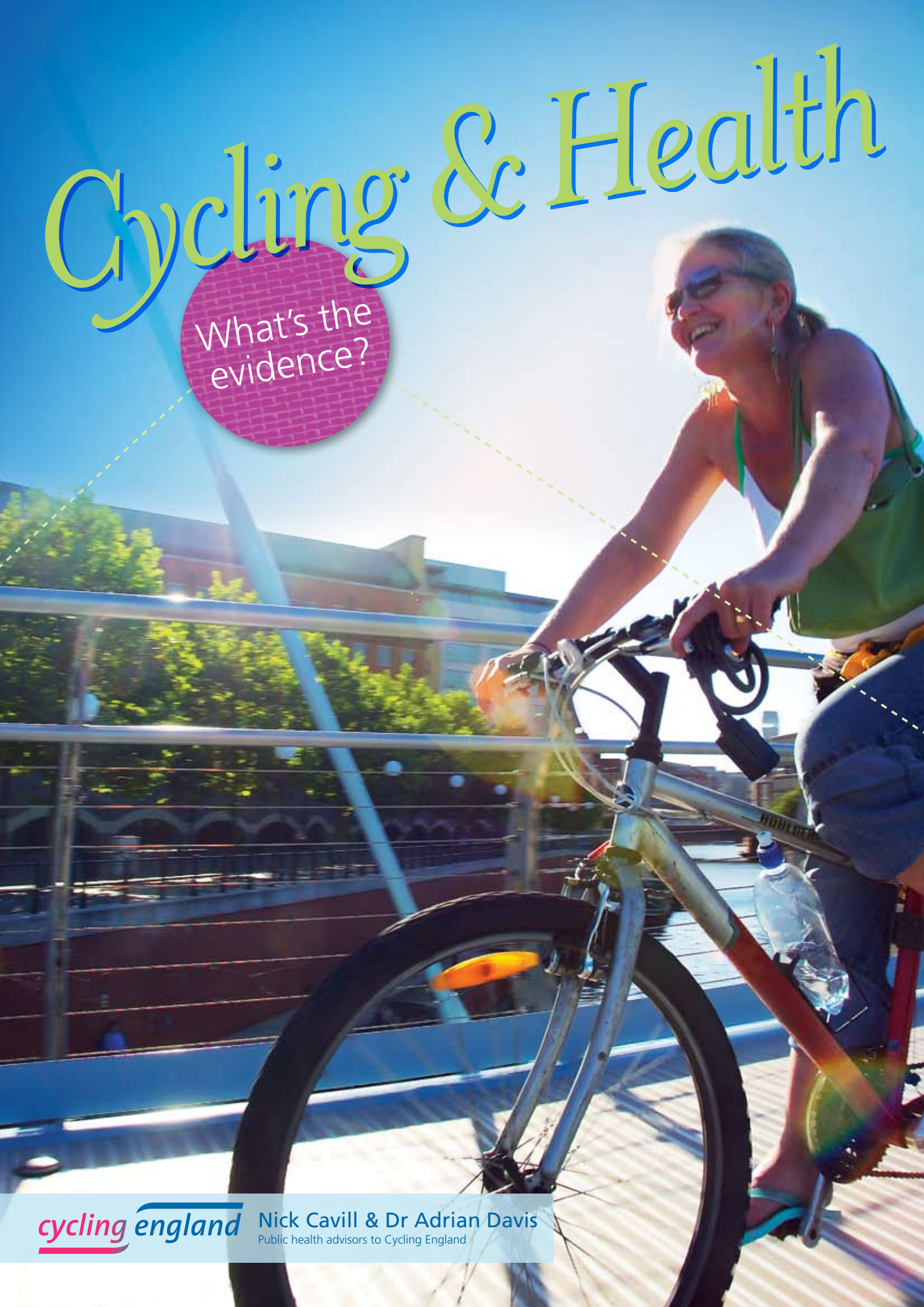
Cycling & Health

What's the evidence?



cycling england

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FOREWORD

Cycling England is the independent, national expert body charged by Government with delivering programmes that get more people cycling, more safely, more often.

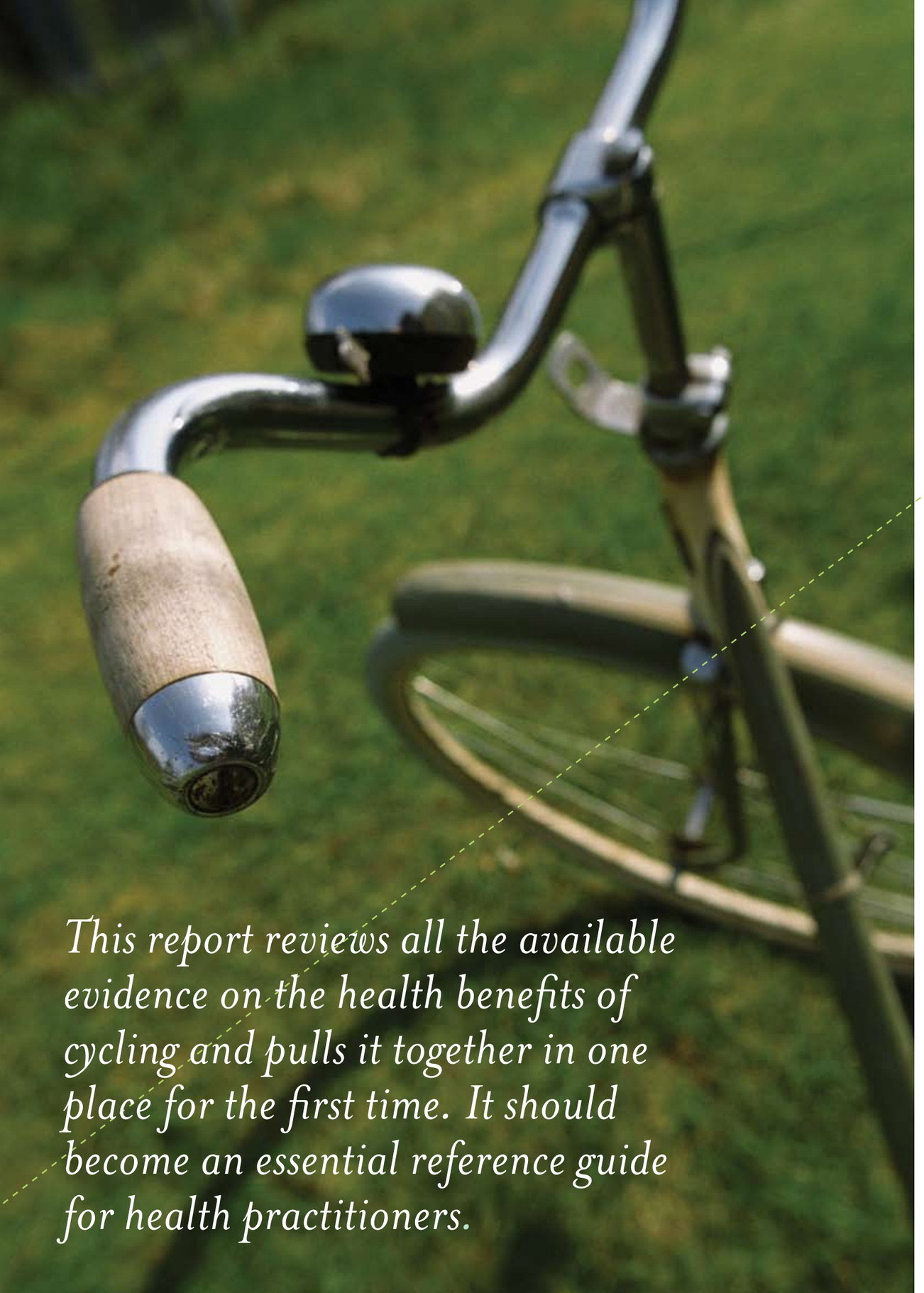
Established in 2005, Cycling England has a budget of £10 million per annum. It is supported by a cross-government group comprising the Department for Transport; the Department of Health; the Department for Children, Schools and Families; the Department of Culture, Media and Sport; the Department for Communities and Local Government; and the Department for the Environment, Food and Rural Affairs.

One of our major themes for delivery is cycling and health. We know that cycling has enormous potential to improve public health through helping people to achieve the recommended level of physical activity as part of their daily travel. We know that the health sector is a valuable partner, able to reach millions of employees and patients who interact with the health service every day. However, it appears that the health aspects of cycling are still being undervalued. NHS engagement with cycling polices and programmes is low and debate continues over the balance between the associated risk and benefit.

This publication sets out to review the evidence that supports cycling for health and provide a solid platform for action. We hope that it will deliver useful facts and figures on cycling and health, and present a concrete justification for promoting cycling on the basis of the strong health benefits.

Our intention is that this report will be used by anyone involved in cycling, to help make the case for cycling and persuade key stakeholders that an investment in cycling is an investment in the nation's future health.

Phillip Darnton
Chairman, Cycling England



This report reviews all the available evidence on the health benefits of cycling and pulls it together in one place for the first time. It should become an essential reference guide for health practitioners.

EXECUTIVE SUMMARY

The health benefits

Cycling is an easy and low-impact activity which can significantly improve individual fitness and which has the potential to have a major impact on public health.

It can help to reduce the risk of a range of health problems, notably heart disease and cancer, the leading preventable causes of premature death.

In a country like the UK, where obesity is at epidemic levels among adults and young people, one of the main benefits of cycling is that people can do it as part of their normal daily activity – by cycling to work, to see friends or to the shops – rather than having to find additional time for exercise.

One study found that people who cycle to work experienced a 39% lower rate of all-cause mortality compared to those who did not – even after adjustment for other risk factors, including leisure time physical activity[1]. Getting on your bike can yield much the same health benefits as doing a specific training programme. Cycling for an additional 30 minutes on most days of the week, combined with reducing calorie intake, can achieve weight loss comparable to that achieved by doing three aerobic classes a week[2].

As well as improving physical health, cycling has a positive affect on emotional health – improving levels of well-being, self-confidence and tolerance to stress while reducing tiredness, difficulties with sleep and a range of medical symptoms[3].

