benefits but also if opportunities are created by changing the physical and cultural landscape – and building an environment that supports people in more active lifestyles. If people of all ages can be engaged in a new way of thinking about active lifestyles, better health can be a realistic goal for all. Physical activity needs to be seen as an opportunity – for enjoyment, for improved vitality, for a sense of achievement, for fitness, for optimal weight, and – not least – for health. It needs to be seen as enjoyable, and as fun – not as unnecessary effort. Perceptions also need to be changed – too many people think they are already active enough.

Current action

We are not starting from scratch. Many of these challenges are already receiving serious attention.

Game Plan,[3] a strategy for delivering Government's sport and physical activity objectives, jointly published in 2002 by the Department for Culture, Media and Sport and the Prime Minister's Strategy Unit, places a major focus on the health gains that could be achieved through increased participation in physical activity. The Activity Coordination Team – established in 2003 to address these issues, and jointly chaired by Ministers from the Department of Health and Department for Culture, Media and Sport – has engaged departments across Whitehall, at the highest level, towards a coordinated physical activity strategy for England. And in March 2004 the Government's announcement of a White Paper on public health signalled a new commitment to address these issues.

Promoting physical activity is a cross-government issue, and a priority for several departments. Already there is significant investment, at national and local levels, to increase participation in physical activity and more active living, and many schemes are already in place. For example, the Department for Culture, Media and Sport and the Department for Education and Skills are investing heavily in improving physical education and school sport with a goal of increasing opportunities for 5-16 year olds in schools. Department for Transport strategies to support increased cycling and walking will also contribute to an environment that promotes, rather than inhibits physical activity. The health importance of physical activity, exercise and sport, is recognised in the *NHS Plan* and in the National Service Frameworks for the NHS. The Health Development Agency has published reviews of the evidence on effective interventions to address activity (see Appendix 3) as well as obesity.

The future: choosing a more active lifestyle

But more needs to be done. Effective solutions need the engagement of a wide range of agencies. No single organisation will have sufficient impact alone. We will need concerted effort from a range of key partners – Government (at national, regional and local levels), leisure and sports services, schools and colleges, town and regional planners, transport planners and providers, architects, countryside agencies, the NHS and social care, voluntary and consumer groups, employers and the media. All will need to work in a coordinated and comprehensive way to influence the way we live.

The following suggestions provide potential areas for action.

Government

- Government to provide leadership, direction and accountability. Almost all government departments have a role to play.

Regions

- Regional Directors of Public Health to provide leadership, working with others in the regional Government Offices, including Regional Sports Boards and leisure services, transport planners and providers, regional development agencies, and industry, to develop and deliver an evidence-based regional physical activity plan, and monitor progress.

The NHS

- Primary Care Trusts to provide local leadership, working closely with sport, leisure and transport providers, and develop sustainable, cost-effective physical activity strategies in the context of Local Strategic Partnerships – to meet health goals. This could include, for example:
  - building on schemes to encourage people to be more active, such as exercise referral and pedometer initiatives, and providing advice and support on active lifestyles
  - developing creative ways to involve patient populations in more active lifestyles, and
  - working with the local authority and voluntary sector to provide information on local facilities, parks, and cycle and walking routes.
- Health care teams to reappraise the therapeutic value of physical activity for those already suffering from chronic diseases and conditions, including coronary heart disease, obesity, osteoarthritis and low back pain, and depression.

Local authorities and communities

- Local transport plans to give particular consideration to walking and cycling as means of commuting and personal travel.
- Local authorities to take steps to make neighbourhoods and communities more 'activity-friendly' – pleasant and safe for walking, cycling and playing.
- Town planners, architects and engineers to ensure that physical activity is facilitated, and not discouraged, in new buildings, streets, housing developments and schools.

Leisure and sports services

- Leisure services to find ways of attracting and retaining participants of different ages and from different ethnic and socioeconomic backgrounds, and should encourage and enable people to try new activities.
- Leisure and sports bodies to set role models and encourage children to be active for life, not just during childhood.

Schools and colleges

- Education professionals and play leaders to encourage children and young people of all abilities, shapes and sizes to take part in sports and activities that engage them throughout life.
- Walking to school and college to be supported and encouraged.

- Higher education to help train a high-quality, professional workforce as experts in promoting health-enhancing physical activity. This is particularly important for interaction with individuals who are at high risk of chronic disease.

Employers and workplaces

- Employers to encourage active travel to work, and ensure that appropriate facilities, such as showers or secure cycle storage, are available.
- Employers to provide opportunities for activity breaks for their staff, and for exercise and sports, and encourage use of stairs.
- Businesses in the community to set role models and use corporate social responsibility programmes to help promote active lifestyles.

Parents and families

- Parents to encourage children to be active, and set active role models themselves.
- Sedentary, housebound activities to be reduced and more active, outdoor pursuits increased.

Government, the private sector, local services and the voluntary sector are all key partners. Rising consumer interest in health and activity is apparent from the leisure, health, and sports pages of our media. I have set out just a few examples of how each sector might contribute, but local innovation will be key. Shifts in both environment and attitudes will be vital if we are to fully realise the health benefits of more active lifestyles.

This is a long-term challenge. The complexity and social implications of the challenge call for long-term effort and long-term investment, over at least the next two decades. It has taken around 50 years to halve the prevalence of smoking cigarettes. We now need to set in place key strategies to engender similar changes in physical inactivity.

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References

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2 Wanless D. *Securing good health for the whole population. Final report*. London: Department of Health, 2004.

3 Department for Culture, Media and Sport/Strategy Unit. *Game Plan: a strategy for delivering Government's sport and physical activity objectives*. London: Strategy Unit, 2002.

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1 Summary

This report sets out the available evidence from around the world for the impact that physical activity has on public health. The evidence clearly demonstrates that an inactive lifestyle has a substantial, negative impact on both individual and public health – specifically, that physical inactivity is a primary contributor to a broad range of chronic diseases such as coronary heart disease, stroke, diabetes and some cancers. The high level of individual suffering caused by these diseases, together with the substantial associated financial costs, make this a major public health issue.

Smoking cigarettes and an unhealthy diet have long been established as major causal factors for chronic disease. This report establishes that physical inactivity is equally important. The report describes the high preventive and therapeutic potential of physical activity to reduce the burden of chronic disease. These effects are demonstrated in people at all stages of life, and in people of both sexes and of differing socioeconomic circumstances. This report endorses the advice for healthy levels of activity, but also suggests – where evidence allows – more specific recommendations for prevention and treatment of individual diseases and conditions. The report does not address evidence relating to how activity patterns can be changed. (That issue is the subject of another document, which is summarised in Appendix 3.)

This report is based on a comprehensive review of the evidence carried out by a distinguished team of academics and expert advisors. It brings together a large and diverse literature from the fields of epidemiology, exercise physiology, medicine, psychology and health economics. The report has been scrutinised by an Advisory Group, and by Expert Reviewers from the UK and around the world.

The public health importance of physical activity

Disease and disability caused by physical inactivity cause serious and unnecessary human suffering and impaired quality of life. The estimated costs of physical inactivity in England are £8.2 billion annually, which does not include the contribution of inactivity to obesity which in itself has been estimated at £2.5 billion annually. These figures include both the costs to the NHS and costs related to the economy, such as absence from work. It is not possible to estimate the number of deaths attributable to inactivity as this is not a documented cause of death. However, the public health importance of physical activity is clear, as adults who are physically active have 20-30% reduced risk of premature death, and up to 50% reduced risk of developing the major chronic diseases such as coronary heart disease, stroke, diabetes and cancers.

However, physical activity levels in England are low in virtually all sections of the adult population, and there are increasing concerns regarding some groups of children, such as teenage girls. Up to two-thirds of men and three-quarters of women report activity levels which substantially increase their risk of contracting a broad range of – possibly up to 20 – chronic diseases.

Overall it appears that, over the past 20 or 30 years, there has been a decrease in physical activity as part of daily routines in England, but a small increase in the proportion of people taking physical activity for leisure. The overall reduction in population activity levels partly reflects other changes that have taken place in society. For example, compared with 30-40 years ago there are fewer manual jobs, and the physically active elements of housework, shopping and other necessary activities have diminished substantially in western society. In England, people undertake less regular travel on foot or by bicycle than in the past: over the last 25 years, both walking (which is the most common form of physical activity) and cycling have declined by 26%.

Children are more active than adults, although it is unclear whether they participate in sufficient activity to achieve the full range of health benefits. About one-third of boys and one-third to a half of girls report activity levels that may compromise their health. Reductions in activity levels among children during the course of normal daily living are likely to have reduced the amount of energy expended and to have contributed to the epidemic of obesity referred to in the Annual Report of the Chief Medical Officer for 2002.

In adults, both physical activity and cardiorespiratory fitness are strongly related to health. In children, the health benefits of physical activity are widely accepted, whereas the role of fitness is suggestive but as yet unconfirmed.

That physical activity should provide such a wide range of benefits might suggest that other underlying factors – such as socioeconomic disadvantage, for example – are at play. However, physical activity is such a fundamental human behaviour that it is capable of influencing most major body systems. Where it has been feasible to conduct controlled experiments of physical activity, changes in health status have resulted which provide evidence against alternative interpretations of associations between physical activity and health.

Appropriate levels of physical activity

Since 1996 the Department of Health’s advice for physical activity has been that adults should aim to take 30 minutes of at least moderate activity on at least five days a week. For children and young people, the advice has been for one hour of moderate intensity physical activity each day and this can be continuous activity or intermittent throughout the day. This advice on physical activity and other very similar recommendations from around the world have been established by various bodies through rigorous processes of review and discussion. They are generally accepted worldwide. This report confirms that, according to the best evidence, these recommendations remain appropriate for general health benefit across a wide range of diseases. The report goes further, however, and suggests that different modes and patterns of activity can be equally effective, and it describes more detailed and specific activity recommendations for individual diseases. See *Recommendations for active living throughout the lifecourse*, opposite.

For most people, the easiest and most acceptable forms of physical activity are those that can be incorporated into everyday life. Examples include walking or cycling instead of driving, and taking up active hobbies and leisure pursuits such as

gardening and social sporting activities. Individual patterns of active living should both improve physical health and promote long-term adherence to activity.

Occupational physical activity can also be an important source of activity, although this is less under the control of the individual. Nevertheless, individuals can endeavour to build more activity into their working hours, for example by creative use of free time and habitual use of stairs.

The risks associated with the recommended levels of activity are low for people of all ages. A larger quantity of activity at higher intensity can bring further benefits and this might be an ultimate aspiration for some people. However, very high levels of fitness training or engagement in vigorous and contact sports both carry higher risk of sports/exercise-related injury. Similarly, progression from one level of activity to another that is too rapid carries higher risk.

Effects across the lifecourse

Evidence of a health benefit for physical activity is seen throughout the lifecourse. In children, effects are predominantly seen in amelioration of risk factors for disease, avoidance of weight gain, achieving a high peak bone mass, and mental well-being. In adults, protection is conferred against the diseases themselves – including cardiovascular disease, cancer, type 2 diabetes – and obesity.

Recommendations for active living throughout the lifecourse

- Children and young people should achieve a total of at least 60 minutes of at least moderate intensity physical activity each day. At least twice a week this should include activities to improve bone health (activities that produce high physical stresses on the bones), muscle strength and flexibility.
- For general health benefit, adults should achieve a total of at least 30 minutes a day of at least moderate intensity physical activity on 5 or more days of the week.
- The recommended levels of activity can be achieved either by doing all the daily activity in one session, or through several shorter bouts of activity of 10 minutes or more. The activity can be lifestyle activity* or structured exercise or sport, or a combination of these.
- More specific activity recommendations for adults are made for beneficial effects for individual diseases and conditions. *All* movement contributes to energy expenditure and is important for weight management. It is likely that for many people, 45-60 minutes of moderate intensity physical activity a day is necessary to prevent obesity. For bone health, activities that produce high physical stresses on the bones are necessary.
- The recommendations for adults are also appropriate for older adults. Older people should take particular care to keep moving and retain their mobility through daily activity. Additionally, specific activities that promote improved strength, co-ordination and balance are particularly beneficial for older people.

** Lifestyle activity means activities that are performed as part of everyday life, such as climbing stairs or brisk walking (see the Glossary in Appendix 1).*

Physical activity also promotes musculoskeletal health and mental health and well-being. The health benefits are even more pronounced in older adults and are particularly important because the diseases involved – most notably osteoporosis, circulatory diseases and depression – affect an older person's ability to maintain an independent lifestyle. In older people, activities that promote strength, coordination and balance are particularly valuable for maintaining capacity to perform common activities of daily living and, in particular, for reducing the risk of falling and of being seriously injured. Activities that promote endurance are important for all ages. The levels of activity recommended for health benefit in adults are also appropriate for older adults, with the provision that the absolute intensity of activities must necessarily be lower, in order to accommodate reduced cardiorespiratory and muscle function consequent to the ageing process. (See the Glossary in Appendix 1 for an explanation of absolute and relative intensities of activity.)

Specific effects

The importance of physical activity with respect to the major chronic diseases is summarised below. Where appropriate, disease-specific activity recommendations – modifications to the more general activity recommendations given above – are stated.

Cardiovascular disease

Physical inactivity and low fitness are major independent risk factors for coronary heart disease in both men and women, at a level similar to that of smoking cigarettes. Inactive and unfit people have almost double the risk of dying from coronary heart disease compared with more active and fit people. Physical activity also has beneficial effects on preventing stroke and treating peripheral vascular disease, and on modifying the classical cardiovascular risk factors such as high blood pressure and adverse lipid profiles.

Physical activity does not need to be vigorous to confer protection from cardiovascular disease: 30 minutes of moderate intensity physical activity a day on at least 5 days a week is sufficient to achieve benefit. Greater benefits can be obtained from a larger volume of activity, but with a 'law of diminishing returns': at higher levels of activity or fitness, smaller declines in risk are observed. Longer sessions of aerobic physical activity do not appear to have a different effect on cardiovascular risk compared with shorter sessions, as long as the total energy expended is equivalent. There is growing support for the benefits of accumulating activity in shorter bouts of activity of 10 minutes or more, interspersed throughout the day. Such shorter bouts have demonstrated positive effects similar to a single long bout of activity of an equivalent total volume of activity, and may help people to become more active in the long term. This is critical, as the strong protective effect of activity is transient – that is, individuals only gain benefit during the periods of life when they lead a physically active lifestyle. Most benefits are lost if the activity is not maintained.

Exercise-based cardiac rehabilitation programmes for patients with coronary heart disease are generally effective in reducing the risk of premature death.

Overweight and obesity

Low levels of physical activity in England are a significant factor in the dramatic increase in prevalence of obesity. Maintaining activity throughout life is important in avoiding weight gain. Physical activity by itself can result in modest weight loss of around 0.5kg-1kg per month but the most effective way to lose weight involves a

combination of physical activity and diet. This will maximise fat loss, preserve lean tissue, and maximise fitness and health benefit. Only a small proportion of those following weight loss programmes maintain their weight loss in the long term. Those who achieve and maintain regular physical activity are more likely to be successful. Physical activity also brings important reductions in risk of morbidity and mortality for those who are already overweight or obese.

Current physical activity advice for adults – of 30 minutes of at least moderate intensity activity on at least 5 days a week – will represent a significant increase in energy expenditure for most people and will contribute to their ongoing weight management. However, in today's sedentary society, and in the absence of a reduction in energy intake, 30 minutes' activity a day on 5 or more days a week may not be enough to prevent the development of obesity for many people, and 45-60 minutes of moderate intensity activity per day may be needed. People who have been obese and have managed to lose weight may need to do 60-90 minutes' activity a day in order to avoid regaining weight. Also, activity that can be incorporated into everyday life may be as effective for weight loss as structured, supervised exercise programmes. This broadens the range of effective choices available for increasing activity among the general public.

Energy expenditure is a direct result of moving body weight and so any movement built into the daily routine will contribute to energy balance. People who need to lose weight should therefore be encouraged to walk more, take up active hobbies and reduce the amount of time they spend inactive.

Diabetes

Physical inactivity is a major risk factor for the development of type 2 diabetes, with active people having a 33-50% lower risk compared with inactive people. High-risk individuals in particular can substantially reduce their risk of developing type 2 diabetes by becoming more active. Regular, moderate intensity physical activity is sufficient to reduce the risk of developing type 2 diabetes, although the optimum type, intensity, frequency, duration or volume of activity needed are unclear. Regular physical activity can produce metabolic benefits that contribute to management of type 2 diabetes. Also, risk of premature death is much lower in active and fit persons with type 2 diabetes than in patients who are inactive and unfit.

Musculoskeletal health

Physical activity increases bone mineral density in adolescents, maintains it in young adults, and slows its decline in old age. Physical activity can delay the progression of osteoporosis by slowing down the rate at which bone mineral density is reduced from the late 20s onwards, but it cannot reverse advanced bone loss. Physical activity may also delay the progression of osteoarthritis, although no evidence directly confirms that onset can be prevented. There are also indications that physical activity may delay the onset of low back pain.

Activities that produce high physical stresses on the bones (for example, chasing games, skipping, running, jumping, gymnastics, jogging or tennis) are necessary throughout life to provide optimal protection against osteoporosis. Such activities in adolescence increase peak bone mass, while post-adolescent physical activity reduces the rate of bone loss. Bone mineral density is not increased at all by low-impact exercises such as swimming. Activities that promote strength, balance and power may be important for older people because of their potential to prevent falls.

Physical activity has beneficial effects for people with osteoarthritis, including those who have had a joint

replacement, but too much physical activity can be detrimental in that it can aggravate the condition.

Aerobics-type exercise programmes can help prevent recurrence of low back pain. General leisure-time activities are also recommended for people with low back pain, but they should avoid: heavier sporting activities which involve lifting, twisting, pulling and pushing; excessive loading of the back muscles; and excessive overall levels of physical activity. Yoga-style exercise, and exercises to increase endurance of the abdominal and back muscles, may also be helpful.

Psychological well-being and mental illness

Mental illness

People who lead an active lifestyle over several years have a reduced risk of suffering symptoms of clinical depression. Physical activity is effective as a treatment of mild, moderate and severe clinical depression. It may also help people with other mental illnesses, and improve their physical and mental well-being even if there is no change in the status of their mental illness.

Mental health

Physical activity helps people *feel* better through improvement in mood, reduced anxiety and enhanced self-perceptions. Physical activity can also help people to function better through alleviation of stress, and improved sleep, and – in older people – through some aspects of cognitive function.

Regular moderate intensity activity can improve psychological well-being. Evidence is strongest for activity which lasts between 20 and 60 minutes. However, shorter bouts (10-15 minutes) of moderate intensity walking can induce significant positive changes in mood. Rhythmic aerobic forms of exercise – such as brisk walking, jogging, cycling, swimming or dancing – appear to be most consistently effective. Resistance exercise may be useful for enhancing self-perceptions, as it can have rapid effects on how the body feels and functions. Competitive sports and vigorous forms of exercise are an important source of psychological well-being for those who are already accustomed to this type of activity. Group recreational sports and activities are also likely to bring social and mood benefits. However, no generic mechanisms have been established to explain the positive effects of activity on psychological improvement. The effects in individuals are likely to be more variable than those found with physiological or biomedical change and may depend on the individual's subjective experiences of the activity and the setting in which it takes place. A range of exercise modes and intensities, based on the participant's previous exercise experiences, preferences and goals, will therefore need to be considered.

Cancer

Physical activity is associated with a reduction in overall risk of cancer. There is a marked protective effect on colon cancer: the most active individuals have, on average, a 40-50% lower risk than the least active. Physical activity is also associated with a reduced risk of breast cancer among post-menopausal women, and possibly also to a reduction in risk of lung cancer. Physical activity can also have an indirect effect through its role in the prevention of obesity which, in the USA, has been estimated to result in 10% of all-cause cancer.

For optimal protection, activity should be maintained throughout the lifetime. The optimal intensity, frequency and duration of physical activity needed for a protective effect have not been reliably defined. Moderate to vigorous intensity physical activity performed frequently may be required for a significant protective effect.

Table 1 Level and strength of evidence for a relationship between physical activity and contemporary chronic conditions

	Preventive effects			Therapeutic effects	
Condition	**Level of evidence†**	**Strength of effect**	**Evidence of a dose response relationship**	**Level of evidence†**	**Strength of effect**
Cardiovascular disease					
Coronary heart disease	High	Strong	Yes	Medium	Moderate
Stroke – occlusive	High	Moderate	–	Low	Weak
– haemorrhagic	Medium	Weak	–	Low	Weak
Peripheral vascular disease	No data/ insufficient data	–	–	Medium	Moderate
Obesity and overweight	Medium	Moderate§	–	Medium	Moderate§
Type 2 diabetes	High	Strong	Yes	Medium	Weak
Musculoskeletal disorders					
Osteoporosis‡	High	Strong	–	Medium	Weak
Osteoarthritis	No data/ insufficient data	–	–	Medium	Moderate
Low back pain	Medium	Weak	–	High	Moderate
Psychological well-being and mental illness					
Clinical depression	Low	Weak	–	Medium	Moderate
Other mental illness	No data/ insufficient data	–	–	Low	Weak
Mental well-being	–	–	–	Medium	Moderate
Mental function	Low	Moderate	–	Low	Weak
Social well-being	No data/ insufficient data	–	–	Low	Weak
Cancer					
Overall	Medium	Moderate	Yes	No data/ insufficient data$ (all cancers)	–
Colon	High	Strong	Yes		
Rectal	Medium	No effect	–		
Breast	High	Moderate	Yes		
Lung	Low	Moderate	–		
Prostate	Medium	Equivocal	–		
Endometrial	Low	Weak	Yes		
Others	Low	Equivocal	–		

† = Volume and quality of data

‡ = From bone mineral density data. Osteoporosis is defined in terms of bone mineral density.

§ = Includes the effect of activity on disease as well as weight status.

$ = However, a low level of evidence indicates weak effects on physical function and fatigue during and following cancer treatment.

This table provides a simplified summary of the nature and volume of evidence and an estimate of the strength of effect of activity currently indicated by that evidence. The 'level of evidence' is intended to be a general indication of the volume and quality of the available evidence. The 'strength of effect' is intended to indicate how positive, or otherwise, the findings are. Three broad categories (descriptors), agreed between the Review Panel and the Expert Reviewers, have been selected within both 'level of evidence' and 'strength of effect'.

There is considerable variability in both the volume and quality of studies found in different areas of research regarding activity and health. Cardiovascular disease is relatively well investigated compared with areas such as obesity and mental health that have only recently attracted interest. The full picture is further confounded by the fact that physical inactivity affects a wide range of diseases and risk factors, many of which may occur in the same individual. The multiple effects of increased activity across these many chronic conditions are rarely considered in study design, so the true value of physical activity in terms of public health may well be under-estimated.

Range of benefits

Whereas the beneficial effects seen within specific diseases are important in their own right, possibly the greatest public health contribution of physical activity is its strength of effect over such a wide range of common diseases. Table 1 gives a simplified overview of the general level of evidence and strength of effect existing across these important diseases. The table shows that, while physical activity constitutes an effective therapy for many conditions, the strongest effects are seen in prevention. Also, stronger relationships are observed where the level of evidence is highest.

The critical message is that health benefits occur concurrently across virtually the full range of diseases. This breadth of action, when combined with the size of the different effects, along with the prevalence of inactivity among the public, makes physical activity one of the main contemporary public health issues.

Conclusion

The extensive evidence reviewed in this report reinforces the view that physical inactivity is undoubtedly one of the major contributory factors to the current epidemics of chronic disease. The encouragement of active lifestyles must be an important element of any future public health strategy.

2 The importance of physical activity for public health

Key points

- Physical inactivity is a serious and increasing public health problem. Strong evidence confirms that there are many potential health benefits from being active, including a lower risk of coronary heart disease, stroke, type 2 diabetes and certain types of cancer. Regular physical activity can have a beneficial effect on up to 20 chronic diseases or disorders.
- Activity levels in England are low. About two-thirds of men and three-quarters of women report less than 30 minutes' moderate intensity activity a day on at least 5 days per week.
- Seven in ten boys and 6 in 10 girls aged 2-15 achieve at least 60 minutes' physical activity each day of the week. However, 2 in 10 boys and girls do less than 30 minutes' activity per day.
- Obesity levels in England are high and rising. Almost a quarter of adults and about 16% of 2-15 year olds are obese. These current levels of obesity are caused by an imbalance between energy expenditure and energy intake.
- The cost of physical inactivity in England – including direct costs of treatment for the major lifestyle-related diseases, and the indirect costs caused through sickness absence – has been estimated at £8.2 billion a year.

Low levels of physical activity have become a major public health problem in most western societies. The evidence shows that the health impact of inactivity in terms of coronary heart disease, for example, is comparable to that of smoking, and almost as great as high cholesterol levels.[4] Low fitness – and especially cardiorespiratory fitness (the body's capacity to perform aerobic physical activity) – is also associated with adverse health consequences. Both physical inactivity and low fitness can be considered as major and equally important risk factors for a wide range of chronic diseases – especially in adults. This report focuses on physical activity as this is the behaviour that needs to change. Fitness can only be modified by changing physical activity behaviour.

Advancing technology has provided immense benefit for progress in many aspects of life, but at the same time it has seriously threatened the level of physical activity in the general population by allowing a 'take-it-easy' culture. Today, there are fewer manual jobs, less routine travel is on foot or by bicycle, and the physically active elements of housework, shopping and other necessary activities have diminished substantially. These trends affect both adults and children. Children are more likely to be driven to school and spend more time watching television than in the past.

This chapter addresses the impact of low levels of physical activity on public health. It:

- presents data on the *prevalence* of inactivity and activity among the population of England
- summarises the evidence for the consequences of this inactivity for a range chronic diseases and conditions – the *burden* of the exposure, and
- makes an estimate of the *costs* of inactivity to public health, based on the percentage of the population who are at high risk of ill health because they do too little physical activity.

