1 Introduction

Knowledge assumed
Principle of energy balance
Procedures for testing aerobic fitness, including prediction of maximal oxygen uptake

EARLY OBSERVATIONS

Physical activity and physical fitness have been linked with health and longevity since ancient times. The earliest records of organized exercise used for health promotion are found in China, around 2500 BC. However, it was the Greek physicians of the fifth and early fourth centuries BC who established a tradition of maintaining positive health through 'regimen' – the combination of correct eating and exercise. Hippocrates (*c.*460–370 BC), often called the Father of Modern Medicine, wrote

> all parts of the body which have a function, if used in moderation and exercised in labours in which each is accustomed, become thereby healthy, well-developed and age more slowly, but if unused and left idle they become liable to disease, defective in growth and age quickly.
>
> (Jones 1967)

Plate 1 A London double-decker bus in the 1950s. Jeremy Morris *et al.* compared the incidence of heart attack in sedentary drivers with that in physically active conductors.

Source: Getty.

Modern-day exercise research began after the Second World War in the context of post-war aspirations to build a better world. Public health was changing to focus on chronic, non-communicable diseases and the modification of individual behaviour. Whilst Doll and Hill worked on the links between smoking and lung cancer, Professor Jeremy Morris and his colleagues set out to test the hypothesis that deaths from coronary heart disease (CHD) were less common among men engaged in physically active work than among those in sedentary jobs. In seminal papers published in 1953, they reported that conductors working on London's double-decker buses who climbed around 600 stairs per working day experienced less than half the incidence of heart attacks as the sedentary drivers who sat for 90% of their shift.

Subsequent studies by Morris and others, in particular Morris' close friend Ralph Paffenbarger in the US, confirmed that the postponement of cardiovascular disease through exercise represents a cause-and-effect relationship. For their contribution, Morris and Paffenbarger were, in 1996, jointly awarded the first International Olympic Medal and Prize for research in exercise sciences.

In the 50 years since Morris' early papers, research into the influence of physical activity on health has burgeoned. This book is not a comprehensive account of this literature; rather it is an attempt to illustrate its extent, strengths and weaknesses and to help students understand the process of evaluation of evidence. Our emphasis will be on topics that comprise major public health issues. But first, it is necessary to 'paint a picture' of some relevant features of today's societies.

MODERN TRENDS

Just three behaviours – smoking, poor diet and physical inactivity – are the root cause of around one-third of deaths in developed countries. These risk factors often underlie today's leading chronic disease killers: heart disease, cancer, stroke and diabetes. Sadly, three modern trends will increase the prevalence of these diseases in the twenty-first century. These are the epidemic of obesity, inactivity in children and the increasing age of the population.

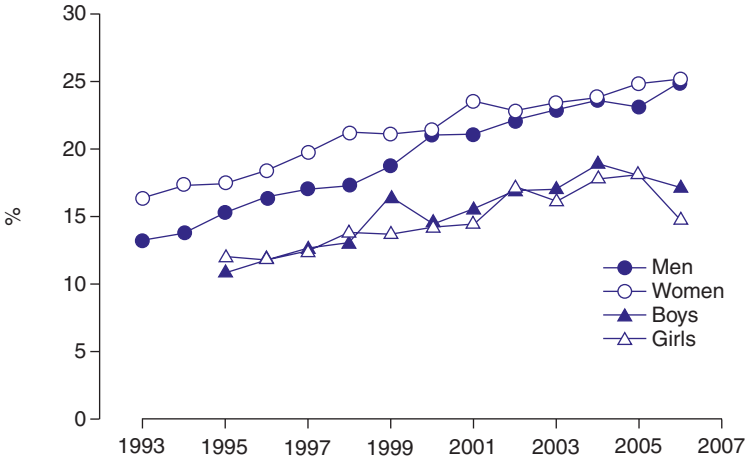
Epidemic of obesity

In parts of the world such as North America, the United Kingdom, Eastern Europe and Australasia, obesity prevalence has risen three-fold or more in the last 25 years. Nearly one-third of American adults are obese, and rates in England are the worst in Europe, with 24% of adults obese and a further 38% overweight in 2006, with no real slowing of the upward trend (Figure 1.1). Moreover, all the signs are that the increase in obesity is often faster in developing countries than in the developed world. For example, in South Africa, nearly 60% of black women have been reported to be either obese or overweight. Even in China, where the overall prevalence is below 5%, rates of obesity are almost 20% in some cities.