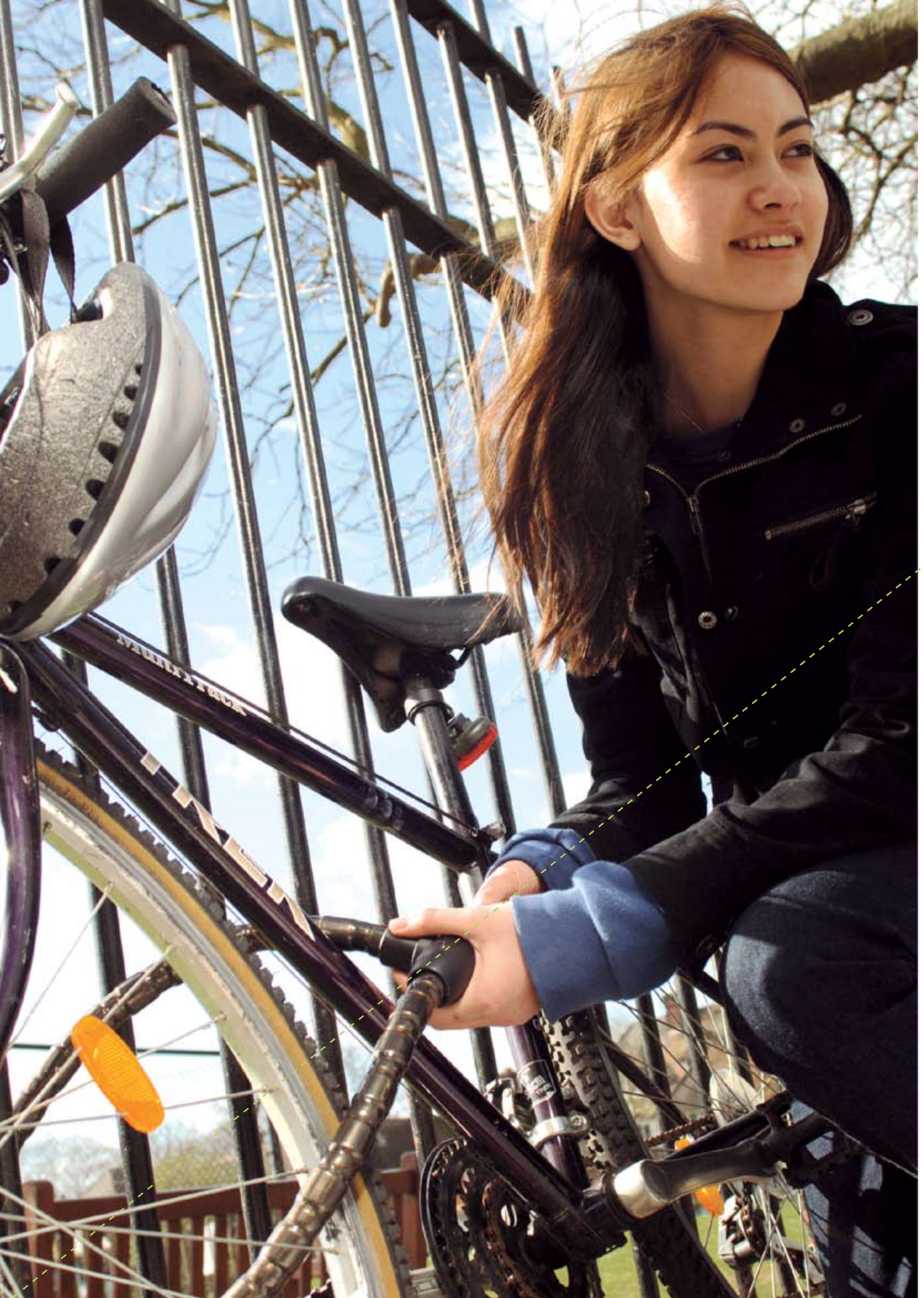
Safety

One of the barriers to taking up cycling is a perception of the physical danger posed by motor traffic. However, the real risks are minimal and, the research suggests, are outweighed by the health benefits by a factor of around twenty to one[4]. It may be more risky to your health to be sedentary.

Conclusion

It's vital for the health of the nation – and the health of the planet – that health and transport professionals focus on positive actions to encourage cycling, especially where a cycle journey will replace a car journey.

Local transport and health authorities need to recognise the potential of cycling to improve many aspects of public health, and place it at the heart of a healthy transport strategy, devising safe cycling policies and promoting the use of cycling – by children and adults alike – on a daily basis.



INTRODUCTION

This report aims to provide a briefing on the links between cycling and health. It sets out to provide a key resource for those interested in understanding and promoting the health benefits of cycling and to assist Cycling England in two main areas of activity:

- *Advocating an increased investment in cycling based on the strong evidence for significant benefits to public health*
- *Working with the NHS to promote cycling: through encouraging patients to cycle; working in partnership with local authorities and other partners; and through improving access to NHS facilities by bike*

This report aims to bring together evidence from a diverse range of sources to make the case for cycling. The report begins by describing the strong evidence that underlines the importance of physical activity and exercise to public health, before exploring the evidence for the specific health effects of cycling. The risks of cycling, both direct and indirect are set out, followed by the wider benefits of cycling. The report is not a systematic review, but the authors have aimed to be as objective as possible in describing the nature and strength of the evidence base.

This report will provide the basis for a summary leaflet published by Cycling England. This will be widely distributed to underline the strong health case for increasing levels of cycling in the UK. It will also be used as a source document for future cycling and health promotions. The authors hope that the report will provide a strong basis for policy change in support of cycling and stimulate further research on cycling and health.

For details of Cycling England's programme of work on cycling and health visit its website www.cyclingengland.co.uk

In the post war period up to the mid 1990s, the road transport sector collaborated little with health professionals beyond the involvement of environmental health officers in the monitoring of air and noise pollution and the health service's focus on traffic casualties. Transport was something of a hidden health issue.[5] There was little encouragement for health or transport professionals to consider cycling as having a direct effect on health.

A BRIEF HISTORY

1

Cycling levels had been in long-term decline, down from 24 billion kilometres in 1949 to just 4.4 billion kilometres by 1994[6]. This decline contrasted with a steep rise in car use and the Government's transport policy was largely congestion-driven, focusing mainly on increasing road network capacity for motorists. This became known as 'predict and provide' – in other words predicting and providing the road space necessary for the rising number of motor vehicles.

By the mid 1990s there were some specific – if rare – examples of inter-sectoral collaboration on transport and health issues beyond traditional areas of concern, such as traffic injuries and pollution [7 8]. At a policy level, however, a notable example of collaboration can be found in England's growing acceptance of the health value of walking and cycling[9], and in 1996 two reports showed a hint of policy convergence.

The launch of the National Cycling Strategy in 1996[10] set targets for quadrupling the number of journeys made by bicycle by 2012 (from a 1996 baseline). In the same year the Department of Health issued the outcome of a consultation on physical activity, A Strategy Statement on Physical Activity. This placed the emphasis on physical activity as part of the routine of daily life and specifically identified cycling (and walking) as a means of achieving recommended physical activity levels. The rationale for this Strategy Statement was the need to address heart disease and stroke as well as the sharp rise in the numbers of overweight and obese in the population[11]. This was a departure from the traditional government focus on sport and exercise as the solution to problems of physical inactivity.

This convergence of policies offered opportunities for inter-sectoral collaboration at both a national and local level in order to achieve some specific transport and health policy objectives. The evidence base for the health benefits of cycling was previously made in a 1992 report published by the British Medical Association (BMA)[12].

The 1998 Integrated Transport White Paper *A New Deal for Transport: Better for Everyone* then made significant references to health and began by acknowledging that:

> *"The way we travel is making us a less healthy nation."[13].*

A brief history

It noted that coronary heart disease is the biggest killer of adults, a problem exacerbated by low levels of walking and cycling and an over-reliance on motorised transport.

Five overarching objectives of transport policy were set out. These were to:

- *improve safety*
- *promote accessibility*
- *contribute to an efficient economy*
- *promote integration*
- *protect the environment.*

The White Paper introduced the concept of Local Transport Plans (LTPs), five-year plans setting out a strategy for transport for a designated area. The second edition of LTP Guidance was issued in 2004[14] and emphasised four key themes:

- *setting transport in a wider context*
- *locally relevant targets*
- *identifying the best value for money solutions*
- *indicators and trajectories.*

Guidance to local authorities from the Department for Transport (DfT) on the development of LTPs included a section on Healthy Communities which stated that:

> *"Policies to promote walking and cycling, to increase use of rights of way, and to improve access to sport and leisure facilities can also help increase levels of physical activity, thereby improving public health…"*

In June 2004 the DfT published Walking and Cycling: An Action Plan, which set out 42 practical actions aimed at increasing walking and cycling. The Department of Health (DoH) has since published *Choosing activity*[15] which sets out a detailed action plan on physical activity (local level action is mainly the work of Local Strategic Partnerships which identify public health outcomes as key priorities within the local area agreements).

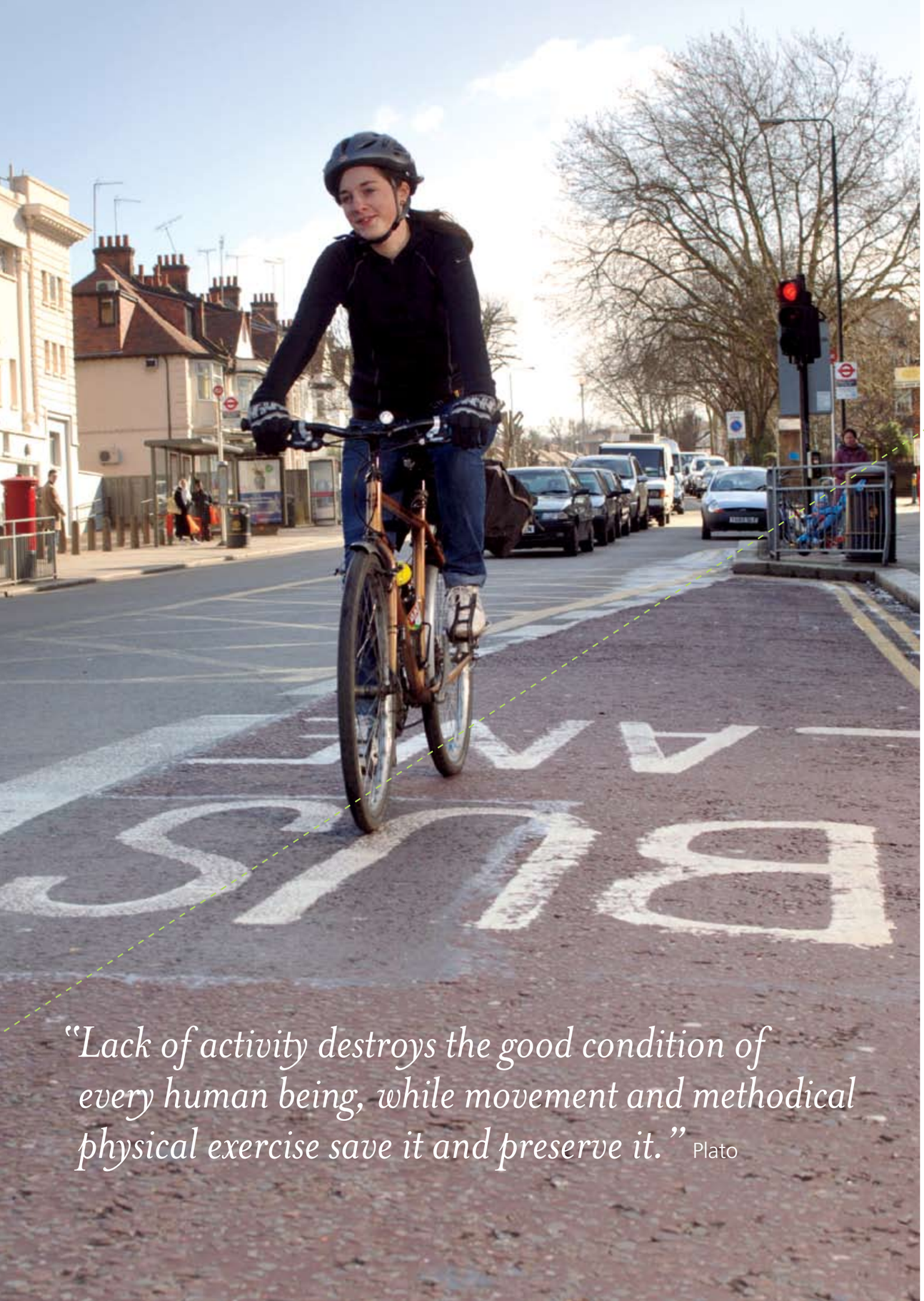
The Health Act 1999[16] finally facilitated joint funding of schemes between health and local authorities. Re-organisation of the NHS as a result of the strategy *Commissioning a Patient-led NHS*[17] set out in 2005, should have resulted in more joint-appointments between the NHS and local government, such as a Director of Public Health for each local authority, who would also be an Associate Director of Public Health in the local Primary Care Trust (PCT).