Patterns and trends of activity and inactivity among adults

Public health is concerned not only with the consequences of inactivity at the individual level, but also with the extent to which inactivity is prevalent in the population.

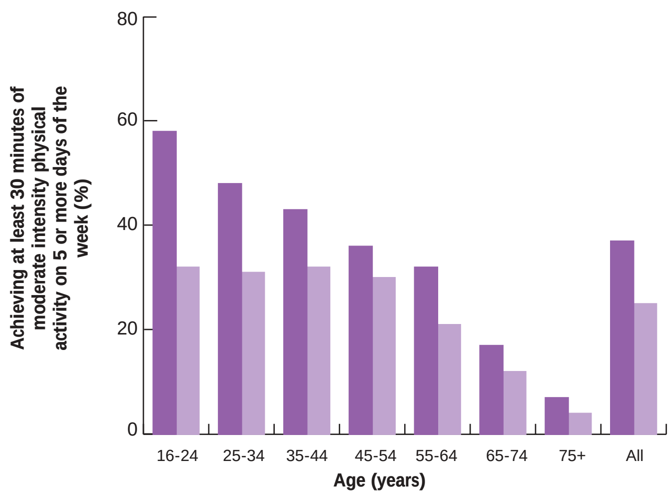
The great majority of adults in England do not participate in physical activity at levels that provide the full range of health benefits. Although some positive effects may occur with less activity, a level that provides reduced risk of a range of diseases is widely accepted as 30 minutes of at least moderate intensity physical activity a day on 5 or more days of the week. It is therefore useful to use this level as an arbitrary threshold for the purposes of ascertaining the prevalence of activity.

In the Health Survey for England 1998, about two-thirds of men and three-quarters of women do less than 30 minutes of moderate intensity physical activity a day on 5 or more days of the week.[5] (See Table 2.) Of particular concern, about a third of men and between a third and a half of women do less than 30 minutes of activity per week (that is, are inactive or sedentary). There are supporting data from the National Diet and Nutrition Survey, which reports that overall between two-thirds and three-quarters of adults in the UK do less than 30 minutes of activity on five or more days each week.[6] This means that inactive lifestyles in England have more than double the prevalence of smoking, or hypertension or high cholesterol. The prevalence of inactivity (doing less than 30 minutes' activity per week) is higher in women than in men. Prevalence increases with age in both men and women: just over 7 out of 10 men and 8 out of 10 women aged 75 years and above do less than 30 minutes of activity per week.

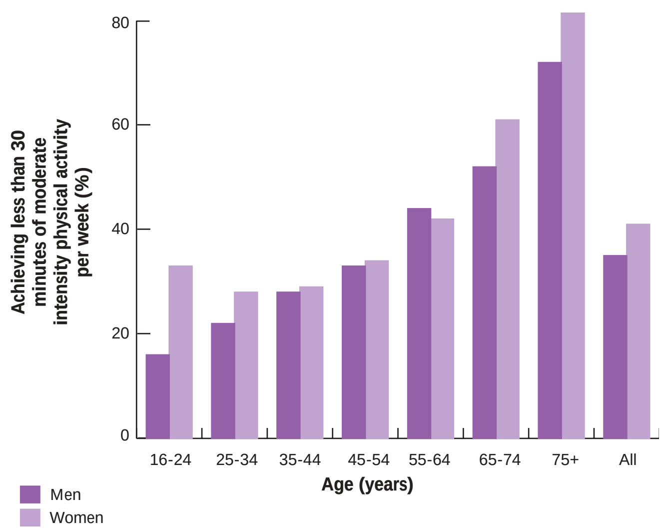
Table 2 Prevalence of activity and inactivity among adults, by sex and age, England, 1998

		Achieving at least 30 minutes of moderate intensity physical activity on 5 or more days of the week (%)	Achieving less than 30 minutes' moderate intensity activity per week (%)
All men and women aged 16+		31	38
Sex	Male	37	35
	Female	25	41
Men	*Age (years)*		
	16-24	58	16
	25-34	48	22
	35-44	43	28
	45-54	36	33
	55-64	32	44
	65-74	17	52
	75+	7	72
Women	*Age (years)*		
	16-24	32	33
	25-34	31	28
	35-44	32	29
	45-54	30	34
	55-64	21	42
	65-74	12	61
	75+	4	82

Prevalence of *activity* among adults (by sex and age, England, 1998)



Prevalence of *inactivity* among adults (by sex and age, England, 1998)



Source: *Health Survey for England 1998*[5]

Data from the UK 2000 Time Use Survey indicates that people who are active enough to gain health benefits achieve this level of activity predominantly through walking. In all demographic groups, walking dominates the activity pattern of the most active people. Other activities which feature strongly are gardening, DIY and 'ball games'.[7]

Trends in adult physical activity

Overall it appears that, over the past 20 or 30 years, there has been a decrease in physical activity as part of daily routines in England, but a small increase in the proportion of people taking physical activity for leisure. The clearest evidence of decreasing adult levels of physical activity in England over recent years comes from the National Travel Survey, which tracks average miles travelled on foot or by bicycle. This survey records journeys on public highways, but excludes walking or cycling for leisure. These data suggest that both walking and cycling on the public highway declined steadily between 1975-76 and 1999-2001. Total miles travelled per year on foot fell by 26% and miles travelled by bicycle also fell by 26% (see Table 3).[8] This produced a difference of 66 miles walked per year between 1975-76 and 1999-2001. For a person weighing 65kg, this represents an annual reduction in energy expenditure equivalent to almost 1kg of fat. However, the General Household Survey of 1996 reports that adults in Great Britain are now *more* likely to undertake certain leisure-time activities – for example, walks of over 2 miles, swimming, keep fit and yoga, and participating in cycling for leisure. Table 4 shows how the proportion of adults taking part in these activities changed between 1987 and 1996.[9]

Table 3 Trends in average miles travelled per person per year on foot and by bicycle, England, 1975/76-1999/2001

	Miles travelled per person per year							
	1975-76	1985-86	1989-91	1992-94	1995-97	1998-2000	1999-2001	% change from 1975-76 to 1999-2001
Walking	255	244	237	199	195	186	189	-26
Bicycle	51	44	41	38	39	38	39	-24

These figures exclude walking and cycling for leisure.

Source: *National Travel Survey: 1999-2001 Update*[8]

Table 4 Trends in selected leisure-time physical activities, by sex, Great Britain, 1987-96

	Men (%)				Women (%)			
	1987	1990	1993	1996	1987	1990	1993	1996
Walking	41	44	45	49	35	38	37	41
Cycling	10	12	14	15	7	7	7	8
Swimming	13	14	15	13	13	15	16	17
Keep fit/yoga	5	6	6	7	12	16	17	17

The figures show the percentage of people taking part in the activities at least once in the 4 weeks before the survey.
The figures are for leisure-time activity only.

Source: *General Household Survey 1996*[9]

In the shorter term, the proportion of the population of England who are inactive has been increasing: the proportion of inactive women (activity less than once a week) increased from 35% in 1994 to 41% in 1998, and the proportion of inactive men increased from 30% to 35%. However, in the same period, the proportion of active people in some age groups increased.[5 10]

Socioeconomic status

Surveys which include both work-related and leisure-time physical activity show that men in the lowest social class (which includes manual workers) are more physically active than those in higher social classes, but there is little difference by social class among women.[5 11]

People in higher socioeconomic groups take part in more leisure-time activity than those from lower socioeconomic groups. For example, in men, age-adjusted rates of walking as a leisure-time activity are 38% higher in social class I than in social class V. For women, rates are 67% higher in social class I than in social class V. Similar trends are observed for sports participation.[5] In both men and women and in all age groups, low educational attainment predicts higher levels of inactivity.[11]

Activity and inactivity among children

Data on physical activity among children in England are found in the Health Survey for England, 2002.[12] Around two-thirds of boys and girls aged 2-11 years achieve at least 60 minutes of moderate intensity physical activity each day. For boys, this level of activity holds through to age 15, whereas in girls levels fall to about half. (See Table 5.)

Boys spend a mean of 14.2 hours and girls 12.2 hours per week taking part in physical activities of at least moderate intensity. For boys this figure holds steady to age 15, whereas for girls there is a steady decline. Large proportions of children report very high levels of activity, with 42% of boys and 33% of girls being active for at least 2 hours per day on at least 5 of the previous 7 days. At all ages, over one-third of boys were active at this high level.

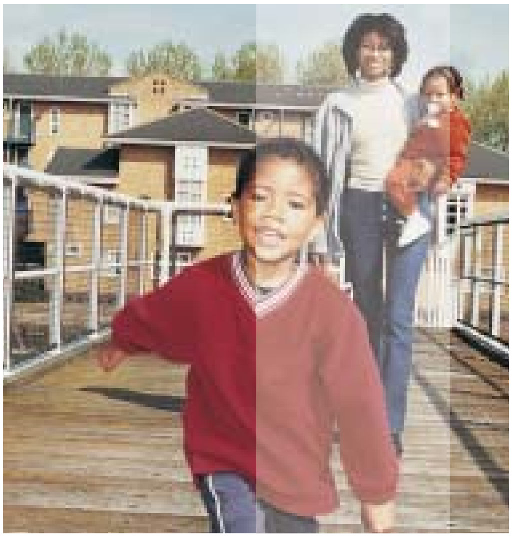


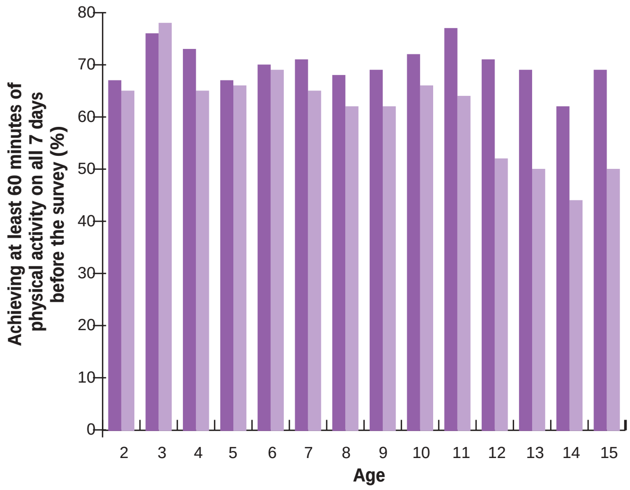
Table 5 Prevalence of activity and inactivity among children, by sex and age, England, 2002

		Achieving at least 60 minutes of physical activity on all 7 days before the survey (%)	Achieving less than 30 minutes' activity per day on the 7 days before the survey (%)
	Boys aged 2-15	70	17
	Girls aged 2-15	61	22
Boys	*Age (years)*		
	2	67	20
	3	76	12
	4	73	12
	5	67	17
	6	70	16
	7	71	14
	8	68	18
	9	69	17
	10	72	16
	11	77	14
	12	71	18
	13	69	15
	14	62	24
	15	69	17
Girls	*Age (years)*		
	2	65	23
	3	78	11
	4	65	21
	5	66	18
	6	69	18
	7	65	22
	8	62	19
	9	62	23
	10	66	17
	11	64	20
	12	52	26
	13	50	27
	14	44	35
	15	50	35

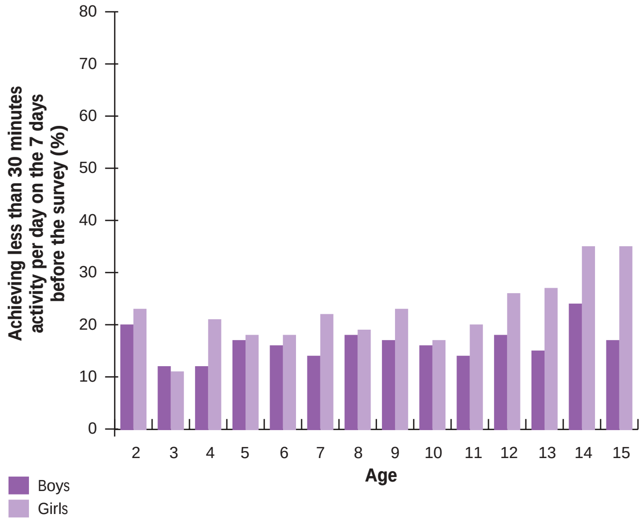
For children up to the age of 12 years, activity was measured by proxy – normally by a parent.
This table is illustrated on page 15.

Source: *Health Survey for England 2002*[12]

Prevalence of *activity* among children (by sex and age, England, 2002)



Prevalence of *inactivity* among children (by sex and age, England, 2002)



Source: *Health Survey for England 2002*[12]

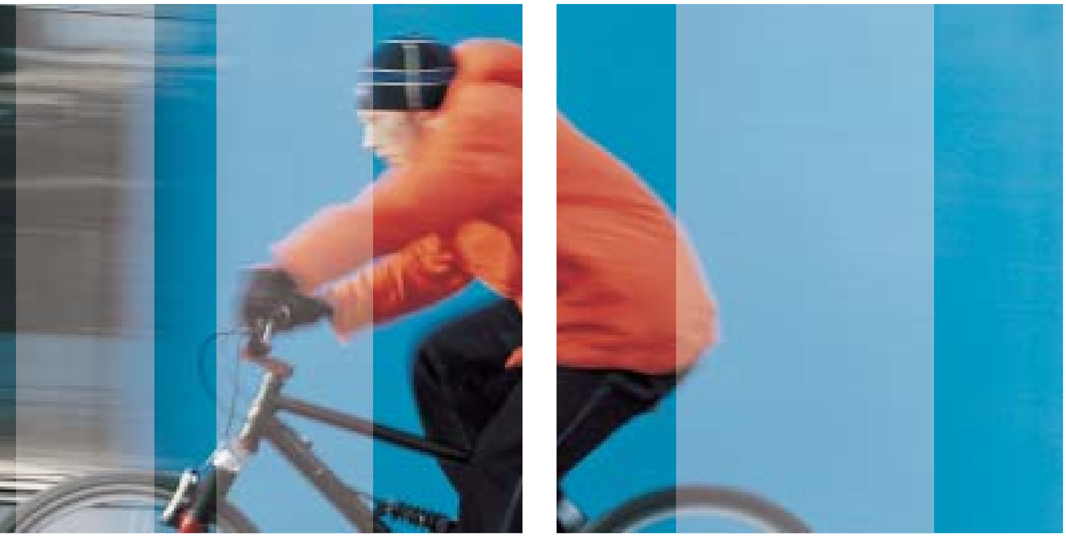
There are some important points to make regarding these data on children's physical activity levels. Children are known to have difficulty recalling their physical activities – a task they need to perform when completing self-report physical activity questionnaires. This is likely to result in children under-estimating their total physical activity. On the other hand, some children may tend to give 'socially desirable' responses in the form of exaggerated activity levels. For very young children, parental report of the child's activity is used, which may also introduce error. The physical activity questionnaire used in the Health Survey for England has not been validated against a criterion method, so it is impossible to say how accurate the reported activity levels are. Furthermore, the Health Survey for England only measures activity outside of school.

Despite these limitations, it is possible to compare Health Survey for England data with other data collected on children of a similar age using objective activity monitors. In a study of over 2,000 European children aged 9-15 years,[13] in which activity levels were measured using accelerometers (motion sensors), virtually all 9-year-old boys and girls in Denmark, Estonia, Norway and Poland achieved 60 minutes of moderate activity per day. For 15 year olds, 8 out of 10 boys and 6 out of 10 girls achieved this level.

The figures presented in Table 5 show that the majority of children in England achieve 60 minutes of moderate activity per day. However, it should be borne in mind that this level of activity – although commonly accepted as the level required to confer health benefits – has only a limited scientific basis.[14,15] Given that levels of overweight and obesity in children are rising, it may be that the 60 minutes' activity per day recommendation is insufficient to prevent weight gain – at least in some children. (See *Physical activity recommendations for children and adolescents* page 22. For a summary of the evidence linking children's and adolescents' physical activity to health in childhood and throughout life, see Chapter 4.

Trends in physical activity in children

There is no evidence that, in the short term, there are major changes in children's activity levels. It is possible to compare the data on physical activity from the 2002 Health Survey for England with



similar data collected in the 1997 survey.[12,16] An analysis of data based on certain variables that were consistent between the two surveys shows that no increase or decrease in activity levels can be detected between 1997 and 2002. However, there are encouraging signs, with increases of 9 percentage points for boys and 14 percentage points for girls in the proportion of those who did at least 30 minutes each day. Before 1997, no nationally representative data on activity among children were collected in England. However, indirect evidence suggests that energy expenditure in children has been declining for several decades.[17]

There are many contemporary threats to children's overall activity levels. There is now a greater use of cars to transport children even on short journeys. Parental reluctance to allow children to play outdoors may have increased through perceived dangers within the physical environment, such as heavy traffic and 'stranger danger'. It has been shown that children are now given less 'licence' to act independently away from the home at later ages than they were a generation ago.[18] There is also more access to television and computers and other sedentary alternatives that attract children.[19] Trends in travel-to-school habits have been described in the Department for Transport's National Travel Survey. In 1985-86, 67% of children aged 5-10 years walked to school, whereas in 1999-2000 the figure had fallen to 54%. The percentage of children of primary school age transported to school by car over the same period increased from 22% to 39%. For primary school children, cycling to school is almost non-existent and in secondary school children, the figure has fallen from 6% in 1985-86 to just 2% in 1999-2000.[8] These trends in lifestyle patterns among children in England, coupled with evidence that childhood obesity is increasing[12] (see page 18), suggest that children's activity levels should be carefully monitored.

The health consequences of inactivity

A wealth of epidemiological evidence, supported by experimental studies and plausible biological mechanisms, supports the conclusion that the human body thrives on regular physical activity. Over time, it is to be expected that the human body will react adversely to constant lack of physical stimuli. An explanation that is widely accepted by evolutionary biologists and anthropologists is that humans have inherited a genome within which important genes may only express themselves appropriately within an environment of regular physical activity. When activity levels fall below critical thresholds, gene expression changes and overt clinical disorders such as cardiovascular disease, metabolic disorders and some cancers manifest themselves.[20] It is only recently in human evolution that energy expenditure (primarily searching for sustenance) has not been inextricably linked to energy intake. With the industrial revolution and more recently the emergence of technological advances, a serious mismatch has emerged between food availability and the energy required to access food – leading to a new pandemic of metabolic conditions such as obesity and type 2 diabetes.

Major chronic diseases

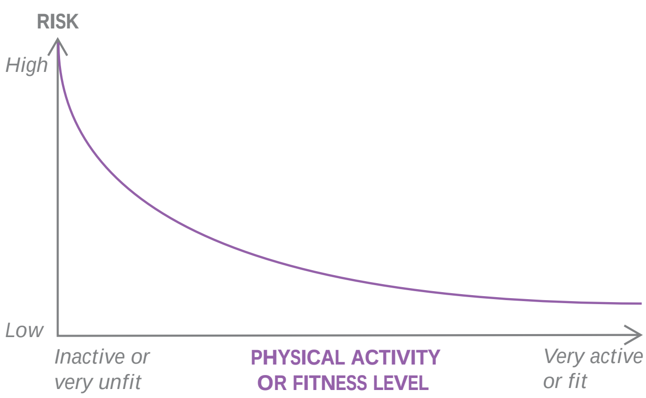
The World Health Organization has reported that physical inactivity is one of the 10 leading causes of death in developed countries, producing 1.9 million deaths worldwide per year.[21] It estimates that physical inactivity is responsible for the following proportions of 'disability-adjusted life years' in developed countries:

- 23% of cardiovascular disease for men and 22% for women
- 16% of colon cancer for men and 17% for women

- 15% of type 2 diabetes
- 12% of stroke for men and 13% for women
- 11% of breast cancer.

Becoming more active can bring substantial benefit. There is a clear dose-response relationship between physical activity and all-cause mortality, and between physical activity and diseases such as coronary heart disease and type 2 diabetes: greater benefits occur with greater activity participation (see Figure 1). From a public health perspective, helping people to move from an inactive level to low to moderately active levels will produce the greatest reduction in risk. A physical activity energy expenditure of 500-1,000kcals per week (about 6-12 miles of walking for an average-weight individual, compatible with the current physical activity recommendations for adults) reduces the risk of premature death by 20-30%. These considerable health benefits hold for both women and men and are evident even up to the age of 80 years.[22]

Figure 1 Schematic representation of the dose-response relationship between physical activity level and risk of disease



This curvilinear dose-response curve generally holds for coronary heart disease and type 2 diabetes: the higher the level of physical activity or fitness, the lower the risk of disease. Curves for other diseases will become more apparent as the volume of evidence increases.

A UK study has estimated that 37% of coronary heart disease is attributable to physical inactivity.[4] The study also estimated that, if people who now have inactive or marginally active lifestyles changed to a moderate level of activity, this could achieve a 10% reduction in coronary heart disease risk. This is comparable to the reduction in coronary heart disease risk that could be achieved by reducing other major risk factors for the disease. For example, the study estimated that lowering cholesterol concentrations to less than 6.5mmol/l could achieve an 11% reduction in coronary heart disease, and lowering diastolic blood pressure by 10mmHg could achieve a 15% reduction in coronary heart disease risk for men and a 12% reduction for women.[4]

Obesity

Obesity has emerged as a new and serious threat to health, with 22.1% of men and 22.8% of women in England classed as clinically obese (body mass index greater than 30kg/m^2).[12] Excess weight increases with age and among people aged 55-74 years more than two-thirds of women and three-quarters of men are overweight or obese.[12]

Obesity is related to social class in adults. Among those classified as ‘professional’ 16% of males and females are obese, while among those classified as ‘unskilled manual’ 23% of males and 29% of females are obese.[12]

The number of obese individuals increased threefold between 1980 and 2002. If recent rates of growth continue, a third of all adults will be obese by 2010, bringing levels of obesity in England up to those currently experienced in the USA.[23] This growth in obesity reflects a worldwide trend which is most marked in, but not restricted to, industrialised countries.[24] In relation to other countries of north west Europe, the increase in obesity in England has been particularly marked.

Levels of overweight and obesity among children in England are also high and rising. In 2002, 30.3% of boys and 30.7% of girls aged 2-15 years were at least overweight, and 16% of boys and 15.9% of girls aged 2-15 were obese.*[12] Incidence of obesity is greater in children from more deprived areas. Also, among those who have two obese parents, the incidence of obesity is 12 times greater for boys and 10 times greater for girls.

In contrast, there are considerable differences between children of different ethnic groups. An analysis of data from the 1999 Health Survey of England has shown that, compared with the general population, Indian and Pakistani boys were more likely to be overweight or obese, and Bangladeshi and Chinese boys were less likely to be overweight or obese.[26] Among girls, more Afro-Caribbean girls were overweight and obese compared with the general population and Chinese girls were much less likely to be overweight or obese. However, it should be noted that there is debate about the relevance of the standard reference ranges for some ethnic minority populations.

The level of obesity among 10-year-old children in the UK is higher than in most north west European countries, but lower than in many Mediterranean countries.[27]

*Levels of overweight and obesity in children and adolescents are estimated using age-related body mass index (BMI) to account for natural changes in body composition with growth and development. Two reference methods to estimate the prevalence of obesity commonly appear in the British literature. The first compares age-adjusted BMI with the values at the 85th (overweight) and 95th (obese) percentiles of 1990 reference data.[25] The second is an international classification designed to map onto the adult BMI estimates at age 18 years. The international classification produces more conservative absolute figures, but the rate of change is similarly marked. The 2002 Health Survey for England provides both sets of figures.[12] The figures given above are based on the percentile comparison method.

It is clear from all data sets that childhood obesity and overweight have increased over the past ten years.[12,28-30] In less than 10 years, incidence of obesity has doubled among boys and increased by 60% in girls. This trend is more apparent in the manual social classes. Since obesity increases with age, the present generation of fatter children will drive prevalence of adult obesity even higher in the next 20 years.

Despite growing recognition of the problem of obesity, there has been no clear decline in the rate of increase in adults or children. The current obesity epidemic is caused by an imbalance between energy expenditure and energy intake, although the relative contributions of each – at both the individual and population level – will vary. What is known for certain is that people are insufficiently active to balance the energy (calories) they consume from food and drink, resulting in positive energy balance which translates in the longer term to increases in overweight and obesity.

Obesity carries considerable human costs: it doubles the risk of coronary heart disease and stroke and increases the risk of some cancers, musculoskeletal problems, and loss of function, and carries negative psychological consequences.[23,31] Furthermore, both obesity and high prevalence of inactivity are responsible for an increase in incidence of type 2 diabetes. Prevalence of this serious metabolic disease has been estimated at 2.9% of adults in the Health Survey for England[5] and type 2 diabetes has also been identified in obese adolescents.[32] (See section 5.3 page 49.) Physical activity has a key role to play in people's attempt to manage their weight, and can help reduce the risk of illness and premature death in overweight and obese people even in the absence of weight loss.[33-35]

Other diseases and conditions

Coronary heart disease, type 2 diabetes and obesity are not the only chronic conditions that are

influenced by inactivity. Booth *et al* have described 20 contemporary chronic disorders that are beneficially affected by regular physical activity.[20] Inactivity also plays a part in cancer, osteoporosis, low back pain, and mental illness such as depression. All of these conditions are common in England and contribute to the burden of human suffering through early death, illness and/or disability. They inevitably add substantially to the rising health care costs.

Quality of life and psychological well-being

Physical activity also has the capacity not only to add years to life, but to bring life to years – through reduced risk of mental disorders, improved quality of life and psychological well-being.