While the figures for adult obesity give rise to concern, those for children presage an even more major public health problem – perhaps one of the most consequential of the twenty-first century. Serious weight-related problems that may be expected to lead to life-threatening disease in adulthood are already being diagnosed in obese adolescents. In England, 16% of children aged between 2 and 15 were classed as obese in 2006, an increase from 11% in 1995 (Figure 1.1); and in the US almost one in three children and adolescents is either overweight or obese. The problem is global, and increasingly extends into the developing world. For example, in Thailand the prevalence of obesity in 5–12-year-olds rose from 12% to 15% in just two years.

The health hazards of obesity and the ways in which physical activity influences weight regulation are discussed fully in Chapter 6, but one general point will be made here. For many people today, everyday life demands only low levels of physical activity and hence energy expenditure. The average decline in daily energy expenditure in the United Kingdom from the end of the Second World War to 1995 has been estimated

Figure 1.1 Prevalence of obesity among men and women (1993 to 2006) and among boys and girls aged 2–15 (1995–2006) in England.



Source: Information Centre (2008).

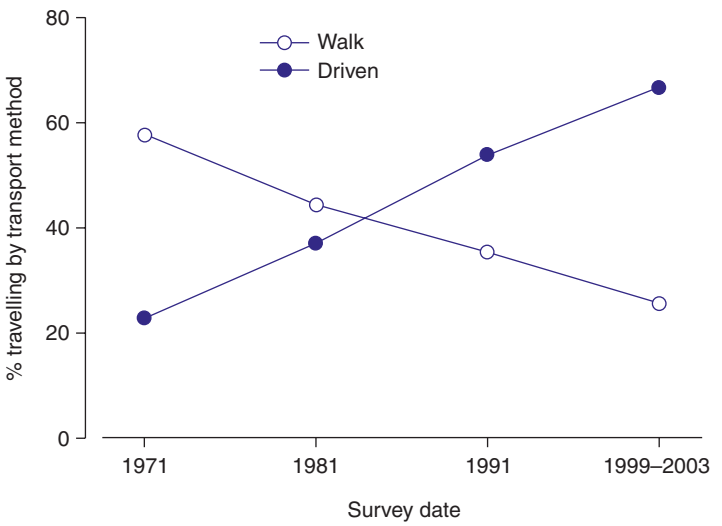
as 3,360 kJ (800 kcal) (James 1995), the equivalent of walking about 16 km (10 miles) less. A large population-based study in which Swedish women recalled retrospectively their daily physical activity at ages 15, 30 and 50 years found a decrease over the last 60 years of the twentieth century equivalent to 45 minutes of brisk walking (approximately 3 miles) (Orsini *et al.* 2006). The modern phase of the obesity epidemic (from 1980 onwards) is therefore probably mediated more by inactivity than by overeating (Prentice and Jebb 1995).

Inactivity in children

The high prevalence of sedentary behaviours in children and youths partly explains their low total levels of physical activity. In industrialized countries young people typically watch 2–2.5 hours of television each day (Marshall *et al.* 2006), but in America around 40% of children in some ethnic groups watch at least four hours daily (Andersen *et al.* 1998). Total 'screen time' is even higher among those with access to computers and video/DVD games. For example, Canadian children aged 10–16 are spending, on average, six hours per day in front of a computer or television screen (Health Canada 2007).

Another factor contributing to low levels of physical activity is the general decline in children's walking and cycling, and the dramatic decline in physically active transport to school. For example, the percentage of Australian children (aged 5–14) that walked to school halved between 1971 and 1999/2003 (van der Ploeg *et al.* 2008). The corollary is, of course, that more children are being driven to school (Figure 1.2). In the United Kingdom the number of primary school children travelling to school by

Figure 1.2 Prevalence of walking and being driven to school 1971 to 2003.



Source: van der Ploeg *et al.* (2008).

car has doubled in the past 20 years, despite the fact that a majority of these trips are under 1 mile (Black *et al.* 2001).

Estimates of overall physical activity levels in children world-wide show a marked decline as age increases, with a particularly steep fall in girls. For example, by the age of 15, only 41% of English girls reach the recommended 60 minutes of moderate-intensity activity daily. In Canada – a country long committed to monitoring and increasing physical activity levels – objective pedometer evidence indicates that 91% of children and young people do not meet the guideline of 16,500 steps per day (Health Canada 2007), raising the prospect that self-report (the basis of most descriptive data) may underestimate the extent of inactivity.