Beyond PCTs and the NHS, health professionals keen to promote physical activity have also embraced the concept of joint working with transport professionals. This partnering includes an increased focus on environmental interventions[18 19] through improvements to the local environment, making it attractive and safe while meeting everyday travel needs[20 21].

The importance of cycling as a means to achieve greater sustainability and improvements to public health was recognised in the Charter on Transport, Environment and Health. The Charter was adopted by Member States of the European Region of the World Health Organisation (WHO) in 1999 at the third Ministerial Conference on Environment and Health[22].

More recently concerns about health, particularly the trend of rising levels of obesity in the population, have led to greater understanding of the importance of walking and cycling as routine physical activity[23 24] and calls for greater efforts at collaborative action between transport and health staff[25].

These concerns have been recognised at a European level with the Children's Environment and Health Action Plan for Europe (CEHAPE)[26] which sets out a regional priority goal to *"…decrease disease caused by a lack of adequate physical activity through the promotion of safe, secure and supportive human settlements for all children."*



"Lack of activity destroys the good condition of every human being, while movement and methodical physical exercise save it and preserve it." Plato

2 THE IMPORTANCE OF PHYSICAL ACTIVITY FOR PUBLIC HEALTH

The main health benefits of cycling come from its contribution to overall levels of physical activity. This section therefore describes the evidence for the health benefits of physical activity in general, before examining specific evidence for the health benefits of cycling.

Physical activity is the broad term used to describe 'any force exerted by skeletal muscle that results in energy expenditure above resting level'[27]. Thus physical activity includes any form of human movement including walking, cycling, play, active hobbies or manual occupations as well as structured exercise or sport.

In common with most Western nations, participation in physical activity has declined in the UK in recent years. This is partly because there are fewer manual jobs, fewer journeys are taken by bike or on foot and the physical elements of housework, shopping and other activities, have significantly diminished.

Up to two-thirds of men and three-quarters of women report low activity levels which substantially increase their risk of contracting up to twenty chronic diseases or conditions[28]. The change in lifestyle has been particularly dramatic for children, with outdoor play often replaced by TV or computer games and an increase in the number of young people driven to school and elsewhere[29].

This decline in routine physical activity has had a significant negative effect on public health. Researchers now recognise the potential to reverse the decline in physical activity such as through the school journey[30].

Health benefits of physical activity

There is now an extremely strong body of research supporting the link between regular physical activity and good health. The first study on this subject in the 1950s found that bus conductors (who were occupationally physically active) had far lower rates of heart disease than bus drivers (who were more occupationally sedentary), despite similar backgrounds. Postmen's health was similarly compared to deskbound telephonists and other office based employees[31].

Since then numerous other studies have reported similar observations, which were reviewed in a landmark report by the US Surgeon General (see Table 1)[32]. More recently the Chief Medical Officer for England has issued a detailed report identifying the importance of regular physical activity[33].

Regular physical activity improves health in the following ways:

- Reduces the risk of dying prematurely
- Reduces the risk of dying prematurely from heart disease
- Reduces the risk of developing diabetes
- Reduces the risk of developing high blood pressure
- Helps reduce blood pressure in people who already have high blood pressure
- Reduces the risk of developing colon and breast cancer
- Reduces feelings of depression and anxiety
- Helps control weight
- Helps build and maintain healthy bones, muscles and joints
- Helps older adults become stronger and better able to move about without falling
- Promotes psychological well-being.

Table 1. The benefits of regular physical activity[28]

All-cause mortality

Regular physical activity reduces the risk of all-cause mortality, meaning that being active reduces the overall risk of dying prematurely from any cause. Many studies show that the likelihood of death is lowest among those who are most active and the greatest benefits from increasing physical activity come to those who are least active to start with.

A review of 44 studies showed that higher levels of physical activity are associated with reduced risk of all-cause mortality for women and men. There is an inverse dose-response relationship, meaning that as the level of physical activity increases, the risk of all-cause mortality decreases[34].

This reduced risk can be achieved through relatively modest amounts of physical activity. For example the Honolulu Heart Programme[35] found that the mortality rate in men who walked less than one mile per day was nearly twice that of men who walked more than two miles per day. Andersen et al[36] reported that higher levels of leisure-time physical activity were associated with lower levels of all-cause mortality in both men and women. Cycling was featured strongly in this study. Cycling to work decreased the risk of dying by approximately 40%.

Cardiovascular disease

The main forms of cardiovascular disease (CVD) are coronary heart disease (CHD) and stroke. About half of all deaths from CVD are from CHD and nearly a third are from stroke. CVD is the main cause of death in Europe, accounting for 4.35 million deaths each year[37]. This figure is the equivalent of 49% of all deaths in Europe (55% for women and 43% for men). CVD is also the main cause of years lost due to an early death. The Global Burden of Disease Study[38] points out that in established market economies an average of 31% of all years of life lost are due to CVD. The government has made CVD a priority in the NHS because it is common, frequently fatal and largely preventable.

Coronary Heart Disease

Lack of physical activity is one of the most important risk factors for CHD. People who have a physically inactive lifestyle have up to double the risk of developing CHD compared to those who have an active lifestyle[39]. Higher levels of physical fitness have also been shown to lessen the harmful effects of other CHD risk factors such as smoking, high cholesterol and high blood pressure.[40]

Studies have consistently shown that a reduction in the risk of CHD can be achieved through relatively low levels of activity. The benefits can be achieved during middle age by replacing an inactive lifestyle with an active lifestyle[41 42]. Previously sedentary people who take up regular physical activity achieve the greatest proportional benefits to health.

As well as cycling, activities that have been shown to protect against CHD include walking, sport, and physical exercise such as moderate to heavy gardening and stair-climbing. Physical activity has to be current to be of benefit and cannot be 'banked' for later life.

Stroke

There is evidence for the protective effect of physical activity against stroke but this relationship is not as strong as for CHD. There appears to be a preventive effect of physical activity on stroke incidence and the majority of studies report lower incidence of stroke in association with regular light to moderate activity, compared to inactivity. Physical fitness is related to risk of stroke. For example a study found that moderate to high levels of cardiorespiratory fitness were associated with lower risk of stroke mortality in men[43] while another study reported similarly for women[44].

Diabetes

Type 2 diabetes, sometimes known as adult onset diabetes, is the most common metabolic disorder worldwide and is associated with a number of illnesses. The incidence of type 2 diabetes has increased dramatically in recent years with cases now being noted in children[45]. Obesity plays a central role in the development of type 2 diabetes[46].

Physical inactivity is a major risk factor for the development of type 2 diabetes and can increase the risk of developing the disease by 33-50%[47]. Physical activity can contribute to prevention and to a reversal or delay of complications, following early detection, of type 2 diabetes. Walking and cycling are associated with reduced relative risk for diabetes[48].

High blood pressure

Regular physical activity can help reduce blood pressure in people with high blood pressure, otherwise know as hypertension. Physical activity can reduce blood pressure in hypertensive patients with average decreases of 11mmHg for systolic and 8mmHg for diastolic blood pressure[49]. Among people with normal blood pressure, reductions are in the range of 4.4 mmHg systolic and 3.2mmHg diastolic. Again those at highest risk appear to benefit most from regular exercise.

Cancer

Physical activity is associated with a reduced risk of dying from cancer[50]. Several studies have indicated an inverse, dose-response relationship with occupational or leisure-time physical activity.

The strongest evidence exists for cancer of the colon. Physical activity has a protective effect on colon cancer with an average risk reduction of 40-50%[51].

Physical activity is also associated with a reduced risk of breast cancer[52 53] and there may also be a protective effect on lung cancer and endometrial cancer, although there is currently insufficient evidence[54].

Overweight, obesity and associated conditions

More than 60% of adults in the UK are overweight, putting them at increased risk of hypertension, coronary heart disease, type 2 diabetes and osteoarthritis[55]. Obesity occurs when a person gains weight to the point of seriously endangering health. It is defined as a body mass index (weight/height^2) of over 30.

Levels of obesity have risen dramatically in England. The proportion of men who were categorised as obese (with a body mass index – BMI – over 30) increased from 13.2% in 1993 to 23.6% in 2004. For women, that figure increased from 16.4% in 1993 to 23.8% in 2004[56]. This can be classed as an epidemic of obesity and on current trends England will catch up with levels in the USA by 2010[57] (see Figure 1).

Figure 1. Prevalence of obesity, adults aged 16-64, 1986/87 – 2003, England. *Source: www.heartstats.org*

Obesity is also an increasing problem in young people. The Health Survey for England in 2004 found that the percentage of children, aged 2-10, that were overweight or obese rose from 22.7% in 1995 to 27.7% in 2003[58].

Weight gain occurs when the energy taken in as food exceeds the energy expended through physical activity. Food surveys in the UK reveal that average energy intake has either fallen or remained unchanged, which implies that obesity is in part caused by the fact that we have failed to reduce our energy intake to compensate for reduced energy expenditure[59].

Importantly, obesity is referred to as a chronic condition that may require lifelong treatment[60] and so prevention is a primary goal. Physical activity does not have to be undertaken at an intense level or in a structured manner to prevent weight gain. One study showed that moderate intensity lifestyle activity, for instance cycling, walking or stair-climbing for an additional 30 minutes on most days of the week, combined with dietary intervention, achieved a weight reduction comparable to doing three aerobic classes a week[61].

However there is not yet a consensus as to the amount of physical activity necessary to prevent weight gain at a population level. A minimum of 60 minutes accumulated throughout the day has been suggested[62]. For most people this level of activity will be difficult to achieve without activity becoming part of their daily routine, such as walking or cycling.

Mental health and well-being

Physical activity is associated with improved subjective well-being, mood and emotions. These effects are seen within all age groups and are independent of socio-economic or health status[63].

Physical activity can also improve self-esteem[64] and can result in positive changes in certain aspects of physical self-perception, such as body image or self-worth. The effect is stronger for those with initially low self-esteem such as mental health patients and those with mild depression. Active individuals also report fewer symptoms of anxiety or emotional distress and improved sleep patterns.

Inactive people are more likely to develop clinically defined depression[65]. Physical activity is effective in reducing clinical symptoms in those diagnosed with severe, moderate or mild depression[66] and has been shown to be equally effective as traditional treatments such as psychotherapy[67]. Those who maintain physical activity for at least six months report less use of medication and are more likely to recover than those who rely solely on medication. There is also strong evidence that physical activity has a positive effect on anxiety with the most notable effects among those who maintain physical activity programmes over several months[68].

Building and maintaining healthy bones, muscles and joints

Physical activity helps to build and maintain healthy bones, muscles and joints and hence preserve independent function. Physical activity has particularly positive effects on three main conditions: osteoporosis, osteoarthritis and lower back pain.

Physical activity has a positive impact on osteoporosis, a bone disorder defined in terms of abnormally low bone mineral density. This condition increases the risk of fracture and often causes pain, disability and deformity. Physical activity, including a measure of impact activities such as running, jumping and skipping (but not cycling), can increase bone mineral density in adolescents, maintain it in young adults and slow its decline in old age[69]. Physical activity can also reduce risk factors for osteoporotic fracture such as low body weight. It is particularly important that young people build up their bone mineral density and maintain physical activity throughout adult life. This is the only cheap, safe and readily accessible way to improve bone strength and reduce the likelihood of suffering a fall or fracture[70].