Risks of physical activity

The wide range of health benefits from physical activity can be experienced with only small risks of negative effects such as injury. Many of these risks are reduced to minimal levels if activity is limited to moderate intensity and if people progress gradually from one level of intensity to the next. Sudden cardiac death, especially in younger people, is a rare but high-profile risk of vigorous physical activity. The rate of occurrence of sudden cardiac death during or directly after exercise is extremely small – less than one death per 1 million exercise hours in middle-aged men.[36,37] Vigorous levels of physical activity may also increase the risk of heart attack, although again much depends on the person's habitual level of physical activity. However, this increased risk appears to apply only to men with high blood pressure.[38]

The costs of inactivity

The disease and disability caused by inactivity bring about serious and unnecessary human suffering and reductions in quality of life both for those who suffer the consequences and for their carers. The total cost of inactivity in England – including both direct costs of treatment for the major lifestyle-related diseases, and the indirect costs caused through sickness absence – has been estimated at £8.2 billion a year.[39] This does not include the contribution of inactivity to obesity which in itself has been estimated to cost £2.5 billion annually: £0.5 billion in NHS costs and a further £2 billion across the economy as a whole.[23] (It is estimated that obesity accounts for 18 million days of sickness per year.) Best estimates are that in western nations approximately 2.5% of total national health care costs are incurred through inactivity.[40] This figure is in line with the figures for England given above. If the proportion of insufficiently active people were reduced by just 5%, theoretically a £300 million saving in costs per year could be achieved.[39]

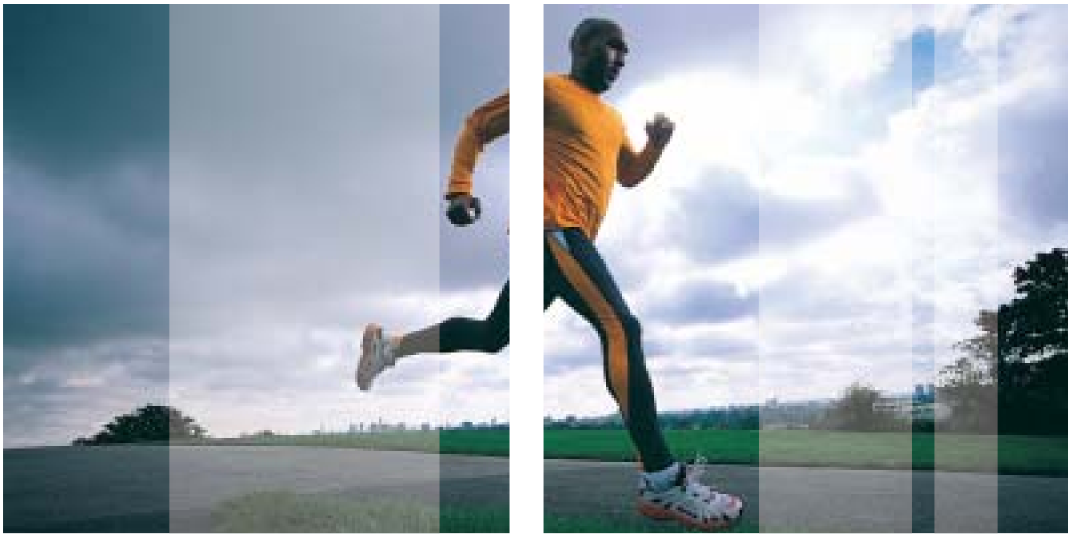
Interpreting the evidence base

Chapters 4-7 set out in greater detail the strong evidence demonstrating the harmful effects of inactivity, as well as the benefits of increased activity for prevention and treatment of a range of common chronic diseases. A lifecourse perspective is adopted to highlight critical health issues at different life stages. Greater weight is assigned to well-designed interventions and prospective observational evidence but where there is a lack of evidence, expert consensus has been considered.

The evidence produced in this report is strong and consistent across many areas of health. Even then, it is likely that the true public health burden of physical inactivity, has been under-estimated, for the following reasons.

Difficulty in measuring physical activity levels

Physical activity comprises a complex set of behaviours that includes habitual active commuting, recreational activities such as gardening, and more



purposeful activities such as gym-based exercise and sport. This presents many measurement challenges, and an instrument that can effectively quantify the true level and pattern of an individual's activity behaviour does not yet exist. Measurement error is likely to reduce the strength of relationships between physical activity and health, and weaken the measured effect of interventions. The complexities of measuring physical activity increase when quantification of lifestyle or incidental physical activity is required. The simpler and broader the measure of activity is (for example, self-report questionnaires), the less reliable and valid it tends to be. However, the accurate assessment of total activity – of which incidental activity forms the major part – is critical, as only then is it possible to achieve a measure of total activity energy expenditure – the most important health-related dimension of physical activity.

Limited research base

The research base for physical activity is limited when compared with many other determinants of health and disease. The field is relatively new, with the first studies appearing in the 1950s and the greater portion appearing after the early 1990s. Also, physical inactivity is not classed as a disease, so government and charitable trust funding for research has been limited. The result is variability in both the volume and quality of studies found in different areas of research regarding activity and health. Cardiovascular disease is relatively well investigated compared with areas such as obesity and mental health which have only recently attracted interest. Furthermore, there are few investigations of the effectiveness of physical activity for patients in health service settings.

Multiple effects of physical activity

Physical inactivity affects a wide range of diseases and risk factors. Many of these diseases – such as obesity, cardiovascular disease, type 2 diabetes and depression – may occur in the same individual. The multiple effects of increased activity across these many chronic conditions are rarely considered in study design, so the true value of physical activity in terms of public health may well be under-estimated. That physical activity should provide such a wide range of benefits might suggest that other underlying factors are at play – for example, socioeconomic disadvantage. However, physical activity is such a fundamental human behaviour that it is capable of influencing most major body systems. Where it has been feasible to conduct controlled experiments of the effect of physical activity, changes in health status have resulted. This has provided evidence against alternative interpretations of associations between physical activity and health.

Conclusions

There is little doubt that physical inactivity is now a major public health issue. Obesity is the main visible sign of inactivity, yet obesity is just one of possibly 20 chronic diseases and disorders for which low activity levels are a known contributory factor. Given the strength of the relationships between inactivity and the individual diseases, the broad range of diseases affected, and the ubiquitous nature of inactive lifestyles, there are few public health initiatives that have greater potential for improving health and well-being than increasing the activity levels of the population of England.

3 Recommendations for active living throughout the lifecourse

Key points

- Physical activity improves health throughout the lifecourse – from childhood through to older age.
- Children and young people should achieve a total of at least 60 minutes of at least moderate intensity physical activity each day. At least twice a week this should include activities to improve bone health (activities that produce high physical stresses on the bones), muscle strength and flexibility.
- For general health benefit, adults should achieve a total of at least 30 minutes a day of at least moderate intensity physical activity on 5 or more days of the week.
- The recommended levels of activity can be achieved either by doing all the daily activity in one session, or through several shorter bouts of activity of 10 minutes or more. The activity can be lifestyle activity* or structured exercise or sport, or a combination of these.
- More specific activity recommendations for adults are made for beneficial effects for individual diseases and conditions. *All* movement contributes to energy expenditure and is important for weight management. It is likely that for many people, 45-60 minutes of moderate intensity physical activity a day is necessary to prevent obesity. For bone health, activities that produce high physical stresses on the bones are necessary.
- The recommendations for adults are also appropriate for older adults. Older people should take particular care to keep moving and retain their mobility through daily activity. Additionally, specific activities that promote improved strength; co-ordination and balance are particularly beneficial for older people.

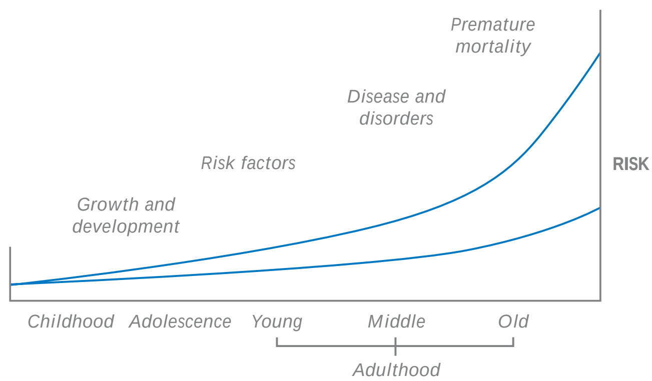
* Lifestyle activity means activities that are performed as part of everyday life, such as climbing stairs or brisk walking (see the Glossary in Appendix 1).

A lifecourse approach to the promotion of physical activity is necessary because the benefits of physical activity to health, and the impact of different types of physical activity, are different at the different key life stages of childhood and adolescence, adulthood, and older age.[43] Exposure to risk through inactivity begins in childhood, but it is not until middle to older age that the resultant increase in morbidity and eventual premature mortality are seen. Furthermore, people's lifestyles and the role of physical activity within their lifestyles vary across age groups. In order to be effective for public health improvement, physical activity recommendations need to promote levels of activity that produce worthwhile health effects but at the same time

reflect what is realistically achievable in the context of people's lives.

Figure 2 shows a hypothetical model of the key stages of disease development throughout the lifecourse. The upper line on the graph represents theoretical rates of progression – through growth and development, development of risk factors, onset of disease and disorders, and premature mortality for inactive individuals. The lower line represents active individuals. In this model, physical inactivity at all stages of life has negative effects in terms of impaired growth and development, or high risk factors, with the final expression as a disease or early death being seen primarily from mid-adulthood.

Figure 2 A lifecourse perspective on the effect of activity on disease risk



The upper line represents risk for individuals with an inactive lifestyle. The lower line represents risk for those with an active lifestyle.

Physical activity recommendations for children and adolescents

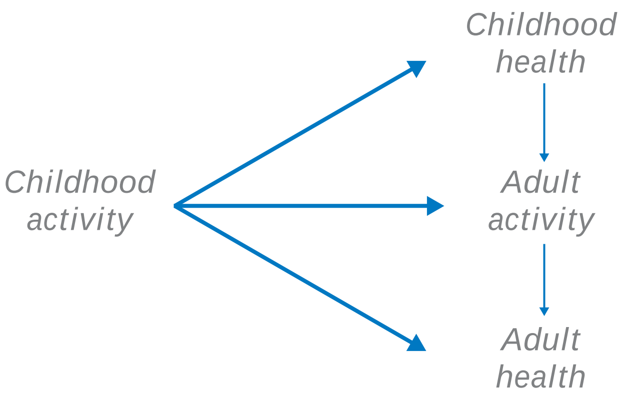
In terms of health, the main reasons for recommending physical activity are:

- for healthy growth and development of the musculoskeletal and cardiorespiratory systems
- to maintain energy balance (in order to maintain a healthy weight)
- to avoid risk factors such as hypertension (high blood pressure) and abnormal lipid profile, and
- to provide the opportunity for social interaction, achievement and mental well-being.

It is not appropriate to base physical activity recommendations for children on evidence of morbidity and mortality. With the exception of the rising incidence of obesity (see Chapter 2), children in England rarely have lifestyle-related diseases, or high risk factors for disease (such as high blood pressure or high cholesterol levels).

Physical activity is not only important for children's current health; it can also provide a stronger platform for maintenance of good health throughout the lifecourse. For example, it can help children and adolescents to maintain optimal body weight, thus reducing later risk of adult obesity; and it can maximise bone development, which can reduce later risk of osteoporosis (see Figure 3). Also, childhood and adolescence provide the greatest opportunity to influence attitudes towards activity. Children who emerge from their school years feeling confident about their physical skills and bodies, and who have had positive experiences of physical activity, are more likely to be active through adulthood.

Figure 3 Hypothetical relationships between physical activity in childhood and health in both childhood and adulthood



Source: Adapted from Blair *et al*, 1989[42]

The evidence for the health benefits of activity for children and adolescents is presented in Chapter 4. This represents an update of the evidence provided by the 1997 Department of Health consensus conference *Young and Active*[14] (see Appendix 2). The main recommendation was that children and young people should do one hour of moderate intensity physical activity each day, and this can be continuous activity or intermittent throughout the day.

There is no further definitive evidence to suggest that this basic physical activity advice should be changed. However, there is accumulating evidence that the majority of children are currently active at this level (see Chapter 2), and yet childhood obesity continues to increase. This may in part be caused by a minority of children taking part in too little activity, or by too high an energy intake, or both. Or it may be that one hour of activity a day is not enough to prevent the current rising obesity trends seen in children. (However, 60 minutes per day may have important health benefits with respect to other diseases.)

The recommendation for health-related activity in children is therefore:

Children and young people should achieve a total of at least 60 minutes of at least moderate intensity physical activity each day. At least twice a week this should include activities to improve bone health, muscle strength, and flexibility.

How can the recommendations be achieved?

Younger children can achieve the 60-minute target through the accumulation of bouts of activity of varying duration throughout the day. This can include short bursts and bouts of physical activity, as well as longer bouts such as when taking part in sports. This reflects young children's natural activity patterns, which include spontaneous play during breaks at school or close to home, walking to and from school, and programmed activity such as PE, sport, swimming or games.

It is important to stress that, at this age, *variety* of activity is important. For example, activities involving moderate to vigorous intensity activity will provide cardiorespiratory benefit. On the other hand, *all* movement that involves carrying body weight – such as walking – will help children and young people to maintain energy balance. For bone health, it is especially important for children to engage in bouts of activities that produce high physical stresses on the bones – such as running, jumping, ball games or gymnastics. Active play involving carrying, climbing, and rough and tumble will help develop and maintain muscular fitness and flexibility. Such a range of different modes and intensities of activity will provide a full range of health benefits across all body systems.

While much of the above still holds for older children, adolescents will begin to adopt adult-like activity patterns and are likely to achieve the recommended activity levels through a different

profile of activities. These might include walking to and from school, organised sports and games, a delivery round, exercise classes, and recreational activities such as dancing.

The activity patterns described above will promote a full range of health benefits. In order to make lifetime activity an attractive prospect to young people, it is critical that educational programmes help children and young people to experience enjoyment in a range of activities, to feel confident about their physical skills and their bodies, and to appreciate the importance and benefits of activity for health.

See pages 26–30 for information on moderate intensity activity, accumulating activity in shorter bouts, and how the recommendations can be achieved.

Recommendations for adults

Throughout adulthood, there is a need to avoid premature risk factors for a range of chronic diseases and conditions, and to maintain energy balance. Chapter 5 presents the evidence on the benefits of physical activity for helping adults to avoid cardiovascular disease, overweight and obesity, type 2 diabetes, musculoskeletal disorders, mental illness and cancer. It also indicates how physical activity has the potential to improve mental well-being. Chapter 7 presents evidence on the physical and psychological risks of engaging in activity and the conditions under which these risks are highest. This wealth of information has been considered against the existing advice for physical activity for adults, that all adults should aim to take 30 minutes of at least moderate intensity physical activity on at least five days a week. This recommendation was originally formulated by a review of evidence and expert consensus in 1994.[43-45] It agrees with recommendations produced by the American College of Sports Medicine and the Centers for Disease Control[46] and endorsed by the USA Surgeon General.[2]

The evidence reviewed in this report suggests that no change to the general recommendation is necessary. The recommendation for health-related activity in adults is therefore:

> Adults should achieve a total of at least 30 minutes of at least moderate intensity physical activity a day, on 5 or more days a week.

This recommendation offers a simple and generic target for physical activity participation and should continue to provide the basis for general guidance for public health. The recommendation maximises both health impact and participation, while minimising the risk.

The evidence shows that the general recommendation may need to be modified to meet the needs of preventing or treating specific diseases. The general recommendation is in itself sufficient to have a beneficial effect on cardiovascular disease, type 2 diabetes, mental health, musculoskeletal disorders and cancer.

Achieving the recommendation of at least 30 minutes of at least moderate intensity physical activity on 5 or more days a week (a total of 150 minutes) will represent a significant increase in energy expenditure for most people, and will contribute substantially to their weight management. However, in many people, and in the absence of a reduction in energy intake, 45-60 minutes' activity each day may be needed in order to prevent the development of obesity. People who have been obese and who have lost weight may need to do 60-90 minutes of activity a day in order to maintain their weight loss. For beneficial effects on bone health, the mode of activity is important: activities that involve higher physical stresses on the bones (for example jumping or twisting movements) are needed. On the other hand, some

of these activities may aggravate existing chronic conditions such as osteoarthritis. These issues are dealt with in more detail in Chapter 5.

See pages 26–30 for information on moderate intensity activity, accumulating activity in shorter bouts, and how the recommendations can be achieved.

Recommendations for older people

'Older people' comprise a large section of the population among whom there is a very wide range of functional ability, from marathon runners to people unable to rise unaided from a chair. They are also the group most at risk from many of the diseases and conditions addressed in this report.

Older people face the prospect of increased morbidity and mortality as part of the natural ageing process. They also experience a gradual loss in muscle mass, muscle strength, muscle power, balance, flexibility and cardiorespiratory function. There is a decline in cognitive abilities, and a higher risk of cognitive impairment, depression, osteoarthritis and falls. Older people are more likely to be dependent on others and susceptible to social isolation, and fear of crime and traffic. Chapter 6 presents the role that physical activity can play in slowing the ageing process, and in helping older people to maintain functional capacity and to reduce their risk of some of these health problems.

Specific guidelines for physical activity for older people have not previously been established in England. The evidence suggests that:

> The recommendations for adults (shown on page 24) are also appropriate for older people.

The evidence also suggests that there are some important additional considerations for older people:

- Older people should take particular care to keep moving and retain their mobility through daily activity.
- Activities that promote improved strength, coordination and balance are particularly beneficial, in addition to endurance which is beneficial for people of all ages.
- Choice of activities should be made in the light of an older person's functional limitations and symptoms of diseases.
- Regular walking remains extremely important for the maintenance of independence and activities of daily living.
- Low to moderate intensity activity can produce a health benefit for older people, possibly because of their relatively lower fitness levels. (Due to the aging process, older people have a reduced cardiorespiratory and muscle function. So the absolute intensity of activities for older people can be lower than it is for younger adults. See *Moderate intensity activity* below, and the Glossary in Appendix 1, for an explanation of this.)
- As there is a greater risk of injury among older people, higher intensity activities, and activities that involve sudden or complicated movements, should be undertaken cautiously, unless the individual is already used to this type of exercise. Certain activities, such as frequently going up and down stairs, can aggravate some existing conditions such as osteoarthritis.
- Activity can also prevent age-related weight gain and help with weight loss.

See pages 26–30 for information on moderate intensity activity, accumulating activity in shorter bouts, and how the recommendations can be achieved.

Table 6 Intensities and energy expenditure for common types of physical activity

Activity	Intensity	Intensity (METS)	Energy expenditure (Kcal equivalent, for a person of 60kg doing the activity for 30 minutes)
Ironing	Light	2.3	69
Cleaning and dusting	Light	2.5	75
Walking – strolling, 2mph	Light	2.5	75
Painting/decorating	Moderate	3.0	90
Walking – 3mph	Moderate	3.3	99
Hoovering	Moderate	3.5	105
Golf – walking, pulling clubs	Moderate	4.3	129
Badminton – social	Moderate	4.5	135
Tennis – doubles	Moderate	5.0	150
Walking – brisk, 4mph	Moderate	5.0	150
Mowing lawn – walking, using power-mower	Moderate	5.5	165
Cycling – 10-12mph	Moderate	6.0	180
Aerobic dancing	Vigorous	6.5	195
Cycling – 12-14mph	Vigorous	8.0	240
Swimming – slow crawl, 50 yards per minute	Vigorous	8.0	240
Tennis – singles	Vigorous	8.0	240
Running – 6mph (10 minutes/mile)	Vigorous	10.0	300
Running – 7mph (8.5 minutes/mile)	Vigorous	11.5	345
Running – 8mph (7.5 minutes/mile)	Vigorous	13.5	405

MET = Metabolic equivalent
1 MET = A person's metabolic rate (rate of energy expenditure) when at rest
2 METS = A doubling of the resting metabolic rate
For a full definition of METS, see Appendix 1.

Source: Based on data from Ainsworth *et al*, 2000[47]

Moderate intensity activity

For general public health benefit, the most appropriate activities are those of moderate intensity. Moderate intensity activity stimulates the body's cardiorespiratory, musculoskeletal and metabolic systems and over time causes them to adapt and become more efficient. In other words, the body gets fitter.

The concept of 'moderate intensity activity' may not be widely understood. A person who is doing moderate intensity activity will usually experience:

- an increase in breathing rate
- an increase in heart rate, to the level where the pulse can be felt, and
- a feeling of increased warmth, possibly accompanied by sweating on hot or humid days.

Also, a bout of moderate intensity activity can be continued for many minutes, and does not cause exhaustion or extreme fatigue when continued for an extended period.

The amount of activity a person needs to do to achieve an activity of moderate intensity varies from one individual to another. A person who is unfit or overweight may only have to walk up a slope to experience these feelings, whereas a very fit athlete may be able to run quite fast before the feelings become noticeable. So, in an activity such as walking, it is important for an individual to focus on their perception of the effort they need to make, rather than their speed. Table 6 gives some examples of the activities that would be light, moderate or vigorous intensity for a person of average weight and fitness. It also shows, for each of these activities, the intensity measured in METs (a measure of how far energy expenditure is raised above the resting level), and the total energy expenditure (in kcals, for a person of 60kg exercising for 30 minutes).

Accumulating activity in shorter bouts

Shorter bouts of physical activity offer an easier starting point for those who have been inactive for some time, and for those who have busy lifestyles and find it hard to make activity a priority. There are now at least 11 randomised controlled trials[48-51] that indicate both fitness and health benefits from equivalent volumes of activity achieved through shorter bouts of 10-15 minutes duration. A small number of interventions indicate that lifestyle activity (which tends to be made up of shorter bouts) can be at least as effective as structured or programmed exercise at a gym or leisure centre, and may have the added benefit of increased compliance.[51 52] There is increasing consensus that the volume of physical activity performed, regardless of intensity, duration or frequency, is the critical health-related dimension.

Given the increasing prevalence of obesity, it is also important that people who need to carefully manage their weight build up to 45-60 minutes of moderate intensity physical activity a day.[31 53] Those who are already obese and who have lost some weight may need to achieve at least 60-90 minutes' activity a day to maintain their healthier weight.[53] Several shorter bouts of activity accumulated throughout the day may make it easier for people to achieve these targets.

How can the recommendations be achieved?

Chapter 2 indicated that the greatest public health gains can be made by moving inactive individuals towards the recommended level. It is therefore important for recommendations and messages to emphasise that steady but successful progress towards higher levels of activity is an important goal. Individuals taking up activity for the first time, or rediscovering it after a period of inactivity, should be encouraged to build up gradually to the recommended level. Of particular importance is the need to change the prevailing cultural and social norms regarding active lifestyles. This will inevitably be a slow process, with the ultimate goal being a society within which daily activity is a natural and habitual event.

Many people find it difficult to translate a set of numbers (such as those in the physical activity recommendations) into a behaviour pattern that is meaningful and that can fit into the way they live their lives. Table 7 describes five increasing 'levels' of physical activity (including the recommended level), the typical activity pattern needed in order to achieve each level, and the health benefits that each level offers. The typical activity pattern for each level includes personal transport, and job-related, household and recreational activities. For any physical activity pattern, the resultant 'level' is a composite measure of the activities performed, how often, how hard and for how long (type, frequency, intensity and time).

Table 7 Levels of physical activity

Level	Descriptor	Typical activity pattern	Health benefits
1	Inactive	Always drives to work or takes public transport. Predominantly sedentary job. Minimal household and garden activities. No active recreation.	Nil
2	**Lightly active**	Will do one or more of: – Some active commuting on foot or by bicycle – Some walking, lifting, and carrying as part of work – Some undemanding household and garden activities – Some active recreation at light intensity.	Some protection against chronic disease. Can be considered a 'stepping stone' to the recommended level (level 3).
3 Recommended level	**Moderately active**	Will do one or more of: – Regular active commuting on foot or by bicycle – Regular work-related physical tasks – for example, delivering post, household decorator – Regular household and garden activities – Regular active recreation or social sport at moderate intensity.	High level of protection against chronic disease. Minimal risk of injury or other adverse health effects.
4	**Very active**	Will do most of: – Regular active commuting on foot or by bicycle – Very active job – for example, labourer, farm worker, landscape gardener – Regular household or garden activities – Regular active recreation or sport at vigorous intensity.	Maximal protection against chronic disease. Slight increase in risk of injury and possibly some other adverse health effects.
5	**Highly active**	Performs high volumes of vigorous or very vigorous fitness training, often in order to play vigorous sports.	Maximal protection against chronic disease. Increased risk of injury and possibly some other adverse health effects.

For most people, the easiest and most acceptable forms of physical activity are those that can be incorporated into everyday life. Examples include walking or cycling instead of travelling by car, and taking up active leisure pursuits and hobbies such as gardening or social sporting activities. However, a larger quantity of activity at higher intensity can bring further benefit and this might be an ultimate aspiration for some people. Those who are already highly physically active and at a high level of fitness should be encouraged to continue. However, very high levels of fitness training or engagement in vigorous and contact sports also carries higher risk of sports/exercise-related injury. Progressing too rapidly from one level to another also carries higher risk.

Table 8 shows how people in different age groups – from young children to retired older people – can achieve the recommended levels of physical activity. A critical issue is that this report focuses on people who have no serious physical limitations that might inhibit progress towards a more active lifestyle. However, there are a significant number of people who do have such limitations. Even at younger ages, a very high proportion of people are reporting locomotor disabilities of some degree. For example, among British adults in the 1996 disability survey, 55% reported some degree of musculoskeletal system disorders.[54]

It is important that activity should provide benefits for the individual in terms of well-being – for example, improved mood, a sense of achievement, relaxation, or simply release from daily stress. It is these outcomes, more than the physical health benefits, that improve adherence to activity patterns and ensure that the health benefits are maintained in the long term. (For more on this, see *Motivation*, page 62.)

It is equally important to consider the strong social and cultural influences on children's activity behaviour. There is now a greater use of cars to transport children even on short journeys.[8] Parental reluctance to allow children to play outdoors may have increased through perceived dangers within the physical environment, such as heavy traffic and 'stranger danger'.[18] There is also more access to television and computers and other sedentary alternatives that attract children.[19] In many ways, children are less in control of their activity habits than children of previous generations.