Thus the summary by the World Health Organization (WHO) that 'in many countries, developed and developing, less than one-third of young people are sufficiently active to benefit their present and future health' may well understate the problem (WHO 2008a).

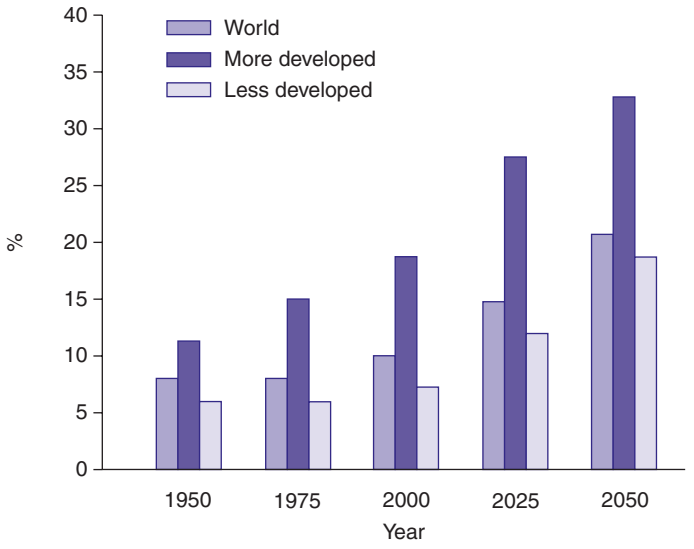
Ageing population

The world is experiencing a demographic transition characterized by an improvement in life expectancy for both men and women, leading to an increase in the total number of older people world-wide. To illustrate the effect on the age structure of populations, using New Zealand as an example, Figure 1.3 shows population 'pyramids' for 2006

Figure 1.3 Age structure of the population of New Zealand in 2006 and projection for 2061.

Source: Statistics New Zealand (2008).

Figure 1.4 Proportion of population aged 60 or over: world and development regions, 1950–2050.



Source: United Nations Department of Economic and Social Affairs: Population Division (2007).

(real data) and 2061 (projections). The 2061 pyramid has a narrower base and a broader top, indicating a smaller number of children, a larger number of old people and a median age of the population that is older by eight years.

The impact, world-wide, of the ageing of populations is shown in Figure 1.4. This histogram shows the percentage of individuals aged 60 in 1950, and at 25 year intervals up to 2050. Developed countries have the highest proportion of older people, the population of Europe being the oldest. A notable aspect of population ageing is the progressive ageing of the older population itself. In most countries, the population aged 80 or over (the oldest old) is growing faster than any other segment of the population. Globally, this sector will likely increase more than four-fold by 2050 (United Nations Department of Economic and Social Affairs 2007).

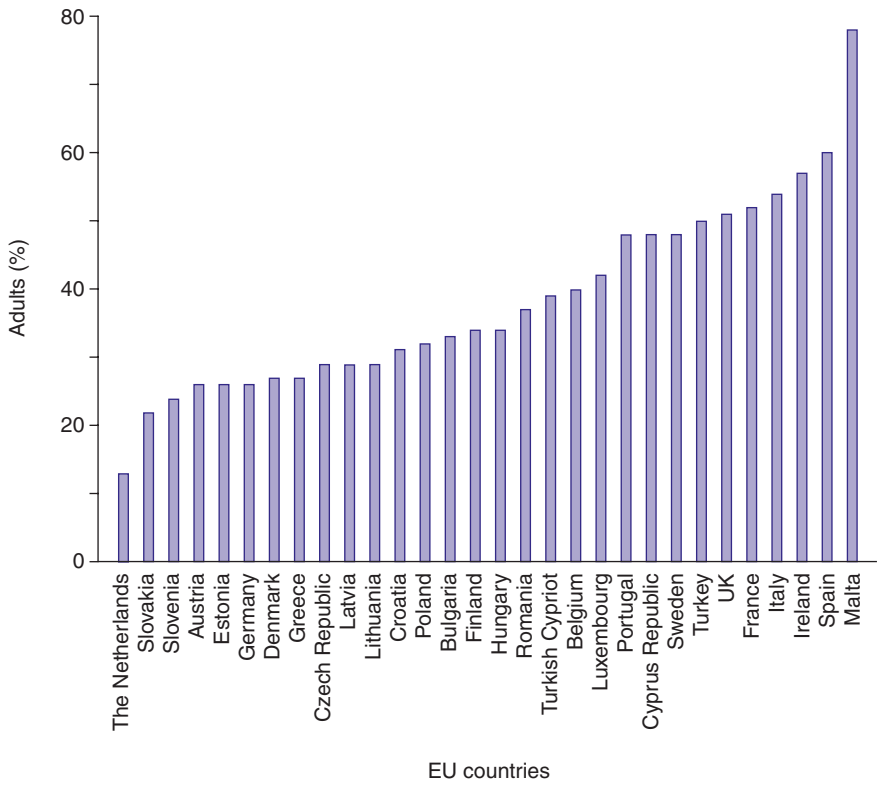
The ageing of a population has enormous social and economic implications, including an increase in age-related diseases and an increased number of frail elderly people. Physical activity has much to offer the elderly in terms of personal and public health: it helps to prevent some important age-related diseases (e.g. type 2 diabetes, osteoporosis[1] and cardiovascular disease); and it enhances functional capacities, leading to a better quality of life and increased capability for independent living (see Chapter 11). Public health policies to attenuate the marked age-related decline in physical activity levels (see following section) are therefore sorely needed.