Although physical activity may help prevent osteoarthritis, currently there is no direct evidence linking the two. Among people with osteoarthritis, walking does have some beneficial effects on disability, pain and patients' overall outcome assessment.

Exercise training is effective in preventing lower back pain. General aerobic-type exercise programmes can help to prevent a recurrence of lower back pain. This type of exercise can be as effective as physiotherapy or use of training machines and is three to four times less expensive[71]. In adolescents high physical fitness levels and especially muscle endurance in the back muscles is associated with lower risk of back pain[72].

Benefits for older people

Physical activity reduces the risk of disease and other conditions which affect the ability of older people to live independently. They experience a reduced risk of falls due to improved body strength, balance and co-ordination. Flexibility and reaction time have also been identified as factors that can be greatly improved by training to produce a reduction in the risk of falls.

Physical activity is also a significant contributor to reducing musculoskeletal pain among older adults[73].

Benefits for children and young people

Regular physical activity is extremely important for young people for three main reasons:

- *to optimise physical fitness, general health and well-being, growth and development*
- *to develop an active lifestyle that can be maintained throughout adult life*
- *to reduce the risk of chronic disease of adulthood*[74].

Generally the prevalence of chronic disease, such as cardiovascular disease, is low in young people. However there is an association between inactivity and a raised risk of chronic disease. A recent study found that cardiovascular risk factors in young people, including high blood pressure and poor cholesterol, was tripled among those who were inactive compared to those who were very active[75].

Obesity is also a significant concern. Levels of childhood obesity have increased significantly in recent years and risk factors such as obesity can track into adulthood[76].

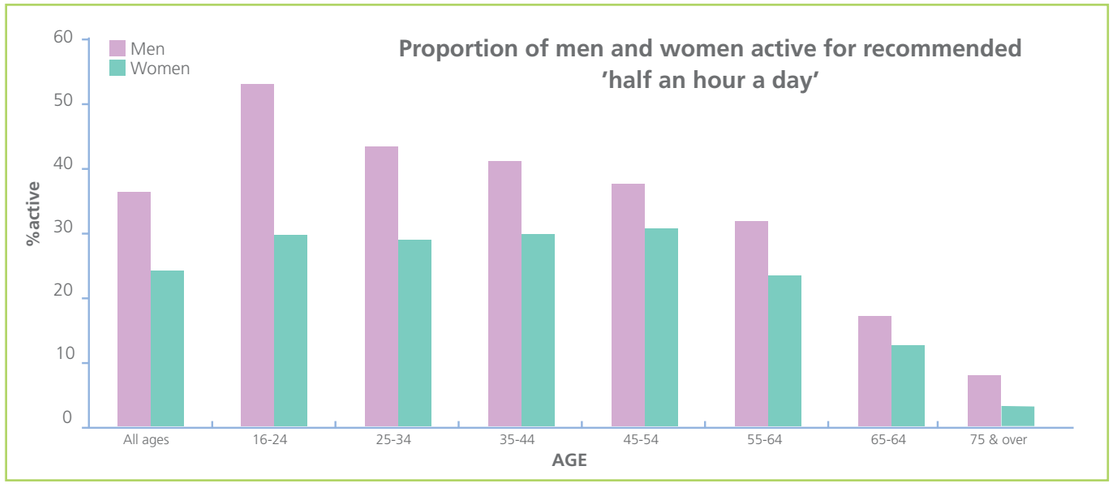


Figure 2. Proportion of men and women active for the recommended half an hour a day. *Source: Health Survey for England 2003*[76]

The importance of physical inactivity compared to other 'unhealthy' behaviours

The evidence presented above shows how many aspects of health can be improved through regular physical activity of at least a moderate intensity. In order to demonstrate how important it is for public health in the UK, it is also necessary to assess physical inactivity compared to other threats to health, along with an estimation of the numbers of people affected.

The risk of inactivity

Physical inactivity carries a 'relative risk' of around two for coronary heart disease. This means that an inactive and unfit individual will have roughly two times the risk of coronary heart disease when compared to someone active and fit. This level of 'relative risk' is similar to those for other factors such as smoking or high blood cholesterol.

From the public health perspective however, the most important issue is the degree of 'population attributable risk'. This provides an estimate of the true public health burden of any threat to health, by multiplying the relative risk by its prevalence within the population. So a potentially serious and debilitating disease would have a low population attributable risk if it only affected a small minority of people. Conversely a disease or condition can become extremely important if it threatens the health of a large number of people.

This is the case with physical inactivity: a large proportion of the population can be classed as insufficiently active. Physical activity tends to decline dramatically with age – markedly so after the age of 54 – and men are more active than women. For example, the Health Survey for England[76] found that only 37% of men and 24% of women undertake recommended amounts of activity. In the oldest age group, just over seven out of 10 men and eight out of 10 women are inactive (see figure 2).

As a result of these low levels of participation in regular physical activity, the population attributable risk of inactivity is high. The National Heart Forum[77] has estimated that 37% of CHD can be attributable to physical inactivity – second to elevated blood cholesterol in its importance, and far higher than smoking. They estimate that 9% of all CHD could be avoided if people became just moderately active. As Table 2 (right) shows, this puts the need for action on physical activity second only to reducing high levels of cholesterol.

Risk factor	Most likely change	% reduction in CHD
Blood cholesterol	All with levels < 6.5 mmol/l	11.0
Physical inactivity	All light and sedentary become moderate	10.0
Blood pressure	50% with levels < 140/90 mm Hg	6.0
Smoking	Prevalence of 24%	0.5
Obesity	6% men, 8% women with BMI >30	3.0
Total		**30.5**

Table 2. Proportion of all CHD that could be avoided if levels of five different risk factors were reduced, UK. *Source: National Heart Forum, 2002*[77]

Costs to society of an inactive lifestyle

The high prevalence of morbidity and mortality related to physical inactivity also carries great financial costs to society. The National Audit Office produced the first authoritative estimates of the costs and consequences of obesity in England. They estimated that obesity accounted for 18 million days of sick leave and 30,000 premature deaths in 1998. On average, each person whose death could be attributed to obesity lost nine years of life. Treating obesity costs the NHS at least £½ billion a year, with the wider costs to the economy in lower productivity and lost output amounting to a further £2 billion each year[25].

Costs have also been calculated for other conditions that are related to physical inactivity. In 2000 CHD was costing the UK economy about £10 billion per annum in days lost due to death, illness and informal care for people with the disease[78].

In the US, the direct health care costs associated with inactivity have been estimated at between US $24.3 billion and US $37.2 billion[79]. This is between 2.4% and 3.7% of total health care costs. When obesity costs are included, this rises to a minimum of 9.4% of all direct costs. It has been found that medical costs were on average $330 lower per year for active persons than their inactive counterparts. Thus the costs to society of inactive lifestyles are clearly significant, not only in terms of the pain and suffering caused by premature death and disability, but also in financial terms – especially costs to the health service.

Trends in activity

In the last 20 to 50 years there has been a downward trend in physical activity in the UK, attributable, it appears, to a decline in the role of manual occupations, a corresponding increase in desk-bound and other sedentary jobs, and changing patterns of participation in sport and leisure activities. Data to support this are rare however, as few longitudinal surveys have been carried out.

The Health Survey for England found that between 1994 and 1998, there was a 5% increase in the proportion of inactive men and a 6% increase in the proportion of inactive women. The proportion of men meeting the current guidelines on physical activity remained unchanged, with a 3% increase among women. Among men aged 16-24 years, however, the proportion active at recommended levels increased by 8% between 1994 and 1998[80].

Data from the General Household Survey[81] suggest a 20% increase in the number of men and a 17% increase in the number of women reporting any walking occasions between 1987 and 1996.

The proportion of men reporting any cycling increased by 50% but remained relatively unchanged for women. Even larger increases are reported year on year by Sustrans which monitors usage on sections of the National Cycle Network (NCN). They report that cycling trips on the Network have grown year on year since 1995, the year in which the NCN received Millennium Commission funding. In 2004 there were 100.2 million cycle trips, an 11.1% increase since 2003 including increased usage due to new routes[82].

However, it is notable that travel surveys find a contrasting picture. The National Travel Survey suggests that both walking and cycling declined between 1975/76 and 2003. Total miles travelled per person per year on foot reduced by 24% (from an average of 255 miles per person per year, to 196 miles). Miles travelled by bicycle reduced by 29%, from 51 to 36 miles[83] over the same period.

It therefore appears from the limited data available that while occasions of infrequent long walks and cycling for pleasure have increased in recent years, walking and cycling for transport purposes have decreased.

Young people are also walking and cycling less, particularly to school. Data on school travel show that the proportion of 5- to 10-year-olds being driven to school has increased from 22% in 1985/6 to 41% in 2004, with corresponding decreases in the proportions walking and cycling[84]. Yet the school journey offers an ideal opportunity for regular physical activity: walking to and from school for a week can use more calories than two hours of physical education[85].

The decline in active travel to school masks a more fundamental issue – that for many young people the opportunities to be physically active as part of daily life are becoming increasingly restricted. Parental concerns over safety mean that many young people are not being given the freedom to explore their surroundings on foot or by bike, severely constraining their mobility and freedom[86 87].

Coupled with this, pressures on the school curriculum have led to a squeeze on the time put aside for physical education and sport. The result is an overall low level of activity among young people. A Department of Health Survey found that around four out of 10 young males (aged 4-18) and six out of 10 young females are not active for the hour a day recommended for young people[88].

How much activity is enough to benefit health

During the mid 1990s, an international consensus was established on the value of regular moderate intensity physical activity. The World Health Organization (WHO) was among many international and national agencies that highlighted the importance of moderate activity for health, encouraging at least 30 minutes of physical activity daily. These 30 minutes can be built up over a day, so that two or three bouts of 10 to 15 minutes each provide important health benefits[89]. For young people (aged 2-16) the aim is to be active for an hour a day.

Cycling is ideally placed to contribute to overall activity levels, as it is one of the few activities that can be carried out as part of daily life, without the need for separate time put aside for exercise. A cycle ride of fifteen minutes (at least two miles for most cyclists) to work, to the shops or to a friend's house and back would meet the daily recommendation for adults. The following section will describe the evidence for the health benefits specifically related to cycling.

Recommended amounts and types of physical activity

The Chief Medical Officer's report[11] sets out detailed recommendations for the level and type of physical activity for health benefits:

Recommendations for active living throughout the life course

- *Children and young people should achieve at least 60 minutes of 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.*
- *Adults should achieve at least 30 minutes a day of moderate intensity physical activity on five or more days of the week.*
- *Recommended levels can be achieved by doing all the daily activity in one session, or through several shorter bouts of activity of 10 minutes or more. Activity can be via lifestyle (performed as part of everyday life, such as climbing stairs or brisk walking), structured exercise or sport, or a combination of these.*
- *There are specific recommendations for adults regarding 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.*

It is important to note that these recommendations are by their nature very general. People with specific health needs should discuss appropriate levels of activity with qualified health or fitness professionals.

The Chief Medical Officer's report also described how different age groups can achieve the recommended levels:

Person: YOUNG CHILD
Activities: 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.

Person: TEENAGER
Activities: Daily walk (or cycle) to and from school.
- 3-4 organised or informal midweek sports or activities.
- *Weekend:* walks, biking, swimming, sports activities.

Person: STUDENT
Activities: 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.