Table 8 How individuals of different age groups can achieve the recommended levels of activity

Person	Activities
Young child	Daily walk to and from school. Daily school activity sessions (breaks and clubs). 3-4 afternoon or evening play opportunities. Weekend: longer walks, visits to park or swimming pool, bike rides.
Teenager	Daily walk (or cycle) to and from school. 3-4 organised or informal midweek sports or activities. Weekend: walks, biking, swimming, sports activities.
Student	Daily walks (or cycle) to and from college. Taking all small opportunities to be active: using stairs, doing manual tasks. 2-3 midweek student sports or exercise classes, visits to the gym or swimming pool. Weekend: longer walks, biking, swimming, sports activities.
Adult – employed	Daily walk or cycle to work. Taking all small opportunities to be active: using stairs, doing manual tasks. 2-3 midweek sport, gym, or swimming sessions. Weekend: longer walks, biking, swimming, sports activities, DIY, gardening.
Adult – houseworker	Daily walks, gardening, or DIY. Taking all small opportunities to be active: using stairs, doing manual tasks. Occasional midweek sport, gym, or swimming sessions. Weekend: longer walks, biking, sports activities.
Adult – unemployed	Daily walks, gardening, DIY. Taking all small opportunities to be active: using stairs, doing manual tasks. Weekend: longer walks, biking, swimming, or sports activities. Occasional sport, gym, or swimming sessions.
Retired person	Daily walking, cycling, DIY or gardening. Taking all small opportunities to be active: using stairs, doing manual tasks. Weekend: longer walks, biking, or swimming.

Source: Partly based on data from the *UK Time Use Survey*, 2003[7]

4 Health benefits of physical activity in childhood and adolescence

Key points

- Physical activity in childhood has a range of benefits during childhood, including healthy growth and development, maintenance of energy balance, psychological well-being and social interaction.
- In terms of risk factors for cardiovascular disease, the primary role of physical activity may be an indirect one – that of helping to prevent excess weight gain during childhood, or helping overweight children to lose weight.
- Physical activity is important for bone health. In particular, exercises that produce high physical stresses on the bones (such as jumping, skipping, dancing and aerobics) during the years of the growth spurt – can help to increase bone mineral density and protect against osteoporosis in later life.
- There is only weak to moderate evidence that participation in physical activity tracks through from childhood to adulthood.

There is a strong justification for encouraging young people to be physically active. Physical activity provides an important vehicle for play and recreation, learning physical and social skills, developing creative intelligence and stimulating growth and fitness. However, there is relatively little direct evidence (compared with adults) linking physical inactivity in children with childhood health outcomes.[55] The chronic diseases described in this report – cardiovascular disease, type 2 diabetes and cancer – require long incubation periods.[56] Childhood and adolescence form the early phases of accumulated exposure to risk factors throughout the lifecourse[41] (see Figure 2, page 22). Children and adolescents very rarely have lifestyle-related diseases such as clinical hypertension (high blood pressure), diabetes, osteoporosis or cardiovascular disease, so the normal markers of morbidity and mortality used by researchers are not evident. However, children and adolescents can have high levels of a range of *risk factors* for diseases – for example, obesity, raised blood pressure, adverse lipid profiles, or low bone mineral density – which can be used instead, although the use of risk factors as markers provides a less robust analysis. Furthermore, the challenges of measuring physical activity in children are even greater than with adults, producing weaker relationships.[3 57] (See *Activity and inactivity among children*, in page 13.)

The evidence presented in Chapter 2 shows that a large proportion of children are quite active. Around two-thirds of 2-11 year olds report at least 60 minutes of moderate intensity activity a day (see Table 5). For boys, this level of activity holds

through to age 15, but in girls it falls to about half. It is therefore important to determine the health benefits that high activity levels can provide, and to identify the health consequences for those children whose activity levels are chronically low.

Physical activity and childhood health

Activity in childhood has a range of benefits during childhood which in themselves justify the promotion of physical activity for children and young people. These include: healthy growth and development of the musculoskeletal and cardiorespiratory systems; maintenance of energy balance (in order to maintain a healthy weight); avoidance of risk factors such as hypertension and high cholesterol; and the opportunity for social interaction, achievement and mental well-being (see Chapter 3).

Obesity

The high, and rising, levels of overweight and obesity among children and young people in England have been described in Chapter 2. In 2002, 30.3% of boys aged 2-15 years and 30.7% of girls were at least overweight, and 16% of boys and 15.9% of girls in this age group were obese.[12]

Children who are obese are more likely to have certain cardiovascular risk factors,[58 59] a higher incidence of premature atherosclerosis (particularly in males)[60] and insulin resistance (a precursor of type 2 diabetes).[61] Obese children are also more likely to have lower levels of physical fitness,[62 63] and are more likely to experience long-term social and economic discrimination,[64] and lower quality of life.[65]

The degree to which inactivity is responsible for the rising levels of obesity in children has not been established. However, there are indications that less active children are more likely to have excess fat,[15 66-71] even as early as late infancy.[72] There is also evidence that children who spend more time involved in sedentary pursuits such as television watching are more likely to have excess fat,[67 73 74] although the strength of this association has recently been questioned.[75 76] This issue is also clouded by the positive associations reported between television-watching and intake of energy-dense snacks.[77]

Interventions using programmed activity (as opposed to free-living activity) have resulted in clinically significant decreases in body fat and body mass index in obese children.[78] Similarly, reductions in body fat have been achieved through an intervention to reduce TV watching time.[79]

Mental health

There is evidence that physical activity is important for children's psychological well-being.[80] Children with lower physical activity levels have more symptoms of psychological distress than more active children. A positive relationship between physical activity and well-being has been identified, independent of social class and health status.[81 82]

Current evidence indicates that physical activity interventions can have a generally positive impact on the mental health of young people. Sport and exercise can provide an important arena for youngsters to be successful and this is experienced through positive effects on self-esteem and self-perceptions of competence and body image,[83 84] with a stronger effect for those already low in self-esteem. Physical activity has also been found to have a weak effect on reducing stress, anxiety and depression in adolescents.[85]

Children with higher physical activity levels are more likely to have better cognitive functioning. A meta-analysis of 44 studies concluded that there is a significant positive relationship between physical activity and cognitive functioning in

children, with a mean effect size of 0.32 (0.27).[86] However, there is little robust experimental evidence to support this relationship.[80] On the other hand, there is evidence that a substantial increase in the amount of school time devoted to health-related physical education does *not* have detrimental effects on students' academic performance, and confers significant health benefits.[87] Similarly, regular participation in sport does not appear to compromise academic achievement.[88] There is equivocal evidence on the question of whether juvenile delinquency is related to lower levels of sport participation.[80]

Cardiovascular disease

Cardiovascular disease is not a disease of childhood, but some children do have certain risk factors for cardiovascular disease, including high blood pressure and high cholesterol levels. Preliminary findings suggest that there may be an inverse association between these risk factors and childhood physical activity: children with lower levels of physical activity are more likely to have risk factors for cardiovascular disease. This may be very important, as there is growing evidence that the determinants of adult cardiovascular disease are laid down early in life.[89-91]

Evidence for beneficial associations between childhood physical activity and blood lipids is equivocal,[55 92] but more recent studies suggest that increases in HDL cholesterol (the 'protective' cholesterol) are associated with regular physical activity in childhood: those who do regular physical activity are more likely to have a higher HDL cholesterol level.[15 93]

No consistent relationship has been established between physical activity levels and blood pressure in children, although the majority of studies show some beneficial, if weak, associations.[55]

Stronger and more convincing relationships have been demonstrated between physical activity and aerobic fitness: children with higher levels of physical activity have higher levels of aerobic fitness.[15 57 94] Multiple risk factors for cardiovascular disease (including raised blood pressure, adverse lipid profile, raised insulin levels, and excess fat) are associated with low levels of aerobic fitness in children: those with low levels of aerobic fitness are more likely to have multiple risk factors for cardiovascular disease.[95]

Obesity may be an important factor in the incidence of cardiovascular disease risk factors during adolescence.[58 62] The primary role of physical activity in the context of childhood cardiovascular disease risk status may, therefore, be an indirect one – that of helping to prevent excess weight gain during childhood, or helping children who are already overweight to lose weight.

Diabetes

The prevalence of type 2 diabetes is increasing in children and adolescents in the UK, although the numbers are small.[32] There is accumulating evidence that obesity, increased insulin resistance, disordered lipid profile and elevated blood pressure are appearing together in children. The concurrent appearance of these risk factors is a clear indication that subsequent diabetes is more likely. In adults, physical inactivity and obesity are known to be major risk factors for type 2 diabetes. The emergence of type 2 diabetes at younger ages may, therefore, be due to the increase of obesity and its associated disorders and the decrease in levels of physical activity observed in children over the past 30 years.[96]

Childhood activity and health as an adult

Obesity

Childhood obesity tracks into adulthood, particularly among those children who have one or two obese parents: 26-41% of children who are obese at pre-school age and 42-63% of obese school-age children become obese adults.[58 97 98] However, obese adults were not all obese when they were younger: more than half of obese adults were not obese as children.[99]

Being obese in childhood can increase the risk of health problems in later life. Adults who were obese as children carry a risk of poorer health and increased mortality compared with adults who were not obese as children.[97 100 101] Such adverse health outcomes may have their origins in early childhood. For example, blood pressure in young adulthood has been shown to increase by 1.6mmHg for every standard deviation score increase in weight gain between the ages of 1 and 5 years.[102]

A systematic review concluded that the evidence that physical activity in childhood was protective against later obesity was "inconsistent but suggestive".[103]

Cardiovascular disease

Although there is little evidence linking childhood physical activity with risk of cardiovascular disease in adulthood, there does seem to be an association between childhood fitness and levels of adult risk of cardiovascular disease.[104 105] Thus, the beneficial role of physical activity may be an indirect one – that of maintaining childhood aerobic fitness.

Bone health

Both boys and girls rapidly gain bone mineral density in childhood and adolescence, especially around the years of the growth spurt, which occurs at about 12 years in girls and 14 years in boys (peak height velocity). It is important to increase bone mineral density because this reduces the chances of age-related loss of bone mass and the likelihood of osteoporosis in later life. (Osteoporosis is a degenerative bone disease that is characterised by low bone mass – or low bone mineral density. The bones become brittle and more prone to fracture.)

Physical activity – particularly in the puberty years and adolescence, and particularly exercise that physically stresses the bone – is important for bone health. A consensus is now emerging[106-108] that, while exercise may enhance skeletal growth in pre-pubertal children,[109 110] the greatest benefit from exercise in terms of bone health occurs in early puberty. Weight-bearing activities incorporating high peak strains, high strain rates and unusual strain distributions are particularly good for increasing bone mineral density.[111] So activities that physically stress the bone – such as jumping, dancing and aerobics, and sports such as gymnastics, volleyball, racquet sports, soccer and mountain-biking – may be particularly effective.[112-115] The duration of such activities may not need to be long to be effective, as the maximum benefit appears to be achieved after only a few repetitions of the activity.[116] Children who do these sorts of physical activity have 5-15% more bone mineral density than inactive children, sufficient to reduce substantially the risk of osteoporotic fracture if maintained into old age.[117] Bone mineral density is not increased at all by low-impact exercises such as swimming.[118]

Physical activity that physically stresses the bone – such as running, jumping and skipping – can increase bone mineral density in adolescents.[118] Achieving as high a skeletal mass as possible during growth will have long-term health benefits, as it provides a reserve of bone tissue to counter the inevitable loss of bone that accompanies ageing,

especially if the activity is maintained. It reduces the likelihood of developing osteoporosis and the attendant risk of fracture. Animal studies have provided strong evidence that growing bone has a greater capacity to add new bone to the skeleton than does adult bone.[111] Peak bone mass is achieved by the age of 20-30,[119] so attempts to enhance bone mass must concentrate on childhood and adolescence.[106 107]

Establishment of lifetime activity patterns

A further benefit of childhood physical activity for adult life may be the establishment of activity as a lifetime habit. If being active as a child positively influences activity behaviour as an adult (good tracking) then childhood physical activity could be said to indirectly influence adult health. Tracking of physical activity through childhood, or through adulthood, appears relatively good,[120 121] but tracking from childhood to adulthood is, at best, weak to moderate.[92 122] Stronger associations between physical activity in childhood and physical activity in adulthood are found when the *quality* of the physical activity experience in childhood, rather than simply the quantity, is taken into account.[123-125] There is an association between body mass index and lower motor ability already in primary school age children.[126] There is also strong evidence to show that, by the time young people leave secondary school, their attitudes to sport and exercise and their level of perceived ability are highly predictive of whether or not they are physically active as adults. So, although the volume of longitudinal data is currently low, it is likely that the way exercise and sport are experienced in childhood and youth will impact on subsequent participation as an adult. Conversely, negative attitudes gained as a young person may persist into adulthood and affect people's willingness to take part in physical activities.[11]

5 The benefits of physical activity for adult health

This chapter sets out the evidence for the impact of physical activity on several diseases and conditions: cardiovascular disease; overweight and obesity; type 2 diabetes; musculoskeletal health; psychological well-being and mental health; and cancer. The health benefits identified (summarised in Chapter 1) start to be seen predominantly in the short to medium term. The diseases prevented or treated are predominantly chronic or recurrent, and physical activity has to be current and continued to offer protection.[127]

5.1 Physical activity and cardiovascular disease

Key points

- Physical activity is a major independent protective factor against coronary heart disease in men and women. Inactive and unfit people have almost double the risk of dying from coronary heart disease compared with more active and fit people. People at high risk of coronary heart disease may benefit even more from physical activity compared with people at lower risk. Physical activity also significantly reduces the risk of stroke and provides effective treatment of peripheral vascular disease.
- Physical activity helps to improve several risk factors for cardiovascular disease, including raised blood pressure, adverse blood lipid profiles, and insulin resistance.
- Thirty minutes of at least moderate intensity physical activity a day on at least 5 days a week significantly reduces the risk of cardiovascular disease.
- Shorter bouts of physical activity, of 10 minutes or more, interspersed throughout the day are as effective as longer sessions of activity, as long as the total energy expended is the same.
- The benefits of physical activity can be gained from activities that can be incorporated into everyday life, such as regular brisk walking, using stairs, or cycling. Physical activity does not need to be vigorous to confer protection.
- Exercise-based cardiac rehabilitation programmes for patients with coronary heart disease are generally effective in reducing cardiac deaths and lead to important reductions in all-cause mortality. Treatment with exercise may also be effective in the rehabilitation of people with stroke. For people with peripheral vascular disease exercise rehabilitation can improve walking ability and the ability to perform everyday tasks, and for those with heart failure exercise training can improve quality of life.

Cardiovascular disease – which includes coronary heart disease and stroke – is the greatest cause of mortality and morbidity in England, and an important cause of disability and loss of function. Cardiovascular disease causes over 200,000 deaths a year and accounts for 39% of all deaths in men and women. Half of cardiovascular disease mortality is attributable to coronary heart disease and about a third to stroke. Cardiovascular disease accounts for considerable premature mortality. For every 100,000 people under 75, 1,317 years of life will be lost due to cardiovascular disease (potential years of life lost).[128] The death rates from coronary heart disease and other circulatory diseases in England are higher than the average for the European Union.[129, 130] The Government has made coronary heart disease a priority in the NHS because it is common, frequently fatal, and largely preventable.[131]

Preventive effects

Coronary heart disease

It has been known since the 1950s that people with higher levels of physical activity have a lower risk of coronary heart disease, and there is a consensus that the association is causal.[132] Early studies of

occupational physical activity and later studies of leisure activity clearly established that physical inactivity is a major independent risk factor for coronary heart disease.[133-137] Inactive people have almost double the risk of dying from coronary heart disease compared with more active people.[138 139]

A low level of cardiorespiratory fitness has been shown to be an independent risk factor for coronary heart disease of a similar magnitude to inactivity.[140-142] Higher levels of cardiorespiratory fitness have also been shown to lessen the harmful effects of other risk factors for coronary heart disease such as smoking, high cholesterol or blood pressure.[143] People with higher levels of cardiorespiratory fitness during young adulthood (18-30 years) have a lower risk of developing cardiovascular disease risk factors in later life, with obesity appearing to play a mediating role.[144]

Both the relationship between physical activity and coronary heart disease, and the relationship between cardiorespiratory fitness and coronary heart disease, are strong, inverse, and follow a curvilinear dose-response pattern: the higher the levels of physical activity or cardiorespiratory fitness, the lower the level of coronary heart disease (see Figure 1 in Chapter 2).[137-139 145 146] For cardiorespiratory fitness, there appears to be a threshold below which risk is particularly high: the 25% of the population with the lowest levels of cardiorespiratory fitness are at particularly high risk of coronary heart disease.[147]

Even small differences in physical activity level can result in important reductions in coronary heart disease risk, especially among the least active.[148]

The benefits of physical activity for cardiovascular disease appear to be just as strong for older people as they are in middle age. In a systematic review, Batty reports that in older men both cardiorespiratory fitness and physical activity are inversely related to coronary heart disease risk: men with higher levels of cardiorespiratory fitness or physical activity have a lower risk of coronary heart disease.[149] Manson *et al*[150] reported that women aged 50-79 years who were more active had fewer coronary events and a lower total number of cardiovascular events compared with less active women.

People at high risk of coronary heart disease – for example men with type 2 diabetes or impaired glucose tolerance – may benefit more from physical activity compared with people at lower risk.[151]

The benefits of physical activity can be gained from moderate intensity activity that can be incorporated into everyday life. For example, regular walking is associated with a reduction in coronary heart disease events,[152 153] and can increase levels of HDL cholesterol (the 'protective' cholesterol).[154] Physically active commuting to work has been associated with lower levels of risk factors for coronary heart disease, such as increased levels of HDL-cholesterol and increased fitness.[155] Recreational activity of 4 hours or more per weekend, moderate or heavy gardening, and regular walking are all associated with reduced coronary heart disease.[156] However, in a study of UK men, Morris *et al* reported that walking, cycling and sports that were not described as vigorous offered no protection against coronary heart disease, nor did other forms of exercise or high volumes of physical activity.[157] Regular stair-climbing has been reported to cause increases in HDL cholesterol, and a reduced ratio of total cholesterol to HDL cholesterol.[158]

Virtually all large, epidemiological studies to date have been on men. However, there is also convincing evidence for the protective effect of physical activity on women from a study of over 70,000 post-menopausal women aged between 50 and 79. This study calculated a physical activity score based on total activity, walking, vigorous exercise, and hours spent sitting.[150] An increasing physical activity score had a strong, graded, inverse association with the risk

of both coronary events and total cardiovascular events in both white and black women: the higher the physical activity score, the fewer coronary events and the lower the total number of cardiovascular events. The age-adjusted relative risks of coronary events for women in increasing quintiles of activity were 1.00, 0.73, 0.69, 0.68, and 0.47, respectively. In other words, the least active women had twice the risk of a coronary event compared with the most active women. Both walking and vigorous exercise were associated with similar risk reductions, and the results did not vary substantially according to race, age, or body mass index. A brisker walking pace and fewer hours spent sitting daily also predicted lower risk. These data indicate that both walking and vigorous exercise are clearly associated with substantial reductions in the incidence of coronary events among post-menopausal women.

Stroke

Fewer data are available for stroke than for coronary heart disease, but evidence from case-control and prospective studies suggests that physical activity can reduce the incidence of stroke.[127 132 159-161] Lee *et al* demonstrated that people who were highly active had a 27% lower risk of stroke incidence or mortality than less active people.[161] Similar results were seen in moderately active people compared with inactive people. Moderately active and highly active people had a lower risk of both occlusive and haemorrhagic strokes compared with those who were less active.

The majority of studies report that those who do regular light to moderate activity have a lower incidence of stroke compared with those who are inactive, and some data suggest that vigorous activity confers no additional benefit. Data for a dose-response relationship are sparse, but one study reported a decreased risk across increasing categories of walking pace in women.[162] Low cardiorespiratory fitness is also associated with an increased risk of stroke in men.[163]

Effects of physical activity on the risk factors for cardiovascular disease

The basic underlying pathology of cardiovascular disease is atherosclerosis[164] (the build-up of fatty material in the wall of the arteries). Factors that accelerate the process of atherosclerosis are recognised as risk factors for cardiovascular disease.

Raised blood pressure

High blood pressure (hypertension) can be both prevented and treated by physical activity. Moderate intensity aerobic exercise is associated with reductions in both systolic (3.8mmHg) and diastolic (2.6mmHg) blood pressure.[165] The effects appear to be largely independent of intensity or frequency of activity.[166-168] Adults with normal blood pressure experience smaller reductions.[169] Both resistance exercise (weight-training) and aerobic exercise (such as walking) have been shown to be effective,[170 171] and reductions in blood pressure are seen both in those who are overweight and those who are normal weight.[165]

Possible mechanisms

Physical activity appears to have both long-term and short-term effects on blood pressure. In the long term, physical activity may reduce blood pressure by preventing obesity, reducing insulin resistance and increasing the capillary density of muscle.[172] In the short term, immediately after a bout of physical activity there are profound acute changes in the mechanisms that regulate and determine blood pressure. The resulting lowering of blood pressure after exercise (post-exercise hypotension) may last for 2 hours in healthy people and for more than 12 hours in those with high blood pressure.[173] It is likely that the underlying mechanisms are linked to the longer term adaptations in blood pressure that occur with

increased activity. The clinical implications of post-exercise hypotension remain obscure.

Blood lipids

The term 'blood lipids' includes total cholesterol, LDL cholesterol, HDL cholesterol (the 'protective' cholesterol) and triglycerides. There is considerable evidence that physical activity can help to improve blood lipid profiles and prevent adverse blood lipid profiles from developing. The main benefit appears to be improved levels of HDL cholesterol.[174] Epidemiological data suggest that a weekly energy expenditure of 1,200-2,200kcals (for example 15-25 miles of brisk walking or jogging a week) is associated with a 0.051-0.077mmol/l increase in HDL cholesterol and a reduction of 0.09-0.22mmol/l in triglycerides. There appears to be a dose-response relationship, with further increases of 0.002-0.077mmol/l in HDL cholesterol possible for each 10-mile or 1,100kcal increment. After controlling for body weight and composition, exercise does not seem to alter total cholesterol or LDL cholesterol. The majority of intervention studies suggest a similar pattern: that exercise training can raise HDL cholesterol and lower triglycerides, but does not alter total cholesterol or LDL cholesterol. Training volumes eliciting energy expenditure of 1,200kcals per week or more can raise HDL cholesterol by 0.051-0.206mmol/l and lower triglycerides by 0.056-0.429mmol/l in men and women. These changes appear to be independent of alterations to body weight or fat levels.[174,175]

Possible mechanisms

The mechanisms underlying such changes remain largely unexplained,[175] but it is clear that the metabolic capacity of skeletal muscle plays a central role. In particular, physical activity reduces the proportion of type 2b, glycolytic muscle fibres, and increases the number of capillaries. These changes mean that the body is better able to metabolise lipids, particularly the saturated fatty acids. Short-term exercise training also induces an increase in muscle LPL (lipoprotein lipase) gene expression, which increases LPL activity within the muscle cell.[176] The likely mechanism is that a combination of low capillary density, decreased capillary blood flow and lowered muscle LPL activity (all of which are associated with inactivity) impairs the breakdown of LDL cholesterol and the transport of HDL3 cholesterol to HDL2 cholesterol.[177]

Insulin resistance

Both resistance exercise and aerobic exercise have been shown to prevent and modify insulin resistance.[178,179] Improvements in glucose metabolism of between 11% and 36% can be expected. For more on physical activity and type 2 diabetes, see section 5.3, page 49.

Endothelial function

There is convincing evidence that atherosclerosis (the build-up of fatty deposits in the walls of the arteries) is an inflammatory disease mediated by the immunological system,[180,181] involving activation of the endothelium (membrane lining) of blood vessels. Regular physical activity has been shown to have a positive effect on the coronary circulation of people with coronary vascular disease through improved endothelial function.[182] Similar improvements have also been seen in the peripheral circulation of normal subjects[183] and people with congestive heart failure.[184]

Possible mechanisms

Physical activity may exert beneficial effects by improving the function of the endothelial cells and promoting an atheroprotective phenotype both in endothelial cells and T cells.[181] Such effects may be due at least in part to repetitive increases in local shear stresses on the endothelium (the stress experienced in the endothelium as a result of the flow of blood through the arteries).[185]

Other risk factors

While physical activity is associated with a reduction in recognised cardiovascular disease risk factors as described above, it is also clear that the protective effect of physical activity is independent of these risk factors.[186] Therefore, there are likely to be other pathways, as yet unclear, by which physical activity confers protection against cardiovascular disease.[127]

Coronary thrombosis (heart attack or myocardial infarction) is a basic feature of cardiovascular disease and is often the specific cause of death. Coronary thrombosis most frequently takes place in the coronary arteries at the site of an atherosclerotic plaque rupture on the lining of the artery. This diseased area of the coronary artery can, if it ruptures, develop a blood clot on it, comprising blood clotting proteins, platelets and red blood cells. This formation has the potential to seal off the blood supply, thus causing the coronary thrombosis.