PREVALENCE OF ACTIVITY/INACTIVITY WORLD-WIDE

Governments and other agencies monitor health behaviours, including physical activity, to inform public health policy and to review the progress of interventions that aim to change behaviours. Many countries survey only leisure-time physical activity, because this type of activity is assumed to be the most amenable to interventions and because occupational work is now uncommon in westernized countries – the source of most national data. The assessment methods used to monitor physical activity unfortunately are varied, but it is clear that physical activity levels are low in many, probably most, countries.

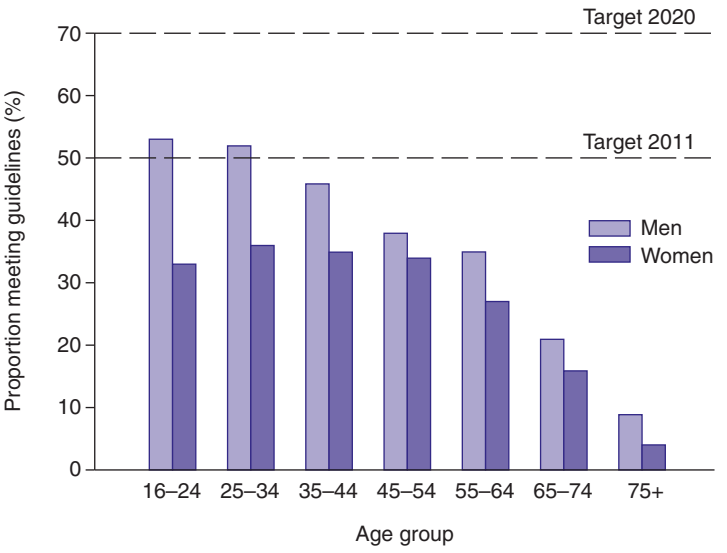
There are two frequently used approaches to presenting data on population physical activity levels: one is to report the proportion of individuals in a specified age/sex-group who are judged to be inactive; the other is to report the proportion of individuals meeting the criteria that identify the minimal 'dose' of activity needed for health benefits. Figure 1.5 shows the percentage of adults in selected European countries that are classified as 'inactive' because they report doing no moderate-intensity

Figure 1.5 Percentage of adults who do no moderate-intensity physical activity in a typical week, 2005, selected European Countries.



Source: European Commission (2006).

Figure 1.6 Proportion of adults in England achieving the physical activity guidelines in 2006, by age and gender.



Source: Information Centre (2008).
Note: Horizontal lines depict government targets for 2011 and 2020.

physical activity. The United Kingdom scores worse than average, with around half the adult population classed as inactive. In the US around 38% of adults are reported to engage in no leisure-time physical activity.

Reporting the proportion of individuals who meet national guidelines has the advantage of allowing governments to set targets for increasing activity levels and then monitor progress towards that target. In England in 2006, only 40% of men and 30% of women achieved the recommended amount of activity – far short of the target of 50% that has been established for 2011 (Figure 1.6). Only one-third of American adults are deemed to be sufficiently active and, although Australians and Canadians appear to do better (46% and 49%, respectively, are classified as sufficiently active), active individuals still comprise a minority of the population.