Person: ADULT – EMPLOYED
Activities: 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.

Person: ADULT – HOUSEWORKER
Activities: 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.

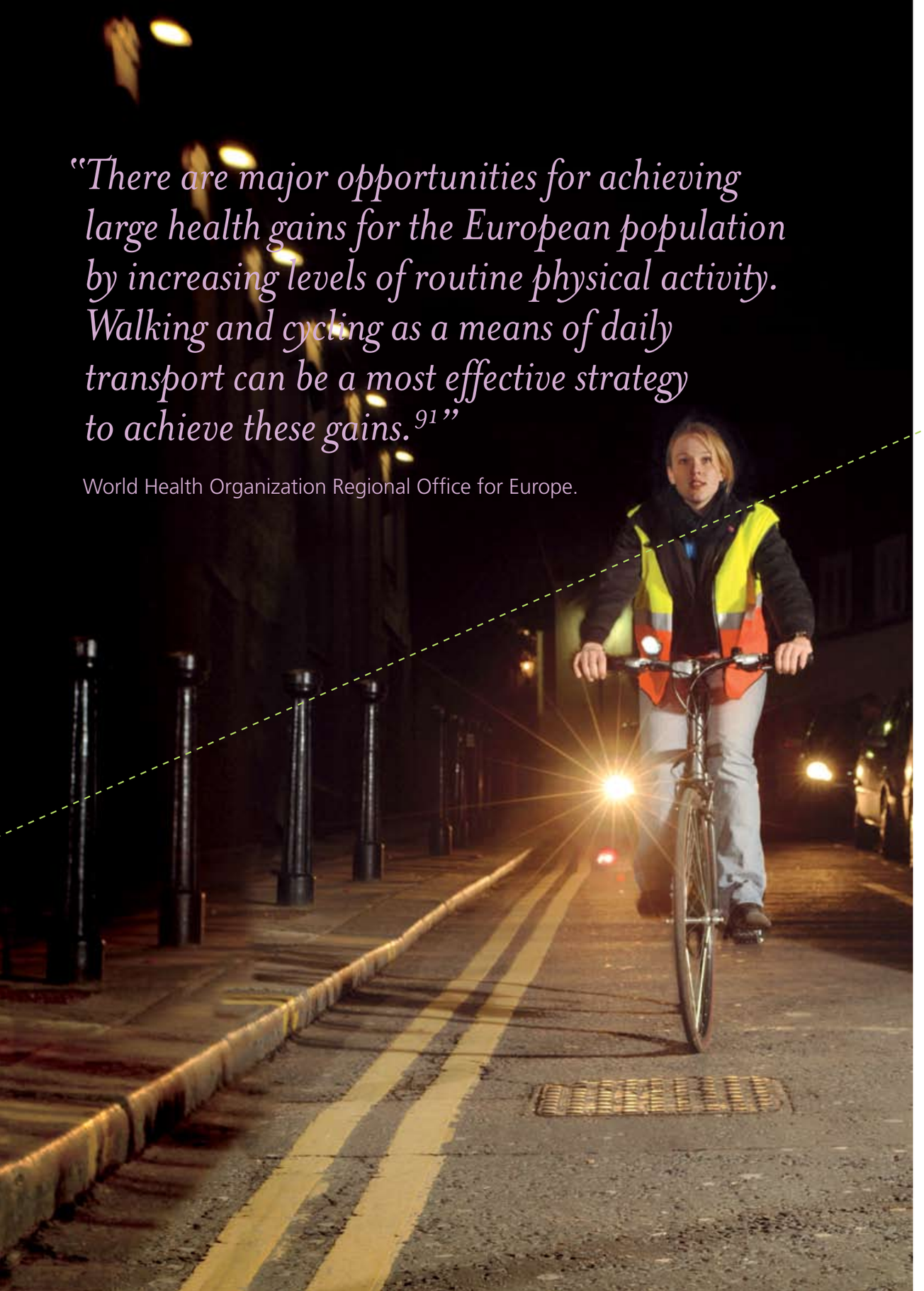
Person: ADULT – UNEMPLOYED
Activities: Daily walks, gardening, DIY.
- Taking all small opportunities to be active: using stairs, doing manual tasks.
- *Weekend:* longer walks, biking, swimming, or sports activities. Occasional sport, gym, swimming sessions.

Person: RETIRED PERSON
Activities: Daily walking, cycling, DIY or gardening.
- Taking all small opportunities to be active: using stairs, doing manual tasks.
- *Weekend:* longer walks, biking, swimming.

Chief Medical Officer's report[11] using data from the UK Time Use Survey, 2003[90]

"There are major opportunities for achieving large health gains for the European population by increasing levels of routine physical activity. Walking and cycling as a means of daily transport can be a most effective strategy to achieve these gains.[91]"

World Health Organization Regional Office for Europe.



3 EVIDENCE FOR THE SPECIFIC HEALTH EFFECTS OF CYCLING

The previous section outlined the strong evidence that exists for the role of physical activity of at least moderate intensity in promoting health and preventing disease. This chapter will look more specifically at cycling, and review the evidence for cycling as a form of moderate intensity physical activity. It will also look into the specific qualities of cycling that can help improve health.

Cycling uses the large skeletal muscles of the body in a rhythmic pattern, with periods of active work usually alternating with rest periods. Longer periods of rest occur in 'normal' urban cycling, dictated by factors such as traffic lights, coasting downhill, or slowing for other road users. The rest periods allow recovery from high levels of activity when in motion and so can facilitate a large amount of energy expenditure during the active phase.

At the same time, the efficiency with which the bicycle transfers human energy to motion allows swift progress relative to energy expenditure. This is in contrast to running where the impact felt with each step can mean that high levels of energy expenditure are difficult to maintain. On a bike, almost 70% of the body weight is distributed to the saddle, handlebars and pedals and so the forces that act as a result of body weight during running or walking are significantly reduced[92].

The energy expenditure by a cyclist depends on a range of factors including speed, fitness, hills, and road and wind conditions. 'Typical' values are shown in Figure 3[93].

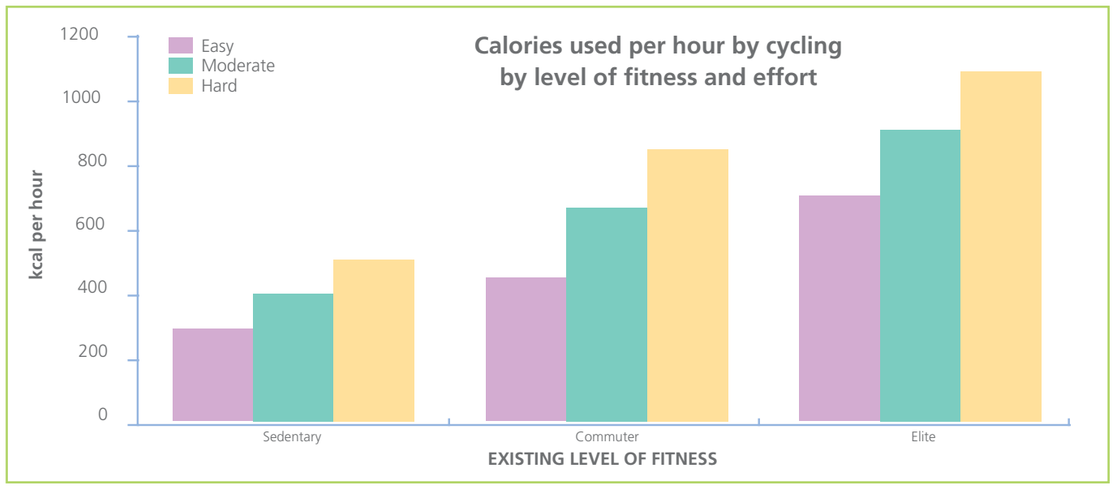


Figure 3. Calories used per hour by cycling by level of fitness and effort.
Source: Joe Beer. Cycle. June 2006[93]

In the laboratory, energy expenditure is relatively simple to measure using a cycle ergometer. 'Normal' cycling, which requires the individual to breathe more heavily but without feeling out of breath, is generally considered to be appropriate for health gain without undue risk. Energy use during normal cycling, such as commuter cycling, is likely to represent around 60% VO2max (which refers to maximum oxygen uptake, and is the standard measure of aerobic fitness).

Such levels of activity are sufficient to produce measurable improvements in fitness over a relatively short period of time[94]. These factors make it a highly suitable activity to provide aerobic exercise and so improve physical fitness[95].

What type of evidence?

There are many different types of research evidence to back up the assertion that cycling has an impact on health, from long term 'epidemiological' studies to experimental designs, and these are outlined below.

Epidemiological studies of cycling and health

Studies which follow cohorts of subjects over time and compare the relationships between different variables provide strong evidence for associations between regular health and cycling.

The most substantive study in this category was carried out by researchers from the Copenhagen Center for Prospective Population Studies. The study involved 13,375 women and 17,265 men aged 20-93 who were randomly selected from a population of 90,000 living in central Copenhagen. Of this cohort 14,976 cycled regularly and 6,954 cycled to work, for about three hours per week on average. The study found that cycling has a strong protective function.

Using self-reported assessments of health, blood pressure, cholesterol, BMI, and risk factors such as smoking, the researchers concluded that:

> *"Even after adjustment for other risk factors, including leisure time physical activity, those who did not cycle to work experienced a 39% higher mortality rate than those who did."* [96]

This is a very important finding as it provides direct evidence that regular cyclists are likely to have decreased mortality compared to non-cyclists, irrespective of the other physical activity they do.

Later analysis has shown higher mortality among those who have reduced their level of cycling compared to those who continue to cycle[97].

Randomised trials of the effects of cycling on fitness, health and mortality.

Randomised controlled trials (where groups of people are randomised into 'intervention' and 'control' groups and the results compared) provide the most reliable evidence for the effect of an intervention. In recent years there have been a number of experiments using this methodology to test the effects of physical activity – including cycling – on health.

Dutch research has demonstrated that cycling as part of normal daily activity can yield much the same improvements in physical performance as specific training programmes. The higher the total distance cycled during a six-month trial period of activity among men and women (who had not participated in regular intensive exercise over the previous six months), the higher the gain in maximal external power and maximal oxygen uptake[98].

For those with a low initial fitness level, a single trip distance of three kilometres per day each way was found to be enough to improve physical performance if repeated at least three times a week. This matches other research which has found that men with low cardiorespiratory fitness, who became fitter, had a lower risk of cardiovascular disease mortality than men who remained at a low level of fitness[99].

Research from Finland provides some of the strongest evidence for the health benefits of cycling, particularly two studies which suggest that journeys to and from work by bicycle provide exercise of sufficient intensity and duration to improve fitness and health, and that travel by bicycle provides greater increases in measured fitness than does walking[100 101].

This intervention involved volunteers at a workplace who had previously commuted by car or by bus and who swapped to cycling for 30 minutes one way and at their own pace, during their journey. The researchers recorded several physiological changes in the cyclists, including improved aerobic fitness; decreased cardiovascular load in submaximal standard work; increased use of fats as an energy source in physical activity and an increase in HDL cholesterol. These changes were observed in healthy young- to middle-aged adults of low to moderate physical fitness.

The researchers concluded that cycling to work has significant potential to maintain or improve health-related physical fitness of previously relatively sedentary healthy adults[102].

Other evidence for the health benefits of cycling

A UK study of non-exercisers who agreed to take up cycling on at least four days a week found that the greatest benefits were near the beginning of the intervention, and the more the volunteers cycled, the fitter they became. Body fat was also significantly reduced among most of those of the volunteers who were overweight or obese at the outset (59% of volunteers).