One protective action of physical activity may therefore be a decrease in coagulation (the tendency of the blood to clot), and an increase in fibrinolysis (the mechanism by which the clots are broken down). A number of emerging potential risk factors associated with this process have been identified, including, for example, blood levels of homocysteine.[187]

Rehabilitation

Exercise-based cardiac rehabilitation programmes for people with coronary heart disease are generally effective in reducing cardiac deaths, and lead to important reductions in all-cause mortality. It is not clear whether exercise alone or a comprehensive cardiac rehabilitation intervention is more beneficial.[188]

Limited evidence suggests that exercise therapy may be effective in the rehabilitation of stroke patients.[189 190]

Exercise rehabilitation for people with peripheral vascular disease generally results in an increase in the distance they can walk before the onset of leg pain and the distance they can walk before pain brings the exercise to a halt.[191] After exercise therapy, patients with peripheral vascular disease improve both their walking ability in the laboratory and their ability to perform everyday tasks.[192 193]

Short-term physical exercise training in selected patients with chronic heart failure may have physiological benefits and positive effects on quality of life.[194]

The transient nature of benefit

There is evidence that the strong protective effect of physical activity on cardiovascular disease is transient. In other words, people have a reduced risk of cardiovascular disease during the periods of life when they lead a physically active lifestyle, but they lose most benefits once they stop being physically active. In the Harvard Alumni study in the USA, active college students who subsequently adopted an inactive adult lifestyle were at greater risk of dying of coronary heart disease compared with inactive students who subsequently adopted an active adult lifestyle.[136]

The effects of lifestyle improvements

People can gain benefits from becoming more active, even if they have previously been inactive until middle age or beyond. Adult men aged 45-84 years who exchanged an inactive adult lifestyle for a more active one over a period of 11-15 years reduced their risk of coronary heart disease.[195] Data from the Stanford Five-City project indicate that increased physical activity over a five-year period is favourably associated with changes in the major risk factors for cardiovascular disease in both men and women.[196] In a large cohort of older British men, those who took up or maintained light or moderate

intensity physical activity had fewer heart attacks (risk ratio 0.66) compared with those who remained inactive.[197] Blair *et al* reported that men who increased their fitness over a five-year period had a reduced mortality risk 44% compared with men who remained unfit over the same period.[198] Even small improvements in cardiorespiratory fitness are associated with a significantly lowered risk of death in middle-aged men, independent of baseline level of fitness.[199]

Required level of physical activity

There is a wealth of data reporting inverse relationships between overall activity level (volume of activity) and reduced risk of cardiovascular disease, particularly coronary heart disease: higher overall activity levels are associated with lower risk of cardiovascular disease. There are fewer data available on the specific types of activity – in terms of intensity, duration, frequency and type – needed to confer a benefit.

Volume of activity

Thirty minutes of moderate intensity physical activity performed on 5 or more days a week leads to a significantly reduced risk of coronary heart disease and stroke. Greater benefits can be obtained at higher levels of activity but there is a 'law of diminishing returns'. The greatest decrease in risk is observed between individuals at the lowest activity/fitness level and those at the next activity/fitness level. At higher levels of activity/fitness, smaller decreases in risk are observed. There is some suggestion that, at the very highest activity levels, no further decrease in risk occurs, or there may be a slight increase in risk.[127] (See Chapter 7.)

Intensity of activity

A large body of evidence suggests that a physical activity intensity of 4-6 METs – which encompasses the range of walking pace from 'normal' to 'brisk' for a healthy, young or middle-aged person – is enough to reduce the risk of cardiovascular disease and to improve risk factors for cardiovascular disease.[195 200-203] Vigorous activity – though protective in its own right – is generally found not to be essential to achieve the protective effect.[156 204 205] Nevertheless, some studies report that more vigorous activities provide some increased benefit,[206 207] and one study reports that activities that are not undertaken vigorously offer no protection against coronary heart disease.[157]

Absolute or relative intensity

The question of whether the key protective element of physical activity is the absolute intensity or the relative intensity* remains unresolved.[208 209] Most studies have used absolute intensity to categorise activities, but there are also indications that relative intensity of activity is important. For example, Lee *et al* reported an inverse association between relative intensity of activity and risk of coronary heart disease in men: the higher the relative intensity, the lower the risk of coronary heart disease. The relationship held even among men who were not active above the accepted minimum absolute exercise intensity of 3 METS.[161] This suggests that, in unfit people, activities with intensities lower than 3 METS may have important beneficial effects. (See the Glossary in Appendix 1 for an explanation of METS.)

*The absolute intensity is the metabolic cost of the activity – the energy expended during the activity. The relative intensity is the absolute intensity in relation to a person's level of fitness (exercise capacity). If a fit and an unfit person do the same activity, the absolute intensity of the activity will be the same for both, but the relative intensity will be greater for the less fit person. See also the definitions in the Glossary in Appendix 1.

Time

Longer sessions of aerobic physical activity do not appear to have a different effect on cardiovascular risk compared with shorter sessions, as long as the total energy expended is equivalent. This has led to growing support for the accumulation of activity in shorter bouts interspersed throughout the day.[48-51]

5.2 Physical activity, overweight and obesity

Key points

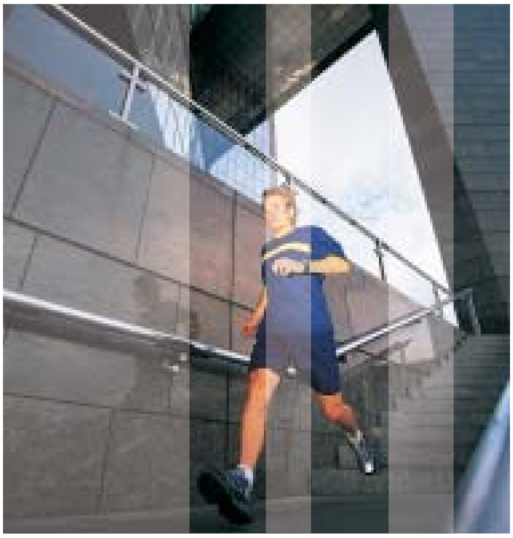
- Low levels of physical activity in England are a significant factor in the dramatic increase in prevalence of obesity.
- Physical activity brings important reductions in risk of mortality and morbidity for those who are already overweight or obese.
- For people who are overweight or obese, the best way to lose weight is by a combination of physical activity and diet.
- Physical activity is important for helping people to maintain weight loss over several months or years. Those who include physical activity as part of their weight loss plan have a better chance of long-term success.
- Achieving the recommendation of at least 30 minutes of at least moderate intensity physical activity on 5 or more days a week (a total of 150 minutes) will represent a significant increase in energy expenditure for most people, and will contribute substantially to their weight management. However, in many people and in the absence of a reduction in energy intake, 45-60 minutes of activity each day may be needed in order to prevent the development of obesity. People who have been obese and who have lost weight may need to do 60-90 minutes of activity a day in order to maintain their weight loss.
- Physical activity that can be incorporated into everyday life – such as brisk walking or cycling – appears to be as effective for weight loss as supervised exercise programmes.
- All substantial movement of body weight – such as steps walked per day, or stair-climbing – contributes to energy expenditure and may help with weight management. People who need to avoid weight gain should reduce the amount of time they spend inactive.

The high, and rising, levels of overweight and obesity in England have been described in Chapter 2. Obesity has emerged as a new and serious threat to health with 22% per cent of men and 23% of women now classed as clinically obese (body mass index greater than 30kg/m^2).[12] Among people aged 55-74 years more than two-thirds of women and three-quarters of men are overweight or obese.[12]

Obesity carries considerable human costs: it doubles the risk of all-cause mortality, coronary heart disease, stroke and type 2 diabetes, and increases the risk of some cancers, musculoskeletal problems and loss of function, and carries negative psychological consequences.[23 31]

Prevention of obesity

The cause of obesity is a chronic imbalance between the amount of energy in the diet and the energy expended by the body in its daily activities.[210] The evidence base on the effects of activity on obesity is rapidly expanding. Clear effects have not been easy to establish in prospective observational or experimental studies because of difficulties of measuring and controlling both physical activity and dietary intake, and also



because of the dynamic nature of weight gain and weight loss.

Inactive people are more likely to be obese than active people. There is an association between energy expenditure (measured by doubly-labelled water) and lower fat mass: those with higher levels of energy expenditure tend to have a lower fat mass.[211 212] (Doubly-labelled water allows an estimate of energy expenditure through its rate of dilution by the body.) There is also an association between body mass index and self-reported time spent inactive: inactive people are more likely to have a higher body mass index.[213 214] Prospective studies have shown that high levels of leisure-time physical activity, remaining physically fit over several years, or becoming fitter are associated with lower risk of substantial weight gain.[215-218] It is also possible that this relationship is in part explained by obesity leading to subsequent inactivity.[219]

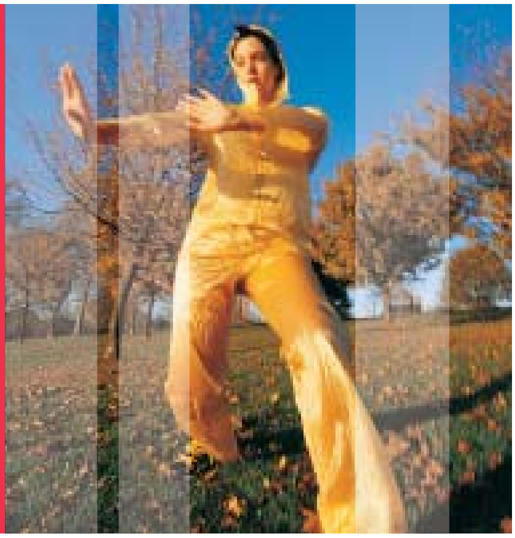
Indirect evidence for the effect of inactivity on overweight and obesity comes from national food consumption and food availability data. National data collected throughout the years of the rapid increase in obesity suggest that energy intake has not risen substantially. Household survey data (which record food purchased for the household) have indicated that energy intake from food eaten at home in the UK has fallen.[23 220 221] Increasing amounts of food are eaten outside the home and there is known under-reporting of food, and these factors may produce an underestimation of energy intake. However, the rising incidence of obesity under these conditions suggests that reduction in activity is one key factor in the increase, and confirms that people are now insufficiently active for the amount of energy they take in.

Treatment of overweight and obesity

Physical activity on its own results in modest weight loss of around 0.5kg-1kg per month.[2 31 222-225] In short-term studies (of less than 4 months), higher levels of physical activity produced greater weight loss than lower levels of activity, but this was not the case in longer-term studies (of more than 26 weeks). On average, weight loss in short-term studies was approximately 85% of what would be expected from the energy costs of the activity.[224] In one study, overweight women who averaged approximately 280 minutes' exercise per week were found to lose twice as much weight as those who exercised for 150-200 minutes per week.[226] It seems that the contribution of physical activity to weight loss can be largely explained by the direct increase in energy expenditure it produces, at least in the short term. The greater the activity level, the greater the contribution to weight loss.[227]

An important effect of physical activity during weight loss is its effect on the *composition* of the weight lost. People who use a combination of a low-calorie diet and physical activity in order to lose weight lose greater fat mass and conserve more lean tissue (mainly muscle mass) than people who use diet alone.[228 229] This is likely to be important in the long term, as fat-free mass largely determines resting metabolic rate (the degree of energy expended by the body while at rest), and this is the bulk of daily energy expenditure for most people. Generally, the higher the fat-free mass a person has, the higher the resting metabolic rate, the more calories expended, and the more energy the body can take in without storing excess as fat.

Fat distribution is an important dimension of obesity, with abdominal deposition (apple-shaped obesity), as opposed to subcutaneous or lower body fat deposition (pear-shaped obesity), being closely linked to metabolic complications such as high blood



lipids and impaired glucose tolerance.* These produce an increased risk of coronary heart disease and type 2 diabetes. Physical activity is effective in reducing abdominal adiposity (apple-shaped obesity) in overweight and obese adults.[31 222 224 230]

The notion that exercising more makes people eat more is not substantiated by research. Negative energy balances have been shown to be tolerable over periods of up to two weeks. A subsequent increase in energy intake does eventually take place but compensates for only about 30% of energy expended through activity. Therefore weight loss can result.[231]

The best way to lose weight is by a combination of a calorie-restricted diet and physical activity. This will maximise fat loss, help maintain lean tissue and provide greatest health improvement. Most research studies have involved programmes of aerobic exercise, at moderate intensity, and usually in group settings. However, several studies have demonstrated that lifestyle activity and walking can also contribute to weight loss. There is little evidence for an extra benefit of resistance training on weight loss when combined with caloric restriction and/or endurance training programmes.[222 232] Resistance training does not appear to prevent the decline in resting metabolic rate which accompanies weight loss through reduced lean tissue mass, at least in men.[233] However, improvement in muscular strength may be important for functional tasks, particularly for people who are very obese and who may struggle initially to manage their body weight.[222]

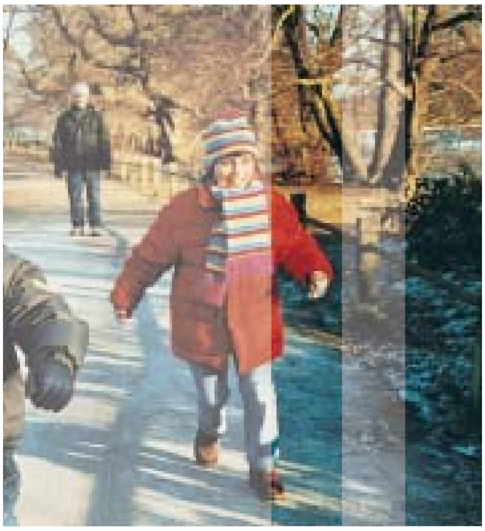
Physical activity may have an important long-term influence on helping people to maintain their weight loss. Only a small proportion of those following weight loss programmes maintain their weight loss in the long term. Those who achieve and maintain regular physical activity are more likely to sustain a higher percentage of their weight loss for several months after a weight loss programme.[229 234] The higher the amount of activity, the greater the weight loss.[226 235] However, the extra energy expenditure caused by the activity appears to only partially explain the results. It has been suggested that the effect of exercise may be partly due to psychosocial mechanisms such as improved capacity to self-regulate and greater self-confidence, which in turn produce more effective dietary control and exercise adherence.

Overweight and obese people are more likely to be in the least active sector of the population and are less likely to take opportunities to be active.[217 236] They are therefore more likely to have difficulty achieving energy balance and will gain further weight. Increasing activity should therefore be seen as an important element of any weight management programme.

Other health benefits for overweight and obese people

Obesity is associated with increased incidence of several other conditions including cardiovascular disease, type 2 diabetes, and some cancers (see sections 5.1, 5.3 and 5.6). One of the main reasons for treating obesity is to reduce the incidence of these diseases. Clinical practice has targeted weight loss of 10% of body weight as this has been shown to bring about substantial improvements in blood pressure, blood lipids and glucose tolerance.[31] There is accumulating evidence from prospective observational studies that physical activity and higher levels of aerobic fitness are effective in improving the health profile not only of normal-weight populations, but also of those who are overweight and obese.[33-35 237] Several studies show that those obese people who are active have a

*Although the waist:hip circumference ratio has been used widely in the past, waist circumference has now become the recognised means of assessment of abdominal deposition at both the individual and population level.



reduced risk of mortality and morbidity, in a dose-response fashion, in comparison with inactive obese people, independent of other factors: the more activity an obese person does, the lower their risk of mortality and morbidity.

Required levels of physical activity

The amount of energy expenditure needed to achieve long-term energy balance depends on energy intake, so it varies from one individual to another. People who take in large amounts of energy will need to be more active to keep their weight stable. Athletes at a high level of training may even have to supplement their intake in order to maintain weight. Conversely, an adolescent girl, for example, who is very inactive may still prevent weight gain by eating very little.

Little is known about how much activity is undertaken by those who successfully manage their weight. However, the low incidence of overweight and obesity in active individuals suggests that there is a clear benefit in regular physical activity. Achieving at least 30 minutes of at least moderate intensity physical activity on 5 or more days a week (150 minutes per week) will represent a significant increase in energy expenditure for most people, and will make a substantial contribution to their ongoing weight management.[52 222 226] However, the evidence indicates that in the absence of a reduction in energy intake, 45-60 minutes of moderate intensity activity per day may be needed to prevent obesity at a population level.[31 53] People who have been obese and have lost weight may need to do 60-90 minutes of activity a day in order to avoid regaining weight.[53]

Accumulating several shorter bouts of moderate intensity physical activity of 10 minutes or more is as effective as doing fewer, longer bouts of equal volume of activity.[51 222 226 238] Activity that can be incorporated into everyday life appears to be as effective for weight loss as structured, continuous supervised exercise programmes, but more research is needed.[51 222] There is little evidence to suggest that higher intensity activity is more effective for weight loss over a 12-month period than the equivalent amount of activity at moderate intensities.[239]

More research is needed to understand the effectiveness of physical activity for weight loss beyond 18 months in adults, and the amount of activity required for the prevention and treatment of obesity in children.

For weight management, the more physical activity a person does, the greater the effect, and all movement – particularly where body weight is carried, as in walking – is helpful. People who need to lose weight should therefore be encouraged to increase their daily movement by walking more steps per day, relying less on labour-saving devices, and replacing sedentary time with active hobbies. For overweight people who find walking too demanding or who have joint problems, swimming is a useful alternative.

5.3 Physical activity and diabetes

Key points

- Physical inactivity is a major risk factor for the development of type 2 diabetes.
- Physically active people have a 33-50% lower risk of developing type 2 diabetes compared with inactive people. The preventive effect is particularly strong for those at high risk of developing type 2 diabetes, as it can reduce their risk of developing the disease by up to 64%.
- Among people with type 2 diabetes, regular moderate intensity physical activity carried out three times a week can produce small but significant improvements in blood glucose control. Both aerobic and resistance exercise programmes produce similar benefits. Higher levels of intensity of physical activity produce greater benefits.
- Moderate to high levels of physical fitness appear to reduce the risk of all-cause mortality in patients with type 2 diabetes.

Although it is not yet possible to prevent type 1 diabetes, there is increasing evidence to suggest that it is possible to prevent type 2 diabetes – or at least delay its onset – by tackling overweight and obesity and promoting physical activity. Type 2 diabetes is the most common metabolic disorder worldwide,[240] and is increasing among adults in England.[5] The best estimate of the prevalence of type 2 diabetes in England is 3.3% for men and 2.5% for women [5], but it is likely that similar proportions again are undiagnosed.[241 242] Estimates of the precise cost of diabetes vary, but according to one study, diabetes accounts for some 9% of the annual NHS budget. This represents a total of approximately £5.2 billion a year.[243] Diabetes is associated with a number of other conditions such as kidney disorders, damage to the retina, and coronary heart disease.

Prevention of type 2 diabetes

Increasing physical activity levels *before* the onset of impaired glucose tolerance appears to have the greatest potential for preventing type 2 diabetes. Insulin resistance is an important precursor of type 2 diabetes and is in its early stages reversible by weight loss and/or increased exercise.[244 245] However, by the time people have developed abnormal glucose levels, the pancreas has already been damaged and there is less opportunity for improving insulin sensitivity.[246]

Physical inactivity is a major risk factor for the development of type 2 diabetes. Type 2 diabetes is more common among people who are physically inactive.[2 247 248] Prospective studies have suggested that people who take exercise have a 33-50% lower risk of developing type 2 diabetes[249 250] and that the greater amounts of exercise taken, the lower the risk of developing the disorder.[249 251] Walking and cycling levels are also associated with reduced risk of type 2 diabetes: those who walk or cycle more are less likely to get type 2 diabetes.[186 252]

The reduction in risk can be seen across a range of physical activity patterns and intensities. However, at present the precise type, intensity, frequency,

duration or volume of activity needed to protect against type 2 diabetes are unknown. Higher levels of physical activity are associated with lower risk of type 2 diabetes in two studies. In one study, increments of 500kcals of energy expenditure in reported weekly leisure-time physical activity were associated with 6% decreases in the age-adjusted risk for the development of type 2 diabetes (up to 3,500kcals per week).[253] Another study reported that people with higher levels of physical activity energy expenditure – including energy expenditure from lighter intensity activities such as walking and gardening – had a lower risk of developing type 2 diabetes.[252] In contrast, one study reported that moderate intensity physical activities undertaken for at least one 40-minute duration per week were needed to protect against the development of type 2 diabetes, while activity of lower intensity was not protective, regardless of duration.[250]

Among those at high risk of developing type 2 diabetes (those having one or more of overweight, high blood pressure, or family history of type 2 diabetes), physical activity can reduce the risk of developing the disease by up to 64%.[250] Three randomised controlled intervention studies in people at high risk because of impaired glucose tolerance have shown that a programme of lifestyle change – focussing on improving diet and increasing physical activity – can delay, or possibly prevent, the development of type 2 diabetes.[254-256] The United States Diabetes Prevention Programme studied the effects of an intensive programme of diet and exercise, a drug (metformin), or a placebo in people with impaired glucose tolerance. The lifestyle modification group received intensive education and support, with care managers delivering a personal 16-lesson curriculum and subsequent monthly follow-up sessions to reinforce behavioural change. Subjects were advised to make a 7% reduction in body weight by a low-fat, low-calorie diet and to take moderate physical activity such as brisk walking for 150 minutes per week. The lifestyle changes in diet and physical activity were found to be more effective in reducing the incidence of type 2 diabetes than treatment with the drug metformin (58% vs 31% reduction in risk).[254]

Consensus is emerging that physical activity may therefore make an important contribution to preventing type 2 diabetes, independent of its

Diabetes is a disease that affects the body's ability to store glucose – an important source of energy. Type 1 diabetes (often referred to as 'juvenile diabetes') develops early in life and describes a lack of ability in the body to produce insulin. Type 2 diabetes (often referred to as 'adult-onset diabetes') develops later in life and describes a lack of ability in the organs and muscles of the body to take in and store the glucose.

Glucose is taken into the body in the form of food, and after digestion it circulates in the blood. The hormone insulin then acts to transport the glucose molecules out of the blood and into organs and muscle cells where they are stored ready for use. The various stages of this process, and its efficiency, are known by a variety of terms. 'Insulin sensitivity' or 'insulin resistance' refers to how sensitive the organs and muscle cells are to the action of insulin. 'Glucose tolerance' refers to how well the body can deal with an ingestion of glucose – how efficiently it stores the glucose.

contribution to weight loss.[257] Preventive intervention studies have used a range of physical activity programmes in combination with dietary changes. In the only study to separate the effects of physical activity from those of dietary intervention,[255] physical activity alone and physical activity plus diet were associated with similar reductions in risk of type 2 diabetes, independent of baseline body mass index and weight change during the intervention. Both of these types of intervention were more effective at preventing type 2 diabetes than dietary intervention alone.

Moderate to high levels of physical fitness also appear to reduce the risk of all-cause mortality in patients with type 2 diabetes.[237]

The protective effect of physical activity appears to apply to adults of all ages. In the Diabetes Prevention Program, where 20% of participants were aged 60 years or over, and the sample size was sufficient to test for differential effects by age,[254] the lifestyle intervention was at least as effective in older people as it was in younger participants.

Possible biological mechanisms

Physical activity reduces the activity of the cells in the pancreas which produce insulin[258] (pancreatic ß-cells) and makes the cellular tissues more sensitive to insulin.[259] Physical activity may also increase the rate at which glucose is taken into the muscles, independent of the activity of insulin.[260]

Treatment of type 2 diabetes

Physical activity produces acute improvements in blood glucose control in both normal and diabetic people.[248] However, the intensity of the physical activity needed for this effect may be at a level that most people would not tolerate.

The long-term effect of physical training on control of blood glucose levels and cardiorespiratory fitness in people with type 2 diabetes has been investigated in several studies. The evidence has been summarised in a number of reviews.[261-263] (The effect on cardiorespiratory fitness is of interest as it is a strong independent predictor of cardiac mortality in people with type 2 diabetes.[261 262 264]) Individual controlled trials have shown no or modest improvements in glycated haemoglobin (a substance which gives an indication of how well glucose levels have been managed over 4 months). However, the pooled effect is a 15% reduction which is clinically significant.[261] Also, regular exercise produces a statistically and clinically significant improvement in aerobic fitness in people with type 2 diabetes.[263] The physical activity programme in these studies typically consisted of three bouts of walking or cycling per week, with each bout lasting about 40 minutes. These studies indicated that regular moderate intensity physical activity can produce small but significant improvements in glycaemic control. Studies with higher exercise intensities tended to produce larger improvements in fitness, glycated haemoglobin and insulin sensitivity.[246 263]

Progressive resistance training has been investigated in a number of studies and produces similar improvements in glycated haemoglobin to those seen with aerobic exercise programmes. Resistance training programmes typically consisted of two to three sets of 10 to 20 repetitions of a range of exercises carried out three times a week.[261 265 266]

Both resistance exercise and aerobic exercise have been shown to prevent and modify insulin resistance.[178] Intervention studies using aerobic exercise have reported improvements in glucose metabolism of between 11% and 36%. Similar results have been achieved with resistance exercise training, and the findings of one trial suggested that

a combined resistance and aerobic exercise programme may be more effective than aerobic activity alone.[179] In the Insulin Resistance Atherosclerosis Study, a multi-ethnic study of insulin resistance and cardiovascular risk factors carried out in the USA, regular participation in both non-vigorous and vigorous physical activity predicted higher insulin sensitivity, even after controlling for body mass index and body fat distribution.

No evidence is available to suggest that the therapeutic benefits of physical activity in adult diabetics decline with age.

5.4 Physical activity and musculoskeletal health

Key points

OSTEOPOROSIS

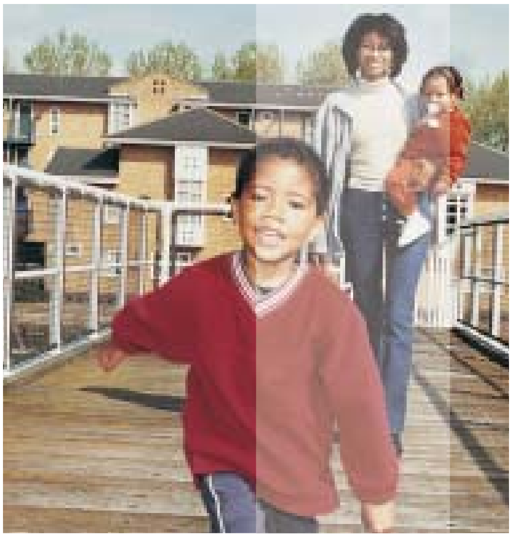
- Physical activity can increase bone mineral density in adolescents, maintain it in young adults, and slow its decline in old age.
- For best protection against osteoporosis there needs to be activity that physically stresses the bone – such as running, jumping, skipping, gymnastics or jogging. Such physical activity can increase bone mineral density in adolescents, maintain it in young adults, and slow its decline in old age. The period of peak height velocity is the best time for young people, especially girls, to increase their bone mineral density.
- Physical activity in later life can delay the progression of osteoporosis, but it cannot reverse advanced bone loss.
- Physical activity programmes can help reduce the risk of falling, and therefore fractures, among older people.