The extent of the fat loss, typically two to three kilograms of fat mass over the period of the trial, meant that they should have achieved a change in energy balance, making it easier for them to control their weight while they continued to cycle[103].

Leg strength increased overall, showing a more even progression over the entire trial: about 8% by the end of the first six to eight weeks of cycling, and 16% by the final assessment. Those cycling more than 19 miles saw an even greater improvement, 26%, compared with 4.5% for those below this distance.

The study also reported attitudinal changes which included perceptions of well-being, self-confidence and tolerance to stress, which all rose. In addition, the reporting of tiredness, difficulties with sleep and a range of medical symptoms declined[104].

In a 1980s study of male factory workers, cycling had the greatest effect on fitness of all the physical activity variables studied. A fitness advantage of about 12% for the cyclists compared with those who did not cycle was reported irrespective of age. Occasional and regular cyclists enjoyed a level of fitness equivalent to being five and ten years younger than their non-cycling counterparts[105].

In a nine-year Whitehall study of 9,000 civil servants between the ages of 45-64, those who cycled for at least an hour a week in the round trip to work or at least 25 miles in the previous week experienced less than half the non-fatal and fatal coronary heart disease than those who took no physical activity during the course of the study[106].

Despite the fact that only 7% of the male employees cycled, meaning the overall numbers were too small for proper analysis, the authors suggested the results did indicate that any habitual cycling in the middle-aged men under study usually entailed enough effort for benefit. Similar key findings – increased protection as energy expended increases – have been made elsewhere[107].

In a cross-sectional study from the US, where cycling was one of a range of physical activities included by the researchers, the results suggested that cycling has a protective function. It recorded that higher levels of physical activity were associated with lower risk for coronary heart disease compared to those who participated in low levels of physical activity.

The Framingham Offspring study did not examine cycling's individual contribution, but cycling for work and leisure – in terms of kilocalories expended – was reported as the ninth most significant activity in men, and seventh among women, out of a total of fourteen[108].

In a post-mortem survey of cyclists and non-cyclists, large myocardial scars and blockages were found among the non-cyclists, who also had more aortic atheroma than the cyclists. The mean age of cyclists with coronary heart disease was also greater than that of the control sample, indicating that cycling may delay the onset of coronary heart disease. The findings are in keeping with the concept that regular cycling provides some protection from the development of coronary heart disease[109].

Cycling and type 2 diabetes

There is little direct research into the links between cycling and diabetes, its prevention or treatment. However, in one study undertaken by 2682 men, where cycling was among the activities involved, the authors concluded that light effort in cycling conformed to the intensity threshold required[110] . The beneficial effects of moderate intensity physical activity appears to be even more important in those sub-groups of the population who are at an elevated risk of type 2 diabetes due to being overweight, having an elevated blood pressure, and a positive parental history of the disease.

There is also good evidence from training studies in which people train one leg and leave the other at rest. In these studies glucose uptake was more than doubled in the trained leg compared to the other[111].

Cycling and cancer

A recent study into the association between physical activity and risk of breast cancer[112] found there was a 'dose-response' relationship, meaning that as the amount of cycling increased, the risk of breast cancer decreased. Women reporting the highest levels of cycling reduced their risk of breast cancer by 34%.

There is also strong evidence for the protective value of physical activity against colon cancer. A study in Shanghai found that regular and frequent physical activity – cycling while commuting – over a long period of time, protects from colon cancer and significantly modifies the BMI-associated risk[113].

Cycling and weight control

A minimum of 60 minutes of moderate intensity physical activity per day has been suggested to help control weight, reducing the threat posed to health through excessive weight gain[114].

Cycling burns at least five kilocalories per minute (depending on a number of factors, notably the body weight of the cyclist), offering the potential to expend considerable amounts of energy over the course of a journey. More importantly it enables people to integrate activity into their daily routine rather than having to find additional time for exercise, helping to balance energy intake and energy expenditure and avoid weight gain.

Cycling is also particularly well suited to overweight or obese people, as approximately 70% of body weight is borne by the saddle, thus providing the required cardiovascular exercise without putting excess strain on the passive musculoskeletal system. For example, during jogging, two to three times the body weight is borne by the hip joint, which would represent a massive overload for these patients[115].

Cycling and psychological well-being

Although there is little direct evidence of the specific benefits of cycling on psychological well-being, it is thought that cycling may have specific benefits due to the uniform, cyclic form of movement. This may help lead to psycho-physical regulation, and reductions of the effects of stress[115].

Summary

There is strong evidence that cycling has the potential to make a significant contribution to improving public health. While a number of high quality studies show a positive effect on longevity, health and wellbeing, most of the evidence is indirect and based on the findings that moderate intensity physical activity of any kind produces health benefits. But cycling is one of the most appropriate types of physical activity for the majority of the population as it can be easily incorporated into daily life, can be carried out at different intensities, and has few side-effects.

There is strong evidence that cycling has the potential to make a significant contribution to improving public health

The benefits outlined above need to be weighed against the risks. This section sets out the evidence for any direct risk of injury as well as indirect risks through road traffic crashes.

4 RISKS OF CYCLING

Risk of injury from cycling

Although injuries sustained during cycling do occur, these are mostly associated with athletes and endurance cyclists. Knee injuries appear to be a particular problem where the knee joint has been under high stress in cycling.

It can occur among new recreational riders but this is usually because they make errors using their bike by setting the saddle too low and the gears too high. These mistakes cause excessive pressure on the patellofemoral joint. Getting a better fitting bicycle and saddle, adjusting the saddle properly, and using lower gears helps reduce such problems[116]. Expert advice from bicycle vendors may help prevent this occurring in the first place.

Another common injury cited in the literature is ulnar nerve lesions among competitive cyclists (the avoidance of which requires frequent changes in hand position). Handlebar problems divide readily into compression syndromes and overuse injuries. These are largely found among endurance and sports cyclists[117] involving extensive cycling and can result in numbness, weakness, and loss of co-ordination in both hands[118].

There is little literature on this issue relating to non-sport and competitive cycling, although some examples are cited by Richmond (1994)[119] who notes that padded cyclists gloves and handlebar padding are widely recommended to alleviate and prevent ulnar compression.

Up to 60% of cyclists studied reported some form of back pain, although again these were athletic and endurance cyclists[117].

Saddle sores, such as chafing, perineal folliculitis and furuncles, have been reported to be a problem among cyclists[120]. Research in the Netherlands found that 20% of all Dutch cyclists suffered to varying degrees, and saddle sores were the most common complaint.

Among men, the second most common complaint was genital anaesthesia (numb penis). This is the result of men sitting in a more forward-leaning posture, with their weight pressing down on the front of the saddle. For women the second most common problem was irritation of the genitals, often leading to urethritis and painful urination and vulvitis.

The researchers concluded that poor saddle design (bicycle seats need to be designed to relieve perineal pressure) or poor adjustment to saddles and handlebars, were major contributors to saddle-related problems.[121]

Genital anaesthesia, where it has been identified in studies, is generally found only among those spending at least three hours per day cycling, indicative of occupational cyclists such as dispatch riders and police bicycling patrol officers[122 123].

Other research suggests that injuries sustained while riding tend to be minor and not require medical attention[124]. It might generally be concluded that injuries sustained during riding among regular commuter cyclists are likely to be minimal and where these occur, riding position and correct adjustment of the machine can ameliorate, if not stop, such problems[125].

Indirect injury risks arising from cycling

Historically the main focus of concern over cycling (and other forms of road transport) among health professionals has been reported road traffic casualties[126]. This concern is shared by existing and potential cyclists: the real and perceived physical danger posed by motor traffic is one of the main barriers to engaging in cycling[127 128 129].

Data from the DfT show that in 2004 there were 16,648 reported casualties among pedal cyclists, including 2,174 cyclists who were seriously injured, and 134 who were killed, as shown in Table 3. Overall this represents a decline in numbers killed or seriously injured, from the 1994-98 average of 38%[130].

This needs to be set against the increase in travel overall – between 1991 and 2004 total distance travelled increased from an average of 6,475 miles to 6,762 miles per person – but with a slight decline in miles cycled.

	1991	2004
Killed	186	134
Seriously injured	3,546	2,174
Slightly injured	20,653	14,340
All cycle casualties	24,385	16,648

Table 3. Cycle casualties in GB: Comparison of baseline average and 2001. *Source: DfT*

It has been noted, however, that there are serious concerns about reported casualties because of the high level of under-reporting and misclassification of injuries. Spence (2003) has reported the following reservations:

> *"The problem with casualty reduction is that by using only one set of data the strategy is in reality very unscientific, not least because the data set used is extremely flawed. Reported accidents are simply that, the accidents that are reported to the police. A succession of studies have shown that, for accidents involving injuries to pedestrians and cyclists, less than half are reported."*

Spence goes on to say that even when accidents are reported to the Police, they are often incorrectly recorded, with the main mistake in recording the severity of injury. A TRL report, "Comparison of Hospital and Police Casualty Data: A National Study" (Transport Research Laboratory 1996) suggests that if official statistics were adjusted to take account of this misreporting, the number of serious casualties would be increased by 52%. He adds:

> *"The same report concluded that the level of incorrect recording had increased significantly over the previous twenty years. Therefore in using reported casualties as our primary source of information we are viewing the problem through a very dim glass indeed."* [131]

In addition, monitoring of cycle activity itself over the past decade has been far less rigorous than for motorised modes. As a result, casualty figures for cyclists need to be treated with caution.

To offset the effect of increased travel, reported casualties are often expressed as a rate per billion passenger kilometres (see Table 4).

This shows that while cyclists do bear a higher risk than car drivers per billion kilometres travelled, they bear a lower risk than pedestrians. This holds true for all active age groups except boys aged 11-14 (who are more at risk)[132].

It is also important to note that the actual risk remains small – amounting to one cyclist death per 33 million kilometres of cycling. It would take the average cyclist 21,000 years to cycle this distance, or, put another way, 21,000 average cyclists would have to cycle for a year before one of them was killed.

These data also present a skewed picture as the types of roads used by cyclists and cars are different, in terms of exposure time. The analysis includes roads such as motorways, which are not used by cyclists. Also, the data include casualties among people aged under 17 who cannot drive cars but are often cyclists.

The Dutch Ministry of Transport attempted to remove this bias, noting that it is more accurate to examine only the risk for distances that can be cycled and not consider the kilometres travelled on motorways, on average the "much safer" kilometres. When they adjusted the data to exclude motorway journeys, they found that the chance of being admitted to hospital following a crash is virtually equal for both modes of transport, but in terms of fatalities per billion kilometres travelled there are nearly twice as many motorists killed as cyclists.

Great Britain	Rates per billion kilometres travelled		
	1981	1991	2000
Cycle	57	47	30
Foot	77	75	48
Car	6	4	3

Table 4. Death rates by mode 1991-2000

In addition, they considered the fact that in the Netherlands, 18 to 34-year-olds drive only a third of the kilometres typically travelled by car.[133] In this analysis, cycling was found to be much safer for individuals aged 18-24 than driving a car. By considering the chance of a fatal accident, persons aged 25-34 could travel by bicycle just as safely as by car for short distances.

It is also important to realise that death rates or casualty rates are extremely blunt indicators as they do not show how people perceive the risk that they take. This can be more important than the 'real' risk, especially if fear of motor traffic stops people from being as mobile as they would like to be.

Age group	Motorists (drivers)	Cyclists
12-14	–	16.8
15-17	–	18.2
18-24	33.5	7.7
25-29	17.0	8.2
30-39	9.7	7.0
40-49	9.7	9.2
50-59	5.9	17.2
60-64	10.4	32.1
64+	39.9	79.1
Total	**20.8**	**21.0**

Table 5. Risk of accident per million kilometres ([134]) *

* excluding i) motorway travel as the risk is ten times less than the rest of the road network and there is no comparable factor for cyclists and ii) adjusting for the hazard that motorists represent for pedestrians and cyclists

Risk to other road users

An important note with regard to the balance of risks and benefits from cycling is that cycling is an extremely safe activity in terms of the risk that cyclists present to other road users. Only around three to seven third parties are killed per year in fatal bicycle crashes, compared to 1,600 third parties killed in fatal car crashes. This is an important issue for public health professionals, who should be considering the impact of transport policies on overall public health.

Safety in numbers

There is now increasing evidence for the phenomenon of 'safety in numbers'. Studies suggest that policies leading to increases in the number of people walking or cycling appear to be effective in improving the safety of people using these modes[135] . Figure 4 shows that there is a strong inverse relationship between the level of walking and cycling in European cities, and the incidence of fatalities.

The Jacobsen study concluded that:

> *"A motorist is less likely to collide with a person walking and bicycling if more people walk or bicycle. Policies that increase the numbers of people walking and bicycling appear to be an effective route to improving their safety…"* [138]

Balance of risks and benefits

The level of risk also needs to be related to the potential benefits in terms of improved health. The potential loss of 'life years' (the life expectancy at age of death of all cyclists) in bicycle fatalities can be related to the potential gain of 'life years' through improved fitness – particularly as a result of a lowered rate of heart disease.

An important report was commissioned by the British Medical Association (BMA) as a result of concerns among medical practitioners about the levels of death and injury to cyclists, which had led to a debate and resolution at the BMA members' annual meeting in 1989 to undertake a study of the dangers of cycling.

The researcher who carried out the study, Mayer Hillman, persuaded the BMA to include the potential benefits of cycling within the research brief. He found that when the risks of injuries to cyclists are considered against the benefits to the individual's health from regular cycling, the evidence favours the promotion of cycling, albeit with considerable emphasis on improving safety:

> *"…existing evidence would suggest that, even in the current hostile traffic environment, the benefits gained from regular cycling are likely to outweigh the loss of life through cycling accidents for the current population of regular cyclists."* [136]

Following the publication of the BMA report, the author then published further evidence on the risk and benefits of regular cycling and concluded that the benefits outweigh the loss of life years in cycling fatalities by a factor of around twenty to one[137].

Furthermore, because it is known the risks can be considerably reduced, as seen in countries such as Denmark and the Netherlands, the potential for an overall benefit to public health from cycling is considerable. Cost-benefit analysis studies from Norway and the USA suggest that the benefits to health significantly outweigh any risks. A Norwegian study of pedestrian and cycling track networks in three cities reported that the net benefit/cost ratio for each was: 4.09 in Hokksund; 14.34 in Hamer; and 2.94 in Trondheim. The author concluded that:

> *"The investment in walking and cycle track networks in the three Norwegian cities appear to be highly beneficial to society."* [138]

An important point, longer term, is that a shift towards streets where a 'critical mass' of cyclists and pedestrians were allocated a more equitable portion of road space would lead to lower motor traffic speeds and volumes, and a reduction in the risks to cyclists per kilometre travelled.

Case study: Odense [139,140]

Odense is the third largest city in Denmark, with 200,000 inhabitants. In 1999 it was awarded the status of 'National Cycle City', by the Ministry of Transport and the National Road Directorate.

Following an investment of DKK 20 million (approx £1.8 million), the project team invested in 50 measures which included physical improvements, changes to regulations and information campaigns.

The evaluation concluded that the project had been able to achieve:

- 35 million new trips by bicycle (or 25,000 new cycling trips per day)
- A 20% increase in cycling, which now accounts for a share of 25% of urban trips
- More than half of the new trips being substitutes for trips that would have been undertaken by car
- A 20% reduction in road traffic injuries involving cyclists, in spite of the overall increase in cycling
- 500 years of lifetime added to the total lifetime of the citizens of Odense, corresponding to five months longer life for males
- A 20% mortality reduction among those aged 15-49
- A DKK 33 million saving (€4.5 million) resulting from the health gains achieved through the project.

Risk of cycling compared to risk from lack of physical activity

It is also important to consider the risk of death from cycling when contrasted with the high rates of death from CHD and other diseases associated with physical inactivity. In 2000, 125,000 people died from CHD in the UK[141]. It is estimated that physical inactivity accounts for 37% of all deaths from CHD[142], meaning that in the year 2000, over 45,000 deaths were due to lack of activity. An increase in regular cycling would be likely to reduce these rates far more than any increase in risk associated with cycling (see Figure 5).

Policies for safe cycling

This analysis brings up the important issue of transport policies to enhance cyclist safety (i.e. reduce risk). Low cycling levels, particularly in cities, are often correlated with transport policies that pay little attention to the safety of cyclists. Conversely, many cities that have been successful in increasing levels of cycling have also reported a corresponding decrease in cyclist casualties.

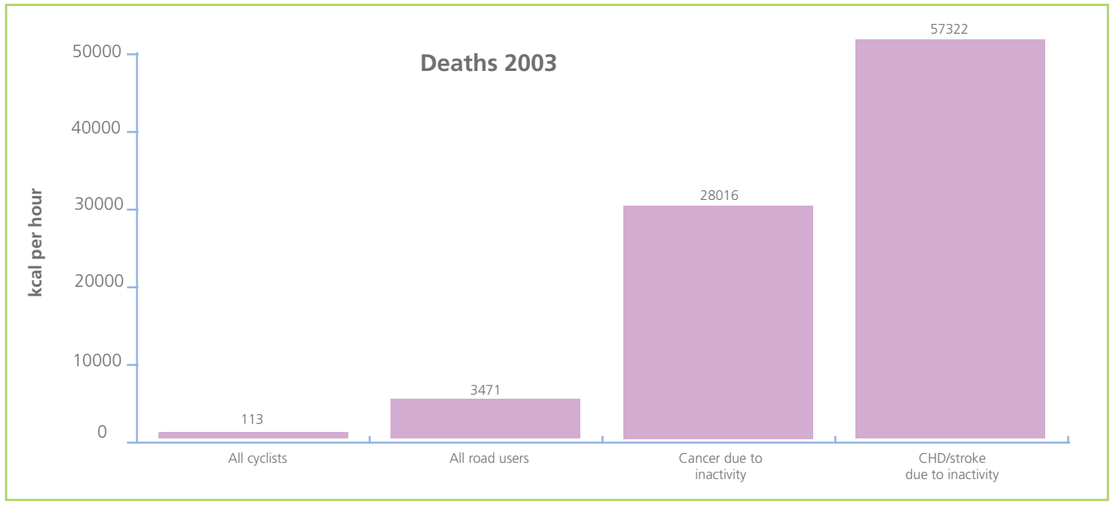


Figure 5. Deaths 2003

Case study: York[143]

In the 1980s, York City Council developed a transport strategy which placed vulnerable road users at the top of a road user hierarchy, and implemented traffic restraint measures across the city which, particularly addressed motor vehicle speeds. Over time, this has led to a reduction in road casualties well above the national average.
The priorities are set out below:

York City Council's Transport Priorities

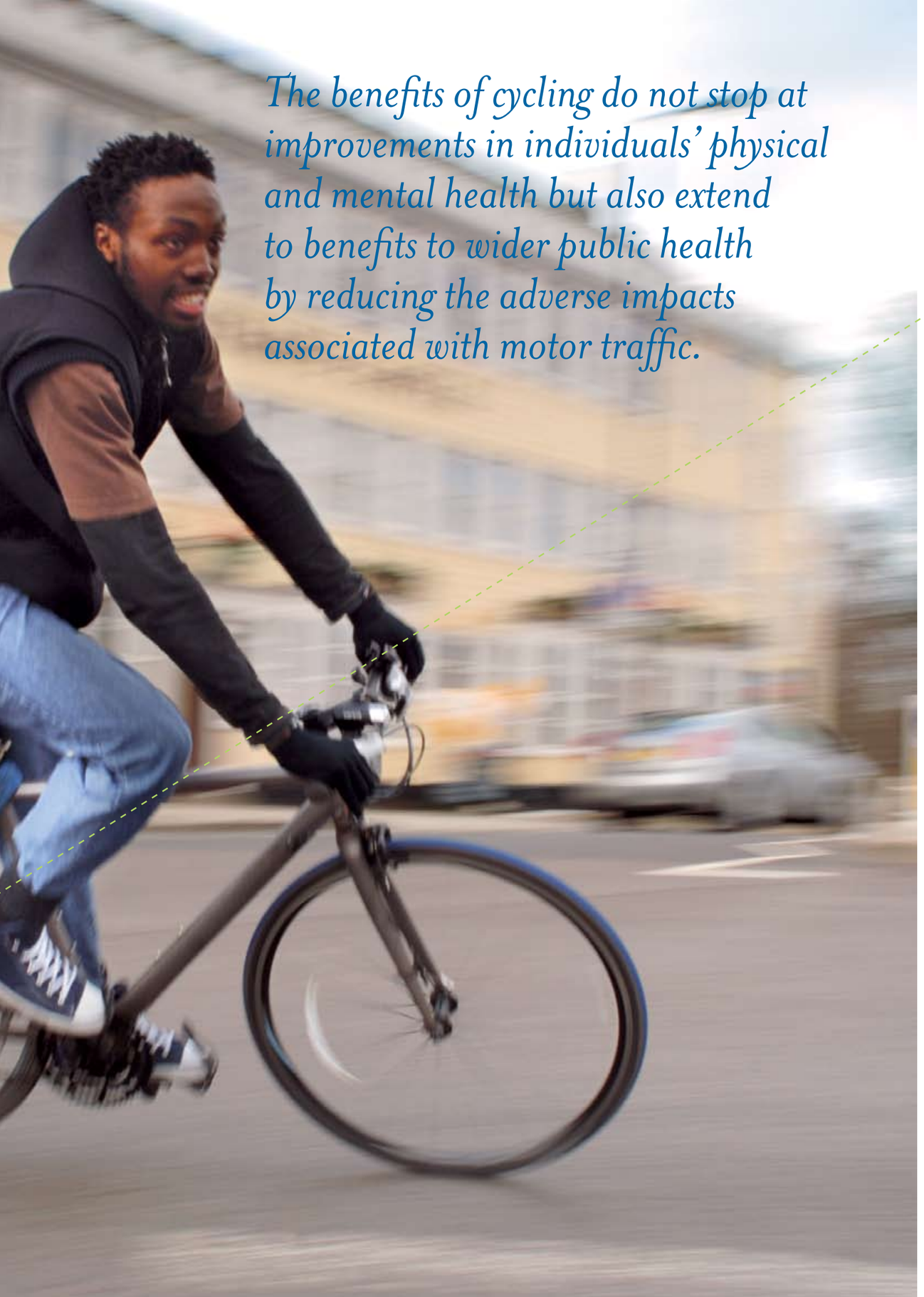
1. Pedestrians
2. People with disabilities
3. Cyclists
4. Public transport passengers
5. Commercial/business vehicles requiring access
6. Car-borne shoppers
7. Coach-borne shoppers
8. Car-borne long-stay commuters and visitors

The hierarchy reviews and challenges a widely held – if generally unconscious – bias towards car travellers in transport planning practice.