OSTEOARTHRITIS

- No studies have directly confirmed that physical activity can prevent the onset of osteoarthritis. However, both absence of and an excess of stress on the joints can increase the risk of osteoarthritis.
- Physical activity can have beneficial effects for people with osteoarthritis, including those who have had a joint replacement, but too much physical activity can be detrimental.

LOW BACK PAIN

- A variety of endurance activities that do not over-stress the lower back can alleviate low back pain. General leisure-time activities are recommended for people with low back pain, but those with low back pain should avoid: heavier sporting activities which involve lifting, twisting, pulling and pushing; excessive loading of the back muscles; and excessive overall levels of physical activity. Yoga-style exercise, and exercises to increase endurance of the abdominal and back muscles, may also be helpful.



This chapter focuses on three conditions which cause considerable disease, disability and loss of function: osteoporosis, osteoarthritis and low back pain.

Osteoporosis

Osteoporosis is a degenerative bone disease that is characterised by low bone mass (or low bone mineral density). In people with osteoporosis, the bones become brittle and more prone to fracture. People who have osteoporosis are prone to bone fractures from even minor trauma. Hip fracture is particularly serious because of the resulting disability. There are around 60,000 osteoporotic hip fractures in the UK each year[267] (around 50,000 in England), and 15-20% of those people with fractures will die within a year from causes related to the fracture.[268] The health and social care costs of osteoporosis in the UK amount to £1.7-1.8 billion a year, with 85-95% of these costs due to hip fractures.[269 270]

Preventive effects

Physical activity that physically stresses the bone – such as running, jumping and skipping – can increase bone mineral density in adolescents, maintain it in young adults, and slow its decline in old age.[118] The effect is greatest in the bones that are most heavily loaded. It is important to increase bone mineral density in adolescents, because this reduces the chances of age-related loss of bone mass and the likelihood of reaching the fracture threshold in later life. Sustained physical activity into the mid-20s maximises peak bone mass.[271] During adulthood, physical activity slows down the rate of bone loss, and some bone gain might still be possible.[272] In old age, physical activity continues to be an important factor in minimising bone loss.

Physical activity may also have other effects, including regulating the production and circulation of hormones, improving balance mechanisms[272] and developing muscle power.[273] These factors may explain why physical activity interventions can prevent up to 25% of falls.[118]

Gender effects

Patterns of bone mineral density differ by gender, even before the menopause.[271 274] Both boys and girls rapidly gain bone mineral density in childhood and adolescence, especially around the years of the growth spurt which occurs at about 12 years in girls and 14 years in boys (peak height velocity). In both males and females, those who reach puberty later have a lower peak bone mineral density, which even the most vigorous subsequent physical activity cannot compensate for. The worst combination for bone health in women is late onset of menstruation combined with early menopause.

Treatment of osteoporosis

Physical activity in later life may delay the progression of osteoporosis, as it slows down the rate at which bone mineral density is reduced. However, it cannot reverse advanced bone loss.

Physical activity can help prevent falls and consequent fractures, which are particularly relevant for people with osteoporosis. Muscle weakness is the strongest risk factor for falling – stronger even than a history of previous falls.[275] Doing more than 5 hours of physical activity a week reduces the risk of hip fracture.[276] Among previously inactive women aged 65-75 years, 20 weeks of twice-weekly exercise classes improved dynamic balance and strength.[277] Other community studies show that physical activity programmes can also reduce rates of falling,[278 279] and that physical activity can be more effective than other forms of intervention such as, for example, home hazard management.[280]

Osteoarthritis

Osteoarthritis is the most common joint disease. Prevalence increases with age and nearly everyone aged over 60 years has affected joints.

Preventive effects

Theoretically, physical activity can help prevent osteoarthritis by strengthening articular cartilage and subchondral bone (bone that lies below or beneath the cartilage), enhancing the role of synovial fluid in nourishing cartilage, strengthening muscles that protect and stabilise joints, and reducing obesity, which is a strong risk factor for knee osteoarthritis. There is no strong evidence that physical activity can prevent the onset of osteoarthritis in the load-bearing joints, although there are some indications that moderate daily general physical activity, especially walking, may be associated with a lower risk of subsequent osteoarthritis, especially among women.[281] This level of physical activity does not increase the risk of knee injury or osteoarthritis.[118]

Both the absence of and an excess of stress on the joints influence the risk of osteoarthritis.[282] Three of the best predictors of hip pain (which may be a precursor to hip osteoarthritis) are: prolonged exposure to sustained sitting; sustained exposure to lifting or moving of heavy weights; and walking for leisure.

Different types of physical activity have different effects on osteoarthritis. High lifetime exposure to walking, running/jogging and track and field athletics is associated with increased risk of hip pain, while swimming, tennis, badminton, soccer, and cycling are associated with no increased risk. Although, in general, walking up and down stairs during the day has clear health benefits – for example for weight management and bone health – those who are susceptible may increase the risk of hip and knee osteoarthritis once they cross a particular threshold, which could be as low as 10 flights of stairs per day.[283]

Treatment of osteoarthritis

Among people with osteoarthritis, walking has weak, beneficial effects on disability, weak to moderate beneficial effects on pain, and moderate to large effects on patients' assessment of outcomes.[118] A broad range of physical activities – either individual activities or a combination – reduce pain, stiffness and disability, and increase general mobility, gait, function, aerobic fitness and muscle strength. Three 40-minute walks a week may help to halt the progression of knee osteoarthritis.[284]

Physical activity can help those who have had a joint replacement, but too much physical activity can be detrimental. If knee osteoarthritis leads to joint replacement, then quadriceps strength is often lost and should be addressed after the operation.[285] Exercise during the periods immediately before and after the operation may help people to resume their normal activities more quickly afterwards.[286] People who have had a joint replacement can recover their aerobic fitness: 1 in 2 patients regain the ability to walk up and down hills. Walking activities especially are recovered in the 3-9 months after the operation.[287] Walking increased by up to an average of 23% in a home-based programme when supported by self-management education.[288] However, too much physical activity following joint replacement can be detrimental: people who regularly take part in sporting activities or heavy manual work after total joint replacement are twice as likely to need revision surgery for loosening in the long term compared with patients who are less active.[289] Physical activity is more likely to provoke hip and knee osteoarthritis in obese people who have had a joint replacement, than in those who are not obese.[290]

Certain levels or types of activity appear to be detrimental to people with osteoarthritis. Older women with severe knee pain who walked more than three city blocks in the past week had a higher risk of disability compared with inactive women.[291] Older adults who reported doing ‘heavy’ exercise (such as digging or gardening) for 3 or more hours per day had a greater risk of knee osteoarthritis compared with those who did no activity.[289] Substituting other activities may avoid the risk of aggravating joint disease. In people with joint laxity or misalignment, knee-strengthening activities may be contraindicated, even though they might have beneficial effects in otherwise uninjured joints.[292]

Non-traditional exercises such as Tai Chi are associated with important psychosocial improvements in people with osteoarthritis – including quality of life – within 12 weeks.[293]

Low back pain

Eighty per cent of people in the UK experience low back pain at some time in their lives.[294] Forty per cent of the UK population report having had back pain in the last year and, of these, 40% had visited their GP.[295] In the UK, it has been estimated that low back pain is responsible for 150 million days a year being lost from work.[296]

Preventive effects

Inactivity has not been shown to be predictor of lower back pain at a population level.[297] However, people who participate in fitness training do appear to gain some preventive effect.[118]

Treatment of low back pain

General aerobics-type exercise programmes can help prevent recurrence of low back pain.[118 298] Similar activities also improve recovery from spinal surgery.[299] The precise type of aerobic exercise does not appear to be important, suggesting that beneficial effects may be mediated by psychosocial factors.[300] It has been suggested that psychosocial stress may be associated with increased muscle tension[301] so it is possible that the psychological and physical benefits of physical activity may be inter-related. Also, in many exercise interventions the delivery style of the programme staff is important in explaining programme outcomes.[302]

Among people with low back pain, regular physical activity following discharge from outpatient rehabilitation was associated with fewer recurrences of persistent pain and with reduced work absenteeism.[303] Furthermore, inactive patients who undergo exercise-based rehabilitation may become more active after they have been discharged from treatment than they were before.[303] These benefits may be more evident in the longer term (6-12 months) than immediately following discharge from formal back care classes.[302]

Certain types of physical activity, as well as excessive levels of physical activity, can increase the risk of low back pain. General leisure-time physical activity does not increase the risk of low back pain, but sporting activities that involve lifting, twisting, pulling, and pushing may increase the risk.[118] Excessive physical activity can also lead to low back pain by causing injury or fatigue failure in spinal tissues. Sustained physical activity can cause muscle fatigue and creep in spinal ligaments, both of which can temporarily increase the risk of injury to the spine. (This may help to explain why having pre-existing back pain increased the risk of exercise-related injury by 67%.[304])

Different types of exercises have different effects on low back pain. Yoga-style exercises that maintain or enhance spine mobility may reduce the risk of bending injuries to the spine, thus reducing the incidence of low back pain. Exercises for increasing


the endurance of specific abdominal and back muscles are more effective at reducing recurrences of low back pain than doing no exercise.[305]

Treatment with physical activity brings about other important changes for people with low back pain, too. For example, a programme of three physical activity sessions a week for 12 weeks is associated with improvement in physical functioning and an improvement in mental health.[298] In a randomised controlled trial which compared a group of people following an exercise programme with a group having manual therapy, after one-year follow-up, 3 in 12 in the exercise arm had returned to work, compared with 8 in 12 of the manual therapy group.[306]

Some studies show that physical activity can have a *positive* effect on back pain even though it has a *negative* effect on the underlying condition of the spine, while other studies show the reverse. For example, prolonged heavy occupational and sporting activities,[307] and awkward postures,[308] increase the risk of low back pain, but do not have a large influence on the condition of the spine.[309] Several vigorous sports, including weight-lifting, have an adverse effect on the spine, but their effect on low back pain is variable.[310 311] Heavy weight-lifting can adversely affect the spine while reducing low back pain.[310] This suggests that psychological factors may be important in low back pain.

For people with chronic neck pain, the use of strengthening exercise, either in combination with spinal manipulation or in the form of a high-technology MedX program, appears to be more beneficial than the use of spinal manipulation alone.[312]

5.5 Physical activity, psychological well-being and mental illness

Key points

MENTAL ILLNESS

- Physical activity is effective in the treatment of clinical depression and can be as successful as psychotherapy or medication, particularly in the longer term.
- It may also help people with generalised anxiety disorder, phobias, panic attacks and stress disorders, and can have a positive effect on psychological well-being in people with schizophrenia.

MENTAL HEALTH

- Physical activity helps people feel better, as reflected in improved mood and reduced state and trait anxiety. It can also help people feel better about themselves through improved physical self-perceptions, and can improve self-esteem, particularly in those with initial low self-esteem.
- Physical activity can help reduce physiological reactions to stress. It may also improve sleep. Those who do not have a good quality or quantity of sleep are particularly likely to benefit.
- Rhythmic aerobic forms of exercise – such as brisk walking, jogging, cycling, swimming or dancing – as well as resistance exercise appear to be effective in achieving mental health benefits.
- The psychological benefits of physical activity help motivate people to maintain physical activity, which is essential if they are to reap the full health benefits of exercise.

Mental illness in the form of depression is predicted to become the second most prevalent cause of disability worldwide by 2020.[313] Mental health problems are already highly prevalent in Britain, with at least 1 in 6 people suffering at any one time.[314] This produces 230 out of every 1,000 consultations in primary care services. Mixed anxiety and depression represents the most common form of mental illness, and prevalence of these conditions in Britain increased from 7.8% in 1993 to 9.2% in 2000.[314] Additionally, 29% of adults report sleep problems or feelings of fatigue. The treatment of mental illness in England requires annual NHS expenditure of £3.8 billion (12.7% of total expenditure), and personal social services expenditure of £0.68 billion (5.3% of total expenditure).[315]

Physical activity can be considered both for its preventive and its therapeutic effects on mental illness, and also for its impact on mental health in the general population. Also, the psychological benefits of physical activity are critical determinants of people's motivation to be physically active, without which the prevention of other diseases discussed in this report cannot be experienced. Although this is a relatively new area of research and the volume of high quality experimental studies

is small, effects are consistent and plausible across a range of mental health outcomes.

Mental illness

Preventive effects

Physical activity can help to reduce the risk of depression, but there are insufficient data to determine the optimal level of physical activity needed for a preventive effect, or to say whether increasingly high levels of physical activity bring a corresponding reduction in risk.[316] Maintaining an inactive lifestyle over several years (minimum of 8 years, maximum of around 30 years) is associated with subsequent clinically defined depression.[317-319] This effect is also found over a five-year period in older people.[320] These studies take account of a wide range of possible confounding factors such as disability, body mass index, smoking, alcohol and social status.

Treatment of depression

Physical activity has been shown to be effective in reducing clinical symptoms in those diagnosed as severely, moderately or mildly depressed.[321-323] Four studies have indicated that physical activity is at least as effective for treating depression as psychotherapy.[322 323] Two studies have shown that physical activity can be as successful at treating depression as medication. For example, one study has shown that, after 16 weeks, exercise equalled the effect of a standard anti-depressant drug.[324] A follow-up study showed that, after 6 months, those who continued to exercise were more likely to recover than those solely on medication.[325] Physical activity is also a potential alternative for the many patients who do not wish to take medication for depression because of side effects.[326] Contrary to common opinion, in these studies, adherence to the exercise programme is at least similar to other forms of treatment. In one study where physical activity was offered as part of psychiatric services, adherence to physical activity was comparable to that of the general population.[327]

Treatment of other mental disorders

Physical activity has modest beneficial effects for people with generalised anxiety disorder, phobias, panic attacks and stress disorders.[328] It can also have a positive effect on psychological well-being in some patients with schizophrenia.[329] Limited research suggests that physical activity may also be a useful additional strategy for drug and alcohol rehabilitation.[330]

Improvement in health and well-being among people with mental illness

Physical activity can have benefits in terms of the well-being and physical health of people with mental illness, even in the absence of recovery from mental illness. People with mental illness have higher levels of morbidity and premature mortality than the rest of the population, mainly due to obesity-related diseases.[331 332] For people with a mental illness such as schizophrenia, lifestyle interventions that include increased physical activity may be more effective in promoting long-term weight control than pharmacological interventions.[333]

Mental health

Perceptions of well-being

There is strong and consistent evidence showing that physical activity makes people *feel better*, and *feel better about themselves*.

Feeling better

Surveys show that physically active people feel happier and more satisfied with life.[334] These effects are seen in populations of all ages and are independent of socioeconomic or health status. Higher levels of physical activity are associated with higher subjective well-being, mood and emotions, life satisfaction and quality of life. A large number of experimental studies, most of which use aerobic forms of exercise, indicate that a single bout of physical activity can result in improved mood and vigour. This effect can be sustained over several weeks in an exercise programme.[335] Activity programmes in community settings can also result in general improvements in subjective well-being over periods of several weeks.[334]

Feeling better about oneself

Physical activity can also make people feel better about themselves.[336-338] These positive changes in self-perceptions have been seen in randomised controlled trials in all age groups including children, although there are few studies with older people. Positive changes are seen in overall physical self-worth as well as specific aspects of physical self-perceptions such as body image, perceived fitness and strength. These changes have been shown in a randomised controlled trial in primary care in the UK.[339] These are important factors as they appear to have a direct independent association with mental health indicators.[337 340] The degree to which changes in physical self-perceptions are accompanied by improvements in overall feelings of worth or general self-esteem is variable.[338] The effect of activity is stronger for those with initially low self-esteem such as special needs groups. For example, positive results have been achieved with adults with learning difficulties, depressed females, youth offenders, obese males, and problem drinkers.[338]

Mental functioning

Stress

Active people report having fewer symptoms of anxiety or emotional distress than inactive people.[82 341-343] A large number of experimental studies have shown that physical activity has weak to moderate beneficial effects on anxiety, and the largest effects are seen in unfit people with high levels of anxiety.[335] Physical activity can help people feel less anxious in general (trait anxiety), and single exercise sessions can help individuals feel less anxious afterwards (state anxiety).

Physical activity may act as a buffering or coping strategy for psychosocial stress although this has yet to be fully established. Moderate intensity physical activity can reduce the short-term physiological reactions to brief psychosocial stressors – as demonstrated by systolic and diastolic blood pressure, galvanic skin response (an indicator of emotional stress which measures the resistance of the skin to electrical current), muscle tension, or self-reported psychological symptoms – and it can help people recover more quickly from those stressors. These benefits are seen in people who are fitter, in people who improve their fitness with training, and even after a single exercise session.[335]

Sleep

Risk of sleep disorders in men and women is significantly lower in those who are regularly active at least once a week, regularly taking part in an exercise programme, and/or walking at a normal pace for more than half a mile a day.[344] Furthermore, people who are regularly active fall asleep faster, and sleep longer and more deeply than inactive individuals. Two meta-analyses report small to moderate effects (0.18-0.52) for single exercise bouts on certain parameters of sleep such

as slow wave sleep (characterised by rapid eye movements, higher levels of brain activity, and increases in blood flow and elevated heart rate), REM Latency, and Total Sleep Time.[345 346] (REM – or rapid eye movement – is an indicator of deeper sleep and periods of dreaming.) Effect sizes for REM sleep were larger for women and less fit people, and when the exercise was aerobic. Exercise may consequently be of moderate benefit in improving well-being in the population by improving sleep quality.

A larger effect is plausible for special populations for whom sleep quality and quantity may be compromised but more research is needed. Brisk walking for 30-40 minutes, four times a week, improves self-rated sleep quality in older adults with moderate sleep complaints[347] and in informal carers caring for a relative with dementia.[348] A high-intensity progressive resistance training programme, 3 days a week for 10 weeks, has improved sleep quality in depressed older people.[349] Physical activity may also be a useful additional treatment strategy in the management of people with obstructive sleep apnoea syndrome.[350]

Cognitive function

Cognitive function includes memory, reaction time, fluid intelligence (reasoning ability), decision-making and problem-solving, all of which are important for everyday activities, work and academic performance. Most of the research into the effect of physical activity on cognitive function has been on academic performance in children (see Chapter 4), and on maintaining cognitive function in older adults (see Chapter 6). Little rigorous research has been conducted on the effect of physical activity on performance and productivity at work.

Social well-being

Good social networks and relationships are often associated with lower risk of premature death and greater well-being.[351] However, little is known about the potential of physical activity to alleviate social exclusion (i.e. where communities or individuals suffer from clusters of problems such as poor education, housing, employment and health) or to enhance social outcomes (such as increased social interaction and feelings of 'community'). It is likely that the impact of physical activity on such social outcomes is greater than the limited evidence base suggests. Many community-based projects involving physical activity programmes have been carried out, but they have rarely been rigorously evaluated and results are rarely published in scientific journals.

It has been suggested that, as part of wider-ranging development initiatives, physical activities could be a *part* of strategies for addressing issues of crime, education, employment, community development and social exclusion.[352] However, the evidence is not yet available to confirm these potential effects.

Rehabilitation and recovery

Physical activity is increasingly being used to improve psychological well-being and quality of life in rehabilitation programmes for people with specific conditions, or in programmes to help people recover from substance abuse. Although such programmes have not been widely evaluated, evidence is emerging of their potential in rehabilitation from cancer[353] (see section 5.6, page 64) and coronary heart disease (see section 5.1, page 38), in helping with long-term weight loss (see section 5.2, page 45), in withdrawal from smoking,[354-356] and in reducing weight gain after stopping smoking.[354]

Motivation

People frequently report the psychological benefits of physical activity as a reason for participating in regular activity. Outcomes such as ‘feeling better’, ‘sense of achievement’ and ‘enjoyment’ help with long-term motivation.[330] Since people need to maintain their activity routines in order to fully realise the health benefits of exercise, this is an important benefit which should not be ignored when designing physical activity programmes.

Possible mechanisms

Various mechanisms have been suggested for explaining the positive impact of physical activity on the prevention and treatment of mental illness, and on psychological well-being and function. The accumulated evidence from several aspects of mental health improvement indicates that factors associated with the process of being physically active, rather than fitness itself, are primarily responsible for the benefits in short- and long-term mental well-being.[334, 357] In most studies where fitness changes have been assessed, only weak relationships with changes in psychological well-being have been found. Processes that have been researched include the following biochemical, physiological, and psychosocial mechanisms.

- *Biochemical mechanisms* include increased circulatory plasma (-endorphins, norepinephrine, and serotonin (a chemical that affects sleep, depression and memory).
- *Physiological mechanisms* include increased core temperature and cerebral blood flow, reduced muscular tension, and neurotransmitter efficiency.
- *Psychosocial mechanisms* include improvements in perceptions of competence or confidence about the body and its capabilities, improved body image, experiencing a sense of achievement, mastery and self-determination. There has been less focus on the social mechanism of affiliation, interaction and support than is warranted.

It has been more difficult to substantiate biochemical and physiological mechanisms than psychosocial mechanisms, partly due to difficulties researching in these areas. The research base is not sufficiently mature to have systematically addressed the conditions under which each of the mechanisms operate. It is likely that multiple mechanisms are effective in a given situation. The dominance of any single mechanism will depend on the characteristics of the exercise (for example, the intensity and duration), the characteristics of the individual, and environmental factors surrounding the exercise. Physiological and biochemical mechanisms may be more dominant at exercise levels of higher intensity. The extent to which preventive mechanisms are similar to therapeutic mechanisms is not known.

Required levels of physical activity

Amount

Evidence is strongest for bouts of moderate intensity activity which last between 20 and 60 minutes. However, this may be because research has focused on formal exercise programmes as opposed to recreational and spontaneous activity. Short bouts (10-15 minutes) of moderate intensity walking have recently been shown to induce significant positive changes in mood in experimental studies.[358]

Type

Rhythmic aerobic forms of exercise – such as brisk walking, jogging, cycling, swimming or dancing – appear to be most consistently effective. Resistance exercise may be useful for enhancing self-perceptions, as it can have rapid effects on how the body feels and functions. Larger effects in

improving mood have been found for resistance training compared with aerobic exercise in older adults.[359]

Competitive sports and vigorous forms of exercise are an important source of psychological well-being for those who are already accustomed to this type of activity. Group recreational sports and activities are also likely to bring social and mood benefits.

No generic mechanisms have been established to explain the positive effects of activity on psychological improvement. The effects in individuals are likely to be more variable than those found with physiological or biomedical change and may depend on the individual's subjective experiences of the activity and the setting in which it takes place. A range of exercise modes and intensities, based on the participant's previous exercise experiences, preferences and goals, will therefore need to be considered.

5.6 Physical activity and cancer

Key points

- Physical activity is associated with a reduction in overall risk of cancer.
- Physical activity has a clear protective effect on colon cancer.
- Physical activity is associated with a reduced risk of breast cancer in women after the menopause.
- For optimal protection against cancer, physical activity should be maintained throughout the lifetime. Moderate to vigorous intensity physical activity performed frequently appears to be required for a significant protective effect.
- People with a recent diagnosis of cancer should aim to do regular, light to moderate intensity activity, depending on their conditioning and current medical treatment.

In England, over 220,000 people are diagnosed with cancer and more than 120,000 die from cancer in a year. Colorectal, breast, prostate and lung cancer account for half of all cases.[129] As in other Western developed countries, more than 1 in 3 people in England will develop cancer during their lifetime[360] and 1 in 4 will die from cancer.[129] Sixty-five per cent of cases occur in those over 65 years of age.[129] A large number of cancers are linked to lifestyle factors such as diet, smoking and alcohol use.

Preventive effects

People who are physically active tend to have a lower overall risk of cancer.[361-363] Several studies have indicated an inverse, dose-response relationship with occupational or leisure-time physical activity or physical fitness – the higher the level of physical activity or fitness, the lower the overall risk of cancer. Moderate to vigorous intensity activity appears most beneficial.[362 364] Frequency is also a factor: more frequent physical activity has been associated with greater risk reductions.[362] Furthermore, physical activity can have an indirect effect through its role in the prevention of obesity which, in the USA, has been estimated to result in 10% of all-cause cancer.[365]

Cancer of the colon

Physical activity has a clear protective effect on colon cancer,[361 366] with a stronger effect observed for the left colon. The most active individuals have, on average, a 40-50% lower risk than the least active. The effects are independent of diet and body mass index in studies that have controlled for these variables.[367] There is some evidence that, to maximise protection, physical activity throughout the lifetime is the most important.[361]

There is no association between physical activity and rectal cancer.

Breast cancer

Physical activity is associated with a reduced risk of breast cancer in post-menopausal women.[361 366 368 369]

Women with higher levels of physical activity have about a 30% lower risk of breast cancer than the least active, and the risk is dose-related: the higher the level of physical activity, the lower the risk. Some studies suggest that the frequency of activity is more important than the intensity for a protective effect.[370 371]

Physical activity during puberty is associated with a lower risk of developing breast cancer later in life.[372] Some studies suggest that activity in adulthood[373-375] and particularly throughout the lifetime[361 374-376] is most important.

Lung cancer

There is evidence that physical activity protects against lung cancer, but the evidence is not entirely consistent.[361 366] Most studies have involved only men, although some also demonstrate a protective effect for women.[377 378] Some of the protective effect of physical activity appears to be reduced after adjusting for other risk factors.[362 364] The absence of any plausible biological mechanism might further detract from the strength of this evidence.

Prostate and testicular cancer

Some studies have reported that physically active men have a lower risk of prostate cancer,[366] but the overall body of evidence does not support a preventive role for physical activity.[366 379-381]

There is insufficient evidence to say whether physical activity has a protective effect on testicular cancer, but most studies suggest no relationship with activity.[361 366]

Endometrial and ovarian cancer

Physical activity has a small protective effect on endometrial cancer. A few studies indicate that there is a dose-response relationship – that those with higher levels of physical activity have a lower risk of endometrial cancer.[361 366 382]

The evidence for ovarian cancer is inconsistent, and it is unclear if there is a relationship with physical activity.[366 383-385]

Gender differences

The protective effect of physical activity on overall cancer risk and on the risk of colon cancer is stronger for men than for women.[361] However, there is insufficient evidence to say whether this is a genuine gender difference or has been caused by discrepancies in research methodology.

Possible mechanisms

The mechanisms behind the apparent protective effects of physical activity have not been established, but the following possible biological mechanisms have been suggested.[386] Physical activity may modify metabolic hormones and growth factors, improve the anti-tumour immune defence system, and regulate energy balance and fat distribution. It may also promote antioxidant defence and DNA repair. Other possible mechanisms relate to specific types of cancer. For example, physical activity may reduce exposure to endogenous sex hormones (such as oestrogen or testosterone) that are implicated in hormone-dependent cancers such as breast, endometrial, prostate or testicular cancer. Physical activity can speed up the transit of food through the body, which may mean that the intestinal tract is less exposed to cancer-causing agents. Changes to levels of insulin, prostaglandin, and bile acids may help prevent cells in the colon from proliferating. Improved lung function may help to prevent lung cancer by minimising the presence of carcinogens in the airways.

There are currently insufficient empirical data to support any of these suggested biological mechanisms and it is generally believed that a combination of factors is responsible for the protective effect of physical activity.[387]

Rehabilitation

There has been little research into the possible effects of physical activity in the treatment of cancer and, so far, there is no evidence to indicate that physical activity can directly affect tumour growth, progression of the disease, or survival. However, physical activity during and following treatment does appear to be associated with a range of improvements in quality of life,[353 388] including improvements in physical and psychological functioning and a reduction in symptoms such as fatigue and nausea. Most of the trials have involved women with breast cancer.

6 Benefits of physical activity for older adults

Key points

- The beneficial effects of physical activity on cardiovascular disease, type 2 diabetes and obesity, as outlined in chapter 5, are also evident for older people.
- Regular lifestyle activity is particularly important for older people for the maintenance of mobility and independent living.
- Strength-training exercises can improve muscle strength, which is important for tasks of daily living such as walking or getting up from a chair.
- Physical activity – and particularly training to improve strength, balance and coordination – has also been found to be highly effective in reducing the incidence of falls.
- Physical activity can help improve the emotional and mental well-being of older people. It is associated with reduced risk of developing depressive symptoms and can be effective in treating depression and enhancing mood.
- Physical activity may improve at least some aspects of cognitive function which are important to tasks of daily living. It is also associated with reduced risk of developing problems of cognitive impairment in old age.

All the diseases covered in Chapter 5 – cardiovascular disease, obesity, type 2 diabetes, musculoskeletal problems, cancers and mental illness – have a greater incidence and impact as people age. Serious problems of cognitive impairment also become more prevalent. Increased disease and disability may reduce the ability of older people to perform everyday tasks, and jeopardise independent living and quality of life. The older population is increasing as a percentage of the total population and life expectancy is increasing. A disproportionate percentage of health costs is therefore incurred through the treatment of older people, and this continues to rise.

A growing body of evidence suggests that diseases and conditions which are the primary cause of loss of function and independence in later life are preventable and physical activity can play an important part. Preventive effects arising from regular physical activity in older age are at least as strong as those found in middle age for all-cause mortality,[22] cardiovascular disease,[389] and type 2 diabetes[254] (see section 5.1, page 38; section 5.3, page 49). This chapter focuses on the effect of physical activity on other issues pertinent to older people: loss of mobility, falls, fractures and muscle strength; and aspects of mental well-being and quality of life.

The high levels of inactivity among older people, and the low proportions of older people who reach the recommended physical activity levels, have been described in Chapter 2. Among 65-74 year olds in England, only 17% of men and 12% of women reach the current physical activity recommendations, while 52% of men and 61% of women are inactive (see Table 2, page 11). Among those aged 75 and above, only 7% of men and 4% of women reach current recommendations, while 72% of men and 82% of women are inactive.[5]

The decline in levels of physical activity with age is not inevitable and contrasts with many south east Asian countries where daily group and individual activity routines such as Tai Chi are the cultural norm. Some of these countries show a levelling off or an increase rather than a decline in activity from middle to older age.[390 391]

Environmental factors may account for some of the decline in activity among older people in England. Older people are more likely than other age groups to be deterred from going out by fear of crime[392] and as pedestrians are more likely to be road traffic accident victims.[393] Crossing a road within the time allowed on traffic light controlled crossings requires an average walking speed that is higher than that achievable by most 70 year olds.[394] Older people report being prevented from taking part in a range of activities because of shortage of transport.[395] They also describe barriers to physical activity such as low social expectations, and lack of suitable exercise settings.[396-398]

Mobility, falls, fractures and muscle strength

Mobility

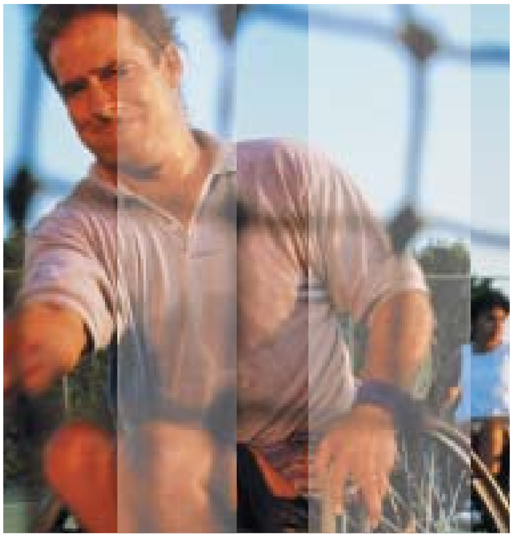
Mobility – the ability to complete everyday tasks requiring physical activity – declines with age. Among people older than 65, 12% cannot manage walking outside on their own and 9% cannot manage stairs unaided.[399] In the over-70s, 25% of women and 7% of men do not have sufficient leg strength to get out of a chair without using their arms.[400] Loss of mobility is associated with a decrease in muscle power: people with lower mobility tend to have a lower level of muscle power.[401] A review of trials and prospective studies[402] concluded that physical activity is associated with reduced subsequent functional disability. Trials also showed that activity, particularly in the form of walking, increased strength and aerobic capacity and reduced functional limitations. However, the effect on more serious functional disability remains equivocal.

Falls and fractures

Falls are a major cause of disability and the leading cause of mortality due to injury in older people aged over 75 in the UK.[403-405] Over 400,000 older people in England attend accident and emergency departments each year following a fall[406] and up to 14,000 people a year die in the UK as a result of an osteoporotic hip fracture.[407] After an osteoporotic fracture, 50% of people can no longer live independently. Fear of falling can provide a significant limitation to daily activities,[408] and osteoporosis can cause fear, anxiety and depression in women patients. Eighty per cent of older women say they would prefer death to a bad hip fracture that would result in permanent placement in a nursing home.[409]

Loss of muscle strength and power

Loss of muscle mass associated with ageing (sarcopenia) is one of the main causes of musculoskeletal frailty and reduced mobility in old age. Physical activity can slow down the loss of muscle mass, but cannot halt it or reverse it. The cause of sarcopenia is not clear. It occurs even in master athletes who maintain very high levels of physical activity, which suggests that ageing *per se*

is the main cause[410] and that disuse accelerates this process.

The most obvious consequences of sarcopenia are loss of muscle *strength* and loss of muscle *power*. Across the age range 65-89 years, the rate of fall of muscle power (3.5% per year) is greater than the rate of fall of muscle strength (1-2% per year).[411] Most daily activities – such as the displacement of body weight during walking or getting up from a chair – require power rather than strength alone. The ability to perform activities of daily living is therefore related to muscle power, and the association is stronger if body weight is taken into account.[412 413]

Physical activity needs to continue into old age in order to confer benefit on muscle strength; physical activity levels during youth and middle age do not affect muscle strength in old age.[414] When older people cease doing physical activity, the loss of muscle mass and strength happens at an even faster rate than during youth and middle age because of the additive effect of ageing and disuse.[415]

Loss of muscle strength in old age may compound the problem of osteoporosis by increasing the risk of falls and the possibility of bone fracture. Muscle weakness in the legs has been found to be highly predictive of the incidence of falls.[416] Quadriceps (upper leg) strength is related to bone mass of the spine and the femur: those with stronger upper leg muscles tend to have higher bone mass. However, the causal role of physical activity in the maintenance of bone mass in old age has not been established.[417]

Effects of physical activity

Mobility

People with higher levels of lifestyle physical activity and sport are more likely to maintain mobility. One study found that lifestyle physical activity and sport were associated with maintenance of mobility among older people over a three-year period.[401]

Muscle strength

The loss of muscle strength and power in old age is due both to the effect of ageing *per se*, as well as to reduced levels of physical activity (disuse). Strength training is effective in mitigating this muscle loss, particularly the component associated with disuse. In general, the greater the disuse, the greater the gain in muscle strength with training.

Regular strength training using external weights or body weight (resistance exercises) has been shown to be highly effective in increasing or preserving muscle strength, even into very old age. Strength-training programmes involving 2-3 sessions per week with loads greater than 65% of 1RM (1RM = the one-repetition maximum, or the load that can be lifted once only) have produced significant improvements in muscle strength in older people. Older people have similar gains in relative muscle strength to those observed in young adults.[418] The increase in muscle strength is accompanied by improvements in functional mobility, such as walking speed.[419]

Aerobic physical activity is not effective in preventing the loss of muscle strength associated with ageing. The rate of decline of muscle strength in the legs of older people who regularly perform high-level aerobic exercise is similar to the rate of decline seen in those who do not exercise.[420]

Falls

Exercise programmes – particularly strength training – have been shown to be highly effective in reducing subsequent incidence of falls among older people.[421 422] In programmes combining strength, balance and endurance training, the risk of falls was reduced by 10%; programmes with balance training

alone reduced the risk by 25%; and Tai Chi reduced the risk by 47%.[422]

Bone health

Section 5.4 in Chapter 5 describes how loss of bone (osteoporosis) can increase the risk of fractures from falls, and how physical activity can help to slow down bone loss, and help prevent falls.

After the period of bone growth in adolescence and young adulthood has passed, it is important to slow down bone loss, although some bone gain is still possible.[272] Physical activity can produce a beneficial bone response in all adult ages, although old bone responds more slowly than young bone.

Well-being and quality of life

Emotional and mental well-being

Physical activity can help improve the emotional and mental well-being of older people. Physical activity is associated with reduced symptoms of depression in older people over a five-year period.[320] Both aerobic-and resistance-type exercise have been shown to be effective in reducing clinical and non-clinical depression among older people.[321,323,423-425] Physical activity can also reduce anxiety in older people[335,426] and enhance mood, even where there is no evident improvement in fitness.[359]

Rehabilitation programmes incorporating physical activity have had a positive effect on the emotional functioning and mental health of older people. A meta-analysis of studies with middle-aged and older people who are cardiac rehabilitation patients, shows that physical activity produces a small to moderate reduction in anxiety and symptoms of depression.[427] Physical activity has also reduced anxiety among older people with chronic obstructive pulmonary disease,[428] newly diagnosed breast cancer patients,[429] and osteoarthritic patients.[293]

Enhancement of cognitive function

Many aspects of cognitive functioning – such as speed and accuracy of response, working memory, and multiple task processing – deteriorate with age and threaten independent living. There is limited evidence that physical activity can improve at least some aspects of cognitive function among older people. Better cognitive performance in older age – particularly in those tasks that are attention-demanding and rapid – is associated with increased aerobic fitness, physical activity and sport participation: those with higher aerobic fitness and levels of activity and sport participation are better able to manage those tasks.[430] However, experimental evidence about whether physical activity can improve cognitive function in older people has been variable.[431,432] A systematic review of 18 intervention studies concluded that exercise training had robust but selective benefits, with the largest benefits occurring for executive-control processes.[433] Improvements occur in processes such as short-term memory, decision-making, and quick thinking. A randomised controlled trial to compare different types of exercise concluded that aerobic activity (walking) showed substantial improvements in these executive-control processes compared with a stretching and toning group.[434]

Prevention of cognitive impairment

As people get older, they have an increased risk of aspects of cognitive impairment such as confusion, dementia and Alzheimer's disease. Physical activity may offer some protection against problems of serious cognitive impairment in old age.[435,436] Two prospective studies show that high levels of physical activity reduce the risk of cognitive impairment, Alzheimer's disease and dementia.[437,438] One of these studies, with women aged 65 or older, indicated that those with a greater physical activity level at baseline were less likely to experience cognitive

decline during the 6 to 8 years of follow-up: cognitive decline occurred in 17%, 18%, 22%, and 24% of those in the highest, third, second, and lowest quartile of blocks walked per week ($P< 0.001$ for trend).[438]

Self-efficacy

Self-efficacy is a person's self-confidence in their ability to achieve tasks or goals even when faced with a range of potential barriers. With regard to physical activity, these may involve both purposeful exercise and activities of daily living. The perceived barriers to physical activity may include physical health status, competing pursuits, lack of support from others, and environmental factors, all of which may be particularly relevant for people in older age. Physical activity programmes that aim to increase self-efficacy through a cognitive-behavioural approach have been successful in changing behaviour.[439] This work is important because there is strong evidence that initial low self-efficacy for physical activity is one of the most important determinants of functional decline with chronic knee pain,[440] of risk of falling,[441] and of future engagement in physical activities.[442]

Physical symptoms

Physical activity can have a beneficial effect on symptoms caused by several diseases. For example, it can help with joint pain for people with rheumatoid arthritis and knee osteoarthritis, and for people with chronic obstructive pulmonary disease it can help with symptoms of breathlessness.[118 284 439 443 444]

Aerobic exercise training has also been reported to increase vigour and reduce fatigue[445] in studies that have included older people. Positive effects on fatigue and energy have been shown in patients with heart failure[446] and chronic obstructive pulmonary disease,[447] and in healthy older people.[339 448] For every 6-10 older people attending a cardiac rehabilitation programme, at least one will have a meaningful improvement in health-related quality of life.[449]

An increase in physical activity can improve sleep for older people.[347 450]

Social functioning

Remaining physically active in older age may offer opportunities for maintaining independence. Daily routines involving walking to local shops may mean less reliance on others while at the same time promoting social and community interaction. Unfortunately, there is little direct evidence to support this,[451] although positive social benefits have been observed in physical activity programmes involving older people.[397 398 452]

7 Risks from physical activity

Key points

- The risks associated with taking part in physical activity at levels that promote health are low.
- Higher risks occur predominantly among those exercising at vigorous levels and those taking part in contact sports and high-volume fitness training.
- All people, irrespective of health, fitness or activity level, should increase activity levels *gradually*. People with low levels of habitual physical activity, who are unfit or who have existing disease, should pay particular attention to this.
- People who have pre-existing musculoskeletal disease have a higher risk of injury caused by physical activity.
- Many injuries that occur during physical activity are avoidable.
- The health benefits of activity far outweigh the risks.

Moderate intensity physical activity represents a substantial public health investment, although injury is a potential downside of participation.[453 454] However, many injuries that occur during physical activity are avoidable.[455]

The people who will benefit most from physical activity are inactive people who begin to take part in regular, moderate intensity activity. If these people increase their level of activity gradually, they are unlikely to face undue risks. The greatest risks from physical activity are faced by:

- people who take part in vigorous sports and exercise
- people who do 'excessive' amounts of exercise, and
- people with existing musculoskeletal disease or at high risk of disease.

Most of the evidence relating physical activity to 'risk' focuses on the risk of sustaining injuries through playing sport. In sport, the nature and intensity of the activity – and therefore the degree of physical and psychological stress placed on the body – is determined by the sport. In activities pursued for health purposes, the individual is in control of all of these factors. This is an important distinction and has an important bearing on our understanding of the concept of 'risk' in relation to different types and levels of physical activity.

It is difficult to define the main risk factors for injury, for the following reasons. Firstly, although there are statistics for incidence of injury for most sports and active pursuits, it is more difficult to find data on the

numbers of people who take part in those activities, and how frequently. Secondly, there is a lack of prospective studies on this topic.[456] Thirdly, it is difficult to identify rates of injury accurately. However, the data available provide some insight into the types of activity-related injuries that occur and what can be done to help prevent them.

Injuries caused by sports and exercise are most effectively managed by early rehabilitation. Early rehabilitation increases the chances of achieving a complete recovery of function, and also reduces the associated individual, community and economic burden. Although it is difficult to assess the potential cost benefits of effective early treatment, some evidence suggests that poor management of injuries may lead to long-term problems.[457] These include early onset degenerative joint disease leading to disability and impairment, or expensive joint replacement surgery.

Costs of sports injuries

In the UK, the annual direct and indirect costs of sport and exercise-related injuries have been estimated at up to £991 million.[458 459]

Predictors of sports injuries

Although, as already stated, data on predictors of sport and exercise injuries are sparse, there is some evidence suggesting the involvement of both extrinsic and intrinsic factors.[460] Extrinsic factors may include: training errors (for example, increasing the level of activity in too short a period of time, or no recovery period after training); surfaces (too hard); footwear (poor quality or unsuitable); or poor equipment (leading, for example, to tennis elbow). Intrinsic factors include biomechanical features such as previous injury, muscle imbalance, loss of flexibility or range of motion, gender, weight, or metabolic conditions.[461]

Other predictors of sports injuries include high pupil-teacher ratios and low level of social support and poverty. In schools with high pupil-teacher ratios and low levels of social support there were more exercise-related injuries compared with all other schools.[462] Poverty adds to these problems and impacts negatively upon preventive behaviour.[463]

Prevention of common sports injuries

People who take part in moderate and vigorous intensity activities have a higher risk of ankle and knee injuries and of general overuse musculoskeletal injuries than those who take part in activity at lower intensities. Most of these injuries are preventable. Since most injuries are mechanical problems, they are more prevalent in older people. Walking has very low levels of injury risk: for example in the USA, only 1% of USA walkers who were walking for exercise report that walking had caused an injury within the previous 30 days.[464].

Type and intensity of activity and injury

In the Aerobics Center Longitudinal Study, a quarter of respondents reported a musculoskeletal injury, of which 83% were activity-related. Sport participants had the highest proportion of all-cause and activity-related musculoskeletal injuries among both men and women. Almost one-third of respondents reported permanently stopping their exercise program after injury.[465]

Former athletes have more degenerative changes in their joints and spine compared with control populations. However, at old age, their good muscle function related to high physical activity level seems to compensate for the effects of degenerative changes on function.[466]

Ankle injuries

Ankle sprains and strains are relatively common. For sports participants, taping and the wearing of ankle braces help to protect against ankle injuries,[467 468] although their effectiveness is debated.[456 469-472]

Knee injuries

Using a knee brace can reduce knee injuries by about 60% in collision sports played at a very high level such as American football.[473] However, bracing has not been widely used as a preventive measure in sport medicine. If a particular individual has a specific problem then it may help, but there is little evidence that supports bracing or taping for all participants.

Overuse injuries

Avoidance of overuse injuries is a critical part of designing and monitoring any conditioning programme, particularly in highly trained young people and within endurance sports.[474]

The use of stretching and warm-up exercises to promote suppleness and flexibility was believed to serve a preventive function against strain injuries to muscles and tendons. However, the most recent data are conflicting. In well-designed studies, stretching before exercise did not protect against strain injuries to muscles and tendons.[475-477] There is minimal evidence to support the use of warm-up exercises in preventing these injuries.[477 478]

Children and sports injuries

Children and especially adolescents suffer other injuries that have different causes from adults' injuries. In team sports, children of the same age compete against each other, but variation in the timing of the growth spurt causes marked differences in height, weight and strength between players. These differences are a major cause of contact injuries.

Adolescents are generally prone to ligament and muscle injuries due to rapid changes in body composition during the growth spurt.

In children, as in adults, injuries are more prevalent in pursuits which involve high volumes and/or high intensities of activity, or high levels of physical contact. High volumes and intensities of activity are often required of elite child performers in many sports. This can result in Sever's disease and Osgood-Schlatter's disease. Reducing high-intensity activity during growth spurts and/or increasing flexibility training may be positive interventions.

New sports injuries

Newer sports, such as snowboarding,[479] in-line skating[480 481] and scooter-riding[482] introduce new injuries. The appeal of some of these sports particularly exposes young people to heightened risk of injury. However, a great part of this risk may be easily reduced. For example, there is evidence suggesting that snowboarding wrist protectors reduce injury risk,[483 484] but their use is not common.

Effects on osteoarthritis

As discussed in section 5.4 in Chapter 5, an excess of stress on the joints may increase the risk of osteoarthritis, and a high lifetime exposure to walking, running/jogging and track and field athletics is associated with increased risk of hip pain. The trauma incurred in activity-related injuries seems to be a central risk factor. In the absence of trauma, heavy exercise exposure is not associated with ankle osteoarthritis.[485] Significant injuries to joint surfaces, or their protective ligaments, are known to cause secondary osteoarthritis. It is therefore likely that elite sports participation – because of its higher risk of joint injury – will result

in higher likelihood of subsequent osteoarthritis compared with recreational physical activity, where joint injuries are less common. Although children recover from injury relatively quickly, it has been shown that joint injury sustained at age 16 manifests as osteoarthritis on average 22 years later.[486]

There is no excess risk of subsequent osteoarthritis in people who participate in moderate intensity activities such as walking, cycling and swimming at levels that place no undue stress on the joints. Risk of arthritis may even be lowered. However, increased risk can be identified in people who have higher levels of exposure (hours per week) and duration (years) to sport and recreational physical activities. It rises further when high levels of occupational and recreational physical activities are combined.[118] There appears to be a threshold level above which the risk is particularly high: 3 hours of heavy physical activity per day, or at least 20 miles of weekly running for knee and hip osteoarthritis. At work, more than 2 hours' daily walking, frequent stair-climbing and lifting weights more than 10 times per week increase the risk of osteoarthritis.[487] Household activities have been related to risk in women: those who do more household activities have a higher risk of osteoarthritis.[488]

Risks for people with pre-existing musculoskeletal disease

People who have pre-existing musculoskeletal disease have a higher risk of injury caused by physical activity. Having pre-existing back pain increased the risk of exercise-related injury by 67%.[304] Certain levels or types of activity appear to be detrimental to people with osteoarthritis. Older women with severe knee pain who walked more than three city blocks in the past week had a higher risk of disability compared with inactive women.[291] Substituting other activities may avoid the risk of aggravating joint disease. In people with joint laxity or misalignment, knee-strengthening activities may be contraindicated, even though they might have beneficial effects in otherwise uninjured joints.[292]

Cardiovascular risks

Section 5.1 in Chapter 5 describes the benefits of physical activity in the prevention and treatment of cardiovascular disease. Extremely rarely, inactive and unfit individuals who start doing vigorous physical activity may face increased cardiovascular risks.

Sudden cardiac death

Sudden cardiac death, especially in younger people, is a rare but high-profile risk of vigorous physical activity. Sudden cardiac death is a dramatic and/or spontaneous death that is thought to be (and usually is) caused by a heart condition and may have been brought on by exercise. In around 1 in every 20 cases of sudden cardiac death – up to 500 every year in the UK – no cause can be found. This is called Sudden Arrhythmic Death Syndrome.[489] The rate of occurrence of sudden cardiac death during or directly after exercise is extremely small – less than one death per 1 million exercise hours in middle-aged men.[36 37] Although existing heart problems may be the main cause of sudden cardiac death during or just after physical exertion, the physical fitness of the individual also plays an important role. Those with low levels of habitual vigorous activity are twice as likely to suffer sudden cardiac death during or after exercise compared with those with high levels of habitual physical activity.[36 490 491] In men with low levels of habitual vigorous activity, the risk of sudden cardiac death while doing vigorous activity is 56 times greater than when not exercising at this level.[490] In men with high levels of habitual activity, the risk during vigorous activity is just five times higher. The risk of

sudden cardiac death is lower for younger people,[492] for women,[492 493] and for moderate intensity physical activity.[494] Moderate intensity physical activity provides the best benefit-harm ratio.[37]

Heart attack

Vigorous levels of physical activity may also increase the risk of heart attack, although again much depends on the person's habitual level of physical activity. Men who are vigorously active experience more heart attacks than those who are moderately and moderately-to-vigorously active.[204] However, this increased risk appears to apply only to men with high blood pressure.[38] Studies of heart attack survivors have shown that there is a higher risk of heart attack during or shortly after heavy physical exertion than during less strenuous or sedentary pursuits.[495 496] However, this increased risk was largely limited to people who did not exercise regularly.

Risks from traffic

The main hazard for walkers, runners and cyclists is an increased risk of unintended injury or death resulting from a motor vehicle crash.

People from the lower socioeconomic groups have a higher risk of a road traffic accident as pedestrians or cyclists.[404]

Cycle helmets are an effective way of preventing injury among cyclists. Helmet-wearing can halve the risk of injuries caused by cycling among children aged 5-12.[497] However, the use of cycle helmets appears to decline with age: adolescents use cycle helmets less often than children.[498] There is some discussion about whether cycle helmet legislation may have an adverse effect on levels of participation in cycling and it is possible that part of the reduction in head injuries seen in some helmet promotion schemes results from this reduction in participation. Other strategies, such as speed reductions, have also been shown to reduce injuries from traffic.[499]

Psychological risks

Physical activity also has implications for psychological health. Section 5.5 in Chapter 5 outlined the many potential benefits for mental health and well-being. However, a small number of people may suffer the following increased risks.