The 1991 Census reported that cycling and walking made up 30% of all journeys to work in York and they still comprised 29% in the 2001 Census. This relative stability for levels of walking and cycling in York should be considered in the light of declines in walking and cycling during this decade in most towns and cities across England.

Helmets

Finally, there has been much debate about the value of cycle helmets. Advocates on one hand wish to see mandatory helmet use[144] quoting studies that show they prevent serious injury to cyclists involved in a crash [145]. Other commentators argue that this might lead to a decrease in levels of cycling and a net loss to public health[146] and that road safety would be better improved through initiatives aimed at increasing the level of cycling and walking[138]. This issue is not reviewed here but there are a number of reference sources available[147].



The benefits of cycling do not stop at improvements in individuals' physical and mental health but also extend to benefits to wider public health by reducing the adverse impacts associated with motor traffic.

5 WIDER BENEFITS ATTRIBUTABLE TO CYCLING

Improved air quality

It has been conservatively estimated that up to 24,000 vulnerable people die prematurely each year and similar numbers are admitted to hospital because of exposure to air pollution from particulates, ozone, and sulphur dioxide, most of which is related to road traffic[148]. Air quality is often worse in more deprived areas[149] and affects vulnerable populations more, exacerbating the symptoms of people with asthma, for example.

Cycling is a pollution-free, environmentally sustainable mode of transport which makes negligible contributions to congestion. A modal shift from motoring to cycling would be good for air quality both at street and district level, and for the environment more generally.

Research published in 1991 suggested that a tenfold increase in cycling from car use could save up to three quarters of a million tonnes of carbon monoxide, 100,000 tonnes of nitrogen dioxide, and 16 million tonnes of carbon dioxide from being emitted into the atmosphere[150].

It is often assumed that cyclists (and pedestrians) are exposed to higher air pollution levels than motor vehicle occupants because they are physically unprotected, and because they may be breathing more deeply than passive car occupants. However, in slow moving traffic, typical of rush-hour traffic, car occupants can be exposed to higher pollutant levels[151]. A review of the literature has concluded that:

> *"Cars offer little or no protection against the pollutants generated by vehicle traffic. Road users can be exposed to significantly elevated levels of pollutants as they are, in effect, travelling in a 'tunnel' of pollution. Those road users travelling closest to the centre of this tunnel tend to experience higher concentrations of pollutants than those nearer to the roadside."* [152]

Car drivers also suffer up to two to three times greater exposure to pollution than pedestrians in slow moving traffic[153]. However, studies in London suggest that short-term peak exposures, such as those seen in the transport micro-environment (for example areas close to main road corridors) can have a different health impact according to mode users[154]. This study suggests that firstly taxi occupants, then bus users, followed by cyclists, are at greater exposure to pollutants than motorists. More research is required in order to better understand exposure of different road users under various traffic conditions.

Noise pollution

Motorised road transport is a major source of noise in the environment. Traffic noise is likely to contribute to sleep-loss, and stress-related problems such as raised blood pressure and minor psychiatric illnesses[155]. A modal transfer away from car use, together with lower speeds, would reduce road traffic noise pollution.

Danger

It has been observed that the greater the motor traffic volumes the lower the levels of non-traffic street activity[156]. This is not surprising since more motor vehicles means more noise and air pollution, and greater perceived risk for those on foot and travelling by bike, particularly for older people and families with young children[157]. Heavy traffic, in particular, can frighten and frustrate children[158].

In contrast, streets with relatively low speed limits are obviously safer for cyclists. A review of 250 20mph zones in England, Wales and Scotland found that crashes involving cyclists had fallen by 29%[159]. In addition, crashes at relatively low speeds (20mph) tend towards less severe injuries and few deaths in contrast to those occurring at speeds of 30mph and above. Figure 6 illustrates how an impact speed above 20 mph has a much greater likelihood of causing serious harm than at 20mph or above.

There is also the potential for improved safety for cyclists through 'critical mass'. Evidence suggests that as levels of cycling go up, the levels of casualties go down[138]. This may be because when there are so many cyclists on the road they can reasonably expect to be seen by motorists, who tend then to give them greater consideration. Also, when there are relatively high levels of cycling in a population, perhaps over 20%, then it is common for some motorists to also be cyclists.

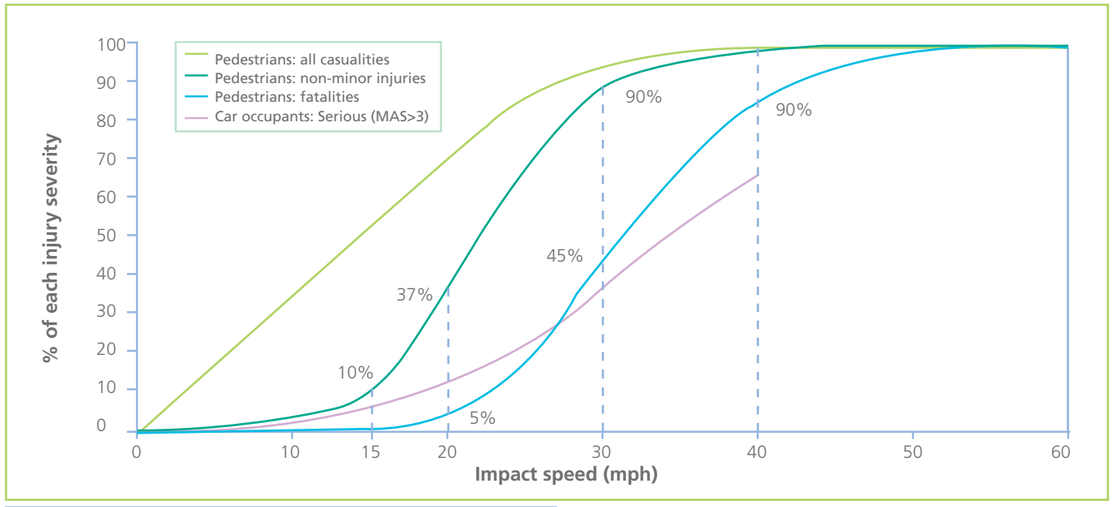


Figure 6. Impact speed and severity of pedestrian injury[174]

At present the case for a critical mass effect is largely intuitive, although lowered risk to each cyclist per unit of exposure, as in cities such as York, Groningen and Copenhagen, suggests that critical mass may have a positive influence in reducing danger to cyclists. Of course, in locations where cycling is commonplace, cycle-friendly infrastructure is also generally more usual.

In addition, there may also be more generic benefits if more people are able to cycle as they can perform a role of 'natural surveillance'. Compared to people in vehicles, cyclists (and pedestrians) are better able to spot anti-social behaviour, deter crime or stop to provide assistance in situations where help is requested.

Increased play and activity opportunities for children

While the Department of Health recommends that all young people should participate in physical activity of at least moderate intensity for one hour per day, research notes that 40% of boys and 60% of girls do not undertake this on most days of the week[160].

Some of the reduction in activity levels in recent years has come about because of an increasingly hostile traffic environment, which has contributed to a strong decline in child cycling[161].

In contrast, traffic environments that are supportive of cycling – which control vehicle speeds through cycle-friendly infrastructure such as traffic calming, and include road space reallocation – can include space for children's play. Research into children's play has concluded that:

> *"Children's need for safe access to a diverse outdoor environment on the front street and opportunities for extending their free range mobility along footpath networks and traffic calmed roads, needs to be incorporated in the estate design and management process."* [162]

Perhaps more importantly however, high traffic speeds diminishes the ability of young people to interact properly with their environment, learn about their surroundings and develop an appreciation of risk and adventure. Streets with speeding traffic do not make good playgrounds. As one BMJ correspondent stated: "The sad reality is that most streets are now linear car parks with a central race track." [163]

Social support and inclusion

High levels of motor traffic can increase the extent to which people are cut off from essential facilities and services, including shops, health facilities, parks and friends and family.

Ease of access to friends and social support is important as social support networks are known to protect health[164], with one study showing that a lack of social support can increase mortality from coronary heart disease by up to four times[165].

Where a cycle-friendly infrastructure makes cycling a viable option, this enhances opportunities for work, learning, health care, food shopping and other key activities and so contributes to social inclusion. As cycling is cheap, relative to car ownership, this also helps those on low incomes to maintain access to work (particularly if public transport is poor), and put money towards food and other critical household expenditure, thus contributing to a reduction in health inequalities.

A high-quality network of separated traffic-free cycle paths and off-road routes is needed to help entice would-be cyclists on to bicycles for local trips. Removing some carriageways from motor vehicle use could also help to reduce their speed, as speed is directly related to perceived and actual carriageway width. It is important to note that 20% of all car trips are under one mile and about 25% are under two miles in length,[166] so there is potential – based on distance – for a transfer of some of these car trips to cycling.

Benefits to health: a key motivator for cycling

The final argument for stressing the health benefits of cycling is that, for many people, improving health can be the key incentive that will encourage them to start or maintain cycling. Various research studies have identified that a significant proportion of car drivers would like to reduce the amount they drive[167] [168].

A survey by the DfT of motorists who had recently reduced some of their short car journeys, showed that 34% had done so to get more exercise compared to 8% who had done it to help the environment or the 2% who wanted to help reduce congestion[169]. Improving health appears to be a key reason why people may change their mode of transport. Cycling can offer a practical and realistic alternative to the car for short journeys, and is arguably an amenable mode of exercise.

Cycling to and from work is considered to be more acceptable and cost-effective than formal work-site exercise classes.[170] Other advantages to employers, reported in a UK survey[171] include improved employee morale, higher productivity and loyalty, and reduced costs associated with car parking provision. In addition, there is also evidence for reduced absenteeism among employees who are physically active on one or more days per week[172].

While perceptions of danger to cyclists remains a barrier to cycling, in a survey for the DfT, most respondents (both cyclists and non-cyclists), say they think cycling conditions have improved over the previous two years, the most common reason cited being the introduction of more cycle lanes. The report also highlights that people judge health improvements as the most important reason for encouraging them to take up or increase their cycling[173].

6 CONCLUSIONS

This report has described the strong evidence for the health benefits of regular cycling. As a healthy form of physical activity, cycling can help to reduce the risk of a range of health conditions, notably heart disease and cancer – the leading preventable causes of premature death. More people cycling, more often, would help to slow or reverse the obesity epidemic among adults and young people. And because cycling is something that can be done as part of daily travel routines, it has the potential to become a habitual form of exercise that can be done throughout life.

There are risks involved in cycling but these are outweighed by the health benefits by a factor of around twenty to one.

Cycling also has the potential to improve broader aspects of community health, by increasing road safety, reducing emissions, creating opportunities for children's play and enhancing social cohesion. Policies to encourage cycling have the potential to affect well-being by re-allocating space away from the car, and giving people a renewed ability to move about more freely in their communities, under their own steam.

Cycling will also have an increasingly important role to play in future transport strategies as the impact of climate change encourages people to look for more benign modes of transport in order to reduce their carbon footprint.

Evidence from this report should be used to help build partnerships between health and transport professionals and focus on positive actions to promote cycling. Local authority transport departments, which have much of the power in developing transport infrastructure, can create more and better facilities for cycling, and implement policies to reduce traffic speeds. Public health agencies can join them in a partnership that focuses on placing cycling at the heart of healthy transport policy, and recognising its potential to improve many aspects of public health.

Cycling will also have an increasingly important role to play in future transport

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