Psychological needs during rehabilitation

Limited research suggests that careful attention needs to be paid to the psychological requirements of some groups during rehabilitation from serious sport or exercise injury. For example, UK evidence suggests that people with higher levels of pre-injury exercise participation experience greater 'confusion' during their rehabilitation.[500] One study found that 67% of people who suffered long-term injury as a result of participating in sport or exercise remained unfit for work for periods of up to one year.[501] The full consequences of work absence in terms of psychological health and general welfare are not known.

Exercise addiction

Obligatory exercise, exercise addiction or exercise dependence are terms used to describe people who exercise excessively without a particular reason or against medical advice, often making exercise a priority over personal relationships, and/or people who experience withdrawal symptoms such as irritability and intolerance when they cannot exercise. It is more likely that the 'exercise dependence' condition is a consequence of persistent underlying psychological dysfunction, obsessive-compulsive symptomatology, perfectionism, drive for thinness, or extreme body dissatisfaction, rather than caused by the exercise itself.[502 503] The incidence of this condition is


unknown, but there is general agreement that it is extremely rare.

Eating disorders, drive for thinness, and body dissatisfaction

Physical activity is not a cause of eating disorders such as anorexia nervosa, bulimia nervosa, and other unspecified disorders, but those who suffer from eating disorders use physical activity as a further means of weight control.[504] The frequency and intensity of exercise are often excessive and likely to be counterproductive to health. Even among people with anorexia and bulimia, physical activity level is associated with greater clinical distress, preoccupation with weight, and body dissatisfaction: those with higher physical activity levels are more likely to suffer these negative effects.

Features of disordered eating patterns or body dissatisfaction are more predominant among females and within activities and sports that involve aesthetic display of the body (such as gymnastics, dance and diving), or where leanness provides an athletic advantage (such as distance running). This suggests that coaches should take care not to generate over-sensitisation to body image, particularly with females in aesthetic or leanness-oriented activities and sports.

Elite female athletes at a high level of training can experience the 'female athlete triad' – disordered eating, amenorrhoea and osteoporosis. Also, elite pre-pubertal athletes may experience a delayed menarche, which alone might cause later health problems.

Other risks

Although not of great concern in terms of public health, other direct or indirect risks are associated with physical activity. People who are active outdoors may risk increased exposure to air pollution, attacks from animals or humans, sunburn, and falls onto hard surfaces. Many people who play sports risk being struck by a bat or ball, colliding with other players, or being subjected to interpersonal violence. Hot or humid weather conditions coupled with severe or prolonged exertion can lead to dehydration, hyperthermia and heat stroke. There is a risk of hypothermia with water sports or activities performed in cold conditions. Risk of bacterial infection increases with some activities (such as swimming), and continued high volumes of exercise can increase the risk of infections due to immunosuppression. High levels of some activities (such as long-distance running) can cause haematological disturbances such as haematuria.

Appendix 1 – Glossary

Abdominal obesity

A waist:hip circumference ratio of 0.95 or more for men, and 0.85 or more for women, indicates abdominal obesity and an increased risk of obesity-related disease. The average waist:hip ratio in the UK is 0.91 for men and 0.80 for women.

Adolescence

Transition from childhood to adulthood. Usually occurs between the ages of 11 and 16 years.

Aerobic activity/aerobic exercise

Physical activity or exercise that predominantly uses aerobic energy metabolism – the production of energy by the oxidation of carbohydrate, fat and (to a lesser extent) protein. Light and moderate intensity exercise is predominantly aerobic. More vigorous exercise uses predominantly anaerobic energy metabolism – the production of energy in the absence of oxygen.

Aerobic fitness/aerobic power

The technically correct term is 'aerobic power' – the body's maximal capacity to perform aerobic physical activity. It comprises two elements:

- the ability of the heart and circulatory system to deliver blood (containing fuel and oxygen) to the working muscles, and
- the ability of the cells of the working muscles to extract and use the fuel and oxygen and perform aerobic work (via aerobic metabolism).

All-cause mortality

Death from all causes.

Body mass index (BMI)

Weight in kilograms divided by height in metres squared: kg/m^2. (See also *Obesity,* and Table 10, page 81.)

Cardiovascular fitness

Term often used synonymously with aerobic power. (See *Aerobic fitness/aerobic power*, above.)

Children

2-11 year olds

Dimensions of physical activity

Sub-components of physical activity – volume, frequency, time, intensity and mode.

Endurance training

Training the body's ability to perform long-duration, aerobic activity.

Exercise

Planned bouts of physical activity usually pursued for personal health and fitness goals. Exercise is a subset of physical activity, which is volitional, planned, structured, repetitive and aimed at improvement or maintenance of any aspect of fitness or health.[1] Exercise is often described in terms of its principal dimensions – frequency, time, intensity, mode and volume.

Fitness

A set of attributes that people have or achieve that relates to the ability to perform physical activity.[2] Specifically, it refers to the ability to perform a given physical task in a specified physical, social and psychological environment.[505] While there is often a focus on cardiorespiratory fitness, this is only one element of fitness that can be enhanced through appropriate activity. Others include strength, flexibility, speed and power. Optimum levels of body fat are also considered an element of fitness. Fitness components can be sports-related or health-related, or both.

Flexibility

The range of motion of a joint.

Frequency

The number of sessions of physical activity over a fixed period.

Health-related fitness

A dimension of fitness that goes beyond pure physical function.[505] It encompasses the following:

- Sufficient functional capacity to perform activities of daily living without undue discomfort. The main determinants are the physical condition of the cardiorespiratory and musculoskeletal systems.
- Optimal weight control. The main determinants are regular physical activity and healthy diet.
- Low levels of risk factors for major diseases – for example, normal levels of body fat, blood pressure, lipids and insulin sensitivity.
- Optimal psychological and social well-being – for example, good mental health and membership of social networks.

Intensity

The rate of energy expenditure that an activity demands – in other words, how hard a person is working. For any given physical task, the absolute rate of energy expenditure (the number of calories burned) is broadly similar for individuals of equal weight. Heavier people will obviously expend more energy performing the task because they have more weight to move. This rate of energy expenditure is the *absolute intensity* of the activity and is usually measured either in 'kcals per kg per minute', or in 'METS' (metabolic equivalents – multiples of resting metabolic rate).

A fitter individual will perceive the intensity of a specific activity to be lower compared with an unfit individual because the fitter individual uses a smaller proportion of their fitness reserve (or capacity). The fitter body copes with the physical task more comfortably. Therefore in some situations it is more appropriate to express intensity relative to fitness level. In this case it is called the *relative intensity* and is measured in units such as '% maximal aerobic power'.

Intensity as a function of fitness

Table 9 outlines the relationships between the different intensities of activities and fitness levels. It shows that, as fitness levels decline, the absolute intensity of the activity that is perceived as 'moderate' also declines.

Lifestyle activity

Activities that are performed as part of everyday life, such as climbing stairs, walking (for example to work, school or shops) and cycling. They are normally contrasted with 'programmed' activities such as attending a dance class or fitness training session.

MET

MET stands for 'metabolic equivalent'. 1 MET = a person's metabolic rate (rate of energy expenditure) when at rest. MET values are assigned to activities to denote their intensity and are given in multiples of resting metabolic rate. For example, walking elicits an intensity of 3-6 METS, depending on how brisk the walk is.

Metabolic cost of activity

The energy expended during an activity. It is usually measured in kcals.

Mode

There are many different modes of activity – for example, jogging, walking, housework and so on. Each type of activity will result in a different range of effects on the various body systems – for example, the cardiovascular system, musculoskeletal system, or immune function.

Muscle power

The product of the force a muscle can exert and the distance over which the force is exerted.

Muscle strength

The force that a muscle can exert.

Obesity

A severe excess of body fatness that is usually defined as a body mass index (BMI) greater than 30. (See *Body mass index*, above, and Table 10.)

In order to make it easier to interpret BMI measurements, a grading system has been developed. This system links increases in BMI to health risks.

Older people

Adults aged 65+.

Table 9 Relationships between the different intensities of activities and fitness levels

	Fitness level (Maximal METS)*			
Intensity	**High** (12 METS)	**Moderate** (10 METS)	**Low** (8 METS)	**Very low** (5 METS)
Very light	Less than 3.2	Less than 2.8	Less than 2.4	Less than 1.8
Light	3.2-5.3	2.8-4.5	2.4-3.7	1.8-2.5
Moderate	5.4-7.5	4.6-6.3	3.8-5.1	2.6-3.3
Vigorous	7.6-10.2	6.4-8.6	5.2-6.9	3.4-4.3
Very vigorous	10.3+	8.7+	7.0+	4.4+
Maximal	12	10	8	5

Values are METS

Source: Adapted from Kesaniemi *et al* 2001[506]

Overweight

An excess of body fatness that is usually defined as a body mass index greater than 25 but less than 30. (See *Obesity*, and Table 10.)

Physical activity

"Any force exerted by skeletal muscle that results in energy expenditure above resting level".[1] The term physical activity therefore includes the full range of human movement, from competitive sport and exercise to active hobbies, walking, cycling, or activities of daily living. Physical activity *per se* is a complex, multi-dimensional behaviour.

Repetition max (RM)

A weight-training term that refers to the weight that an individual can lift a fixed number of times. For example, 1RM is the weight an individual can lift just once. 10RM would be the weight an individual can just about lift 10 times before failing.

Resistance training

Training with weights (or body weight) to increase muscular strength, power or anaerobic endurance.

Sport

For the purposes of this report, sport is defined as a subset of physical activity, which involves structured competitive situations governed by rules. However, in mainland Europe and increasingly within the UK, sport is often used in a wider context to include all exercise and leisure physical activity.[3]

Time

The duration of a single activity session.

Volume

The total amount of physical activity performed over a fixed period. It is a combination of the frequency, time and intensity of all activity bouts during that period.

Waist circumference

A waist circumference of over 35 inches (90cm) for women and over 40 inches (102cm) for men indicates a substantially increased health risk due to overweight/obesity.

Weight-bearing activities

Activities where the body supports its own weight.

Table 10 Classification of body mass index

Body mass index (kg/m^2)	WHO classification
Below 18.5	Underweight
18.5-24.9	Healthy weight
25.0-29.9	Grade 1 obesity (Overweight)
30.0-39.9	Grade 2 obesity (Obesity)
40.0 or above	Grade 3 obesity (Morbid obesity)

Source: World Health Organization, 1997[507]

Appendix 2 – Previous advice on levels of physical activity

Adults

In 1994, the Health Education Authority (HEA) held an international symposium, *Moving On*[1], and made proposals on three national objectives on physical activity for adults.

In 1996, the Department of Health developed a *Strategy Statement on Physical Activity*[2], which set out the new recommendations to:

- Promote the value of moderate activity on a regular basis for sedentary people.
- Inform people of the value of maintaining 30 minutes of moderate activity on at least 5 days a week for those who already take some moderate activity and
- Advocate, for those already taking some vigorous activity, the maintenance of a total of three periods of vigorous activity for 20 minutes a week.

Children and Young People

In 1998, the HEA added the following primary and secondary recommendations for children and young people aged 5-18 years.

Primary recommendations:

- All young people should participate in physical activity of at least moderate intensity for one hour per day.
- Young people who currently do little activity should participate in physical activity of at least moderate intensity for at least half an hour per day.

Secondary recommendations:

- At least twice a week, some of these activities should help to enhance and maintain muscular strength and flexibility, and bone health.

For the primary recommendation, activity may be performed in a continuous fashion or intermittently accumulated throughout the day.

1 HEA (1994) *Moving On: International perspectives on promoting physical activity*. London: Health Education Authority

2 Department of Health (1996) *Strategy Statement on Physical Activity*. London: Department of Health

Appendix 3 – Interventions to increase physical activity among adults

The Health Development Agency*reviewed current evidence from selected good-quality systematic reviews and meta-analyses published between 1996 and November 2001 on effectiveness of public health interventions for increasing physical activity among adults. This appendix is a summary of *A Review of the Evidence on the Effectiveness of Public Health Interventions for Increasing Physical Activity amongst Adults: A Review of Reviews*, by M Hillsdon, C Foster, B Naidoo and H Crombie, published by the Health Development Agency, London, in 2004. Reviews from which these findings are taken are listed at the end of this appendix. Full findings including method are published[508] and are available on the Health Development Agency website at www.hda.nhs.uk/Documents/physicalactivity_evidence_briefing.pdf

Findings

Interventions in health care settings

Five systematic reviews investigated the effectiveness of interventions in health care settings including general practice, hospital outpatient clinics and hospital exercise facilities. (*Ashenden et al, 1997; Eakin et al, 2000; Eaton and Menard, 1998; Lawlor and Hanratty, 2001; Simons-Morton et al, 1998*)

- Evidence from systematic reviews suggests that brief advice from a doctor, based in primary care, supported by written materials, is likely to be effective in producing a modest, short-term (6-12 weeks) effect on physical activity.
- There is some evidence from systematic reviews that referral to an exercise specialist, based in the community, can lead to longer-term (more than 8 months) changes in physical activity.
- Evidence from systematic reviews suggests that the short-term effectiveness of primary prevention interventions is associated with single factor interventions (physical activity only) which focus on the promotion of moderate intensity physical activity (typically walking) in an inactive population.

Interventions in community settings

Two systematic reviews investigated the effectiveness of interventions in community settings. (*Dunn et al, 1998; Hillsdon and Thorogood, 1996*)

- Evidence from systematic reviews suggests that community-based interventions targeting individuals are effective in producing short-term changes in physical activity.
- Evidence from systematic reviews suggests that community-based interventions targeting individuals are likely to be effective in producing mid- to long-term changes in physical activity.
- Evidence from systematic reviews suggests that interventions based on theories of behaviour change, which teach behavioural skills and that are tailored to individual needs, are associated with longer-term changes in behaviour.
- Evidence from systematic reviews suggests that interventions that promote moderate intensity physical activity, particularly walking, and are not facility-dependent, are also associated with longer-term changes in behaviour.

*The Health Development Agency is the national authority on what works to improve people's health and to reduce health inequalities. It works in partnership across sectors to support informed decision-making at all levels and the development of effective practice. The Health Development Agency's role in achieving this aim is to:

- gather evidence of what works
- advise on good practice, and
- support all those working to improve the public's health.

- Evidence from systematic reviews suggests that studies that incorporate regular contact with an exercise specialist tend to report sustained changes in physical activity.

Older adults

One systematic review investigated the effectiveness of interventions in older adults. (*King et al, 1998*)

- Evidence from a systematic review suggests that interventions designed specifically for adults aged 50 and above are effective in producing short-term changes in physical activity.
- Evidence from a systematic review suggests that interventions designed specifically for adults aged 50 and above are likely to be effective in producing mid- to long-term changes in physical activity.
- Evidence from a systematic review suggests that interventions that use behavioural or cognitive approaches with a combination of group and home-based exercise sessions rather than a class or group-only format are associated with longer-term changes in behaviour.
- Evidence from a systematic review suggests that interventions that promote moderate and non-endurance physical activities (for example, flexibility exercises) are associated with long-term changes in behaviour.
- Evidence from a systematic review suggests that interventions that use telephone support and follow-up are also associated with long-term behaviour change.

What is not known

Disadvantaged groups

None of the reviews identified effective interventions in the disadvantaged groups examined. Population surveys have reported that the prevalence of physical *inactivity* is higher in some ethnic minority groups, people in low-income households, those in lower social classes and people with low levels of education. Therefore, it is imperative that future exercise promotion research is carried out in these groups.

However, ethnicity, income, social class and education are inter-related and it will be necessary to examine the independent association between these factors and physical activity to inform appropriate intervention study designs. Formative research will almost certainly be required to better understand the particular needs of different disadvantaged groups.

Policy interventions

At present, no review-level evidence of the effectiveness of interventions aimed at changing policy or the environment regarding physical activity is available.

Limitations of this review

This review was limited to experimental or quasi-experimental study designs, thus excluding a substantial amount of literature from consideration. This observation highlights the important point that, when no review level evidence to support a certain intervention or programme has been found, it does not mean there is absolutely no evidence of its effectiveness, just that no evidence was found from systematic reviews that met the inclusion criteria. Before other types of study designs can be included in reviews such as this, there will need to be an agreed method for systematically synthesising or reviewing such work. There are a number of projects underway nationally and internationally to develop an appropriate methodology.

Reviewed reviews

Ashenden R, Silagy C, Weller D. A systematic review of the effectiveness of promoting lifestyle change in general practice. *Family Practice* 1997; 14: 160-76.

Dishman RK, Oldenburg B, O'Neal H, Shephard RJ. Worksite physical activity interventions. *American Journal of Preventive Medicine* 1998; 15: 344-361.

Dunn AL, Andersen RE, Jakicic JM. Lifestyle physical activity interventions. History, short- and long-term effects, and recommendations. *American Journal of Preventive Medicine* 1998; 15: 398-412.

Eakin EG, Glasgow RE, Riley KM. Review of primary care-based physical activity intervention studies: effectiveness and implications for practice and future research. *Journal of Family Practice* 2000; 49: 158-168.

Eaton CB, Menard LM. A systematic review of physical activity promotion in primary care office settings. *British Journal of Sports Medicine* 1998; 32: 11-16.

Hillsdon M, Thorogood M. A systematic review of physical activity promotion strategies. British *Journal of Sports Medicine* 1996; 30: 84-89.

King AC, Rejeski WJ, Buchner DM. Physical activity interventions targeting older adults. A critical review and recommendations. *American Journal of Preventive Medicine* 1998; 15: 316-333.

Lawlor DA, Hanratty B. The effect of physical activity advice given in routine primary care consultations: a systematic review. *Journal of Public Health Medicine* 2001; 23: 219-226.

Simons-Morton DG, Calfas KJ, Oldenburg B, Burton NW. Effects of interventions in health care settings on physical activity or cardiorespiratory fitness. *American Journal of Preventive Medicine* 1998; 15: 413-430.

CDC Community Guide

The Centers of Disease Control and Prevention in the United States (Taskforce on Community Preventive Services, 2001) has also prepared a report "The Community Guide" on community-based interventions.

The Community Guide's systematic review of the effectiveness of selected population-based interventions designed to increase levels of physical activity, focused on interventions in three areas:

1. Informational approaches to increasing physical activity
2. Behavioural and social approaches to increasing physical activity
3. Environmental and policy changes to increasing physical activity

Further information can be obtained from www.thecommunityguide.org/pa/default.htm

Appendix 4 – Department of Health policy on physical activity

This appendix presents the policy context in which physical activity is based (at the time of publication of this report), along with details of relevant policy documents that have included action on physical activity.

Planning and Priorities Framework 2003-2006[509]

Relevant Department of Health Public Service Agreement objective: Reduce substantially the mortality rates from the major killer diseases by 2010: from heart disease by at least 40% in people under 75; from cancer by at least 20% in people under 75.

Objectives	Target
Supporting the National Service Framework for coronary heart disease	■ In primary care, update practice-based registers so that patients with coronary heart disease and diabetes continue to receive appropriate advice and treatment in line with National Service Framework standards, and *by March 2006*, ensure practice-based registers and systematic treatment regimes, including appropriate advice on **diet**, **physical activity** and smoking, also cover the majority of patients at high risk of coronary heart disease, particularly those with hypertension, diabetes and a body mass index greater than 30
Supporting the National Service Framework for older people	■ Includes targets to support the promotion of independent living and healthy and active life
Reducing health inequalities	■ Contribute to a national reduction in death rates from coronary heart disease of at least 25% in people under 75 *by 2005* compared to 1995-1997, targeting the 20% of areas with the highest rates of coronary heart disease ■ Contribute to a national reduction in cancer death rates of at least 12% in people under 75 *by 2005* compared to 1995-1997, targeting the 20% of areas with the highest rates of cancer
Supporting the National Service Framework for mental health	Health and social services covering: ■ Promoting mental health for all, working with individuals and communities ■ Combating discrimination against individuals and groups with mental health problems, and promoting their social inclusion
National Service Framework for diabetes	
Standards	
To develop, implement and monitor strategies to reduce the risk of developing Type 2 diabetes in the population as a whole and to reduce the inequalities in the risk of developing Type 2 diabetes.	Local health services are expected to set themselves challenging, measurable targets that will result in tangible service improvements.

For further information

Further information on National Service Framework policies and other useful documents can be found at the links given below.

NB National Service Framework standards are not mandatory as targets are, but are levels of performance the Department of Health **expects** all organisations to meet over a 10-year period. The pace of delivery/change is up to them locally, taking into account local priorities.

National Service Framework for coronary heart disease

The National Service Framework for coronary heart disease,[131] launched in 2000, sets 12 standards for improved prevention, diagnosis and treatment, and goals to secure fair access to high quality services, over a 10-year period.

www.dh.gov.uk/assetRoot/04/04/90/70/04049070.pdf

National Service Framework for older people

The National Service Framework for older people,[408] published in 2001, sets national standards for improving health and social services for older people. It sets new national standards and service models of care for all older people whether they live at home or in residential care, or are being cared for in hospital.

www.dh.gov.uk/assetRoot/04/07/12/83/04071283.pdf

National Service Framework for mental health

The National Service Framework for mental health,[510] launched in 1999, is a comprehensive statement on how mental health services will be planned, delivered and monitored. The National Service Framework lists seven standards that set targets for the mental health care of adults aged up to 65.

www.publications.doh.gov.uk/pub/docs/doh/mhmain.pdf

National Service Framework for diabetes

The National Service Framework for diabetes[511,512] is a concerted effort to make sure that people, wherever they live, receive the same excellent standard of care. Embodied in the National Service Framework is the central value of the NHS Plan – that good service is the outcome of genuine partnership between the patient and the provider.

www.publications.doh.gov.uk/nsf/diabetes/index.htm

The NHS Plan

Sustained increases in funding aligned with significant, decentralising reforms are the basis for the NHS Plan which was published in 2000.[513] This document aims to redress geographical inequalities, improve service standards, and extend patient choice, and it constitutes the biggest change to healthcare in England since the NHS was formed in 1948.

www.dh.gov.uk/assetRoot/04/05/57/83/04055783.pdf

The Cancer Plan

This government strategy document, published in 2000, sets out the actions needed to improve cancer prevention and screening services, cut cancer patient waiting times, enhance treatment and palliative care services, and boost UK cancer research.[514]

www.dh.gov.uk/assetRoot/04/01/45/13/04014513.pdf

Appendix 5 – Methods

This Appendix describes the method used to compile this report.

Phase 1 Literature searches

A general search strategy aimed at locating studies relating to physical activity was developed and refined. In consultation with Expert Reviewers, the strategy was then modified and combined with medical subject headings (MeSH) and text words relating to the subject matter of each individual section of the review.

Searches were initially performed electronically in the Cochrane Library (The Cochrane Database of Systematic Reviews; Database of Abstracts of Reviews of Effectiveness; Health Technology Assessment Database; NHS Economic Evaluation Database) to locate existing systematic reviews on each subject. Subsequent electronic searches were performed in Medline, Embase and The Cochrane Controlled Trials Register to locate relevant studies. Additional databases were searched for certain topics (for example, CancerLit for cancer, and PsychInfo for mental health and social well-being). The National Research Register was also searched to locate ongoing and recently completed studies in the UK. Search terms were adapted for each database according to its MeSH terms. For health outcomes that had recently been systematically reviewed (for example cancer, cardiovascular disease, type 2 diabetes and musculoskeletal disorders) searches were conducted for the years 2000-02 to update the body of evidence. For other subjects, the publication date was not restricted. Searches were performed during February 2002. During the editing and publication stages of the review, any new studies appearing after February 2002 were identified by individual reviewers and included if appropriate. The language of publication was not limited.

The results of each search were downloaded and titles and abstracts were scanned. Irrelevant papers were deleted. Each Expert Reviewer was sent a list of publications of potential value to their section of the review. Reviewers selected papers that contributed new data to the overall body of evidence. Articles that could not be obtained locally were ordered through the British Library Document Supply Service. Other means of locating important or new evidence involved scanning the bibliographies of relevant articles, contacting colleagues and other experts in the field, and searching the Internet.

Phase 2 Appraisal by Expert Reviewers

Expert Reviewers (listed in Appendix 6) synthesised and interpreted the existing and new evidence on their subject. Findings of previous reviews were assimilated and conclusions modified in the light of new data. Where possible, the differential effects of physical activity dimensions (such as mode and intensity) were delineated. Similarly, differential effects on population groups based on age, gender, socioeconomic status and ethnicity were assessed. Cost-benefit data were also included.

Phase 3 Review Panel appraisal

The Review Panel (listed in Appendix 6) read all reviews and held consensus meetings to discuss findings, agree final interpretations, and establish overall conclusions. The Review Panel summarised the key findings and conclusions, and these were checked for accuracy by the original Expert Reviewers.

Phase 4 Advisory Group

Findings were collated into a report for consideration by an Advisory Group including experts and health professionals (see Appendix 6). The Advisory Group members made comments on content and accuracy, and key findings. Advisory Group comments on scientific content were subject to the same evidence criteria as were applied to the original review, and the report was revised in the light of their advice.

Phase 5 Re-appraisal by Expert Reviewers

The original reviewers were asked to re-appraise the revised document to consider changes made following the Advisory Group's meetings, to update their original reviews and to comment on the report overall.

Phase 6 Final appraisal by Advisory Group and International Peer Reviewers

The final report was submitted for review to the Advisory Group and International Peer Reviewers. The comments were subject to the same evidence criteria as were applied to the original review, and the report was revised in the light of advice received.

Appendix 6 – Acknowledgements

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