Two features of the data on physical activity are common to most developed countries: the rapid decline with increasing age; and higher levels of activity in men than in women. For example, the data from the United Kingdom in Figure 1.6 show that, whereas 54% of men and 33% of women aged 16–24 fulfil the guideline for health benefits, these figures decline to 17% and 12%, respectively, in the age group 65–74 years.

Activity levels within countries also vary considerably with racial/ethnic group. In the United Kingdom, adults of Bangladeshi or Pakistani origin are the least active, and in the US there is particular concern at the low levels of activity among Hispanics. In developing countries, a decline in physical activity appears to follow in the wake of economic growth, so the prevalence of inactivity world-wide may be expected to rise as the economies of these countries progress.

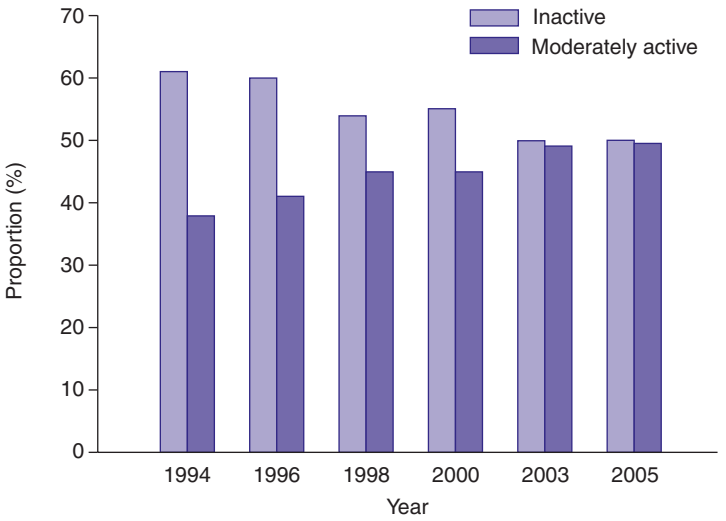
TRENDS OVER TIME IN PHYSICAL ACTIVITY LEVELS

Few countries have collected comprehensive data in a standardized manner over enough decades to identify long-term trends in physical activity levels. Exceptions are Canada and Finland.

Canada has a long history of commitment to the study of physical activity levels. National surveys of leisure-time physical activity were carried out in 1981 (fitness as well as activity), 1988, 1995, 1998, 1999, 2000, 2001 and 2005. From 1995 onwards the same instrument, the Physical Activity Monitor, has been used. Comparison over time reveals that substantial inroads were made in reducing sedentary living during the 1980s and early 1990s. In 1981, over three-quarters of adults aged 18 and older were considered insufficiently active for health benefits, but levels of inactivity decreased to 71% in 1988 and to 63% by the mid-1990s. Subsequent progress has been slow, although the percentage of the population that was at least moderately active increased significantly between 1994/5 and 2004/5 (Figure 1.7). However, a majority of adult Canadians are still not sufficiently active, despite considerable efforts by government agencies to promote physical activity.

Health behaviours have been monitored in Eastern Finland at five-year intervals since 1972, when the community-wide North Karelia Project was initiated with the aim of reducing high rates of cardiovascular diseases. Twenty-five years of change in leisure-time, occupational and commuting physical activity have been described

Figure 1.7 Trends in the proportion of inactive and moderately active adults in Canada 1994/5–2004/5.



Source: Canadian Fitness and Lifestyle Research Institute (2005).
Note: Activity levels based on estimated average daily energy expenditure. Inactive: less than 1.5 kcal per kilogram of body mass per day (equivalent to walking no more than 15 minutes per day). Moderately active: more than 1.5 kcal per kilogram of body mass per day (walking for 0.5 hours per day is equivalent to 1.5–2.9 kcal per kilogram per day, walking for one hour per day is equivalent to just over 3 kcal per kilogram per day).

(Barengo *et al.* 2002). The proportion of both men and women engaging in high levels of leisure-time physical activity has increased since 1972, as has the proportion of women participating at a moderate level (defined as at least four hours per week of activities such as walking or cycling). Repeated surveys of representative samples of the Finnish population overall confirm that participation in recreational physical activity has increased over the past two decades in young, working-age and elderly people – although walking and cycling in commuting have decreased (Vuori *et al.* 2004).

More recently, other countries have begun to monitor activity levels in a consistent manner. Since 1996 the UK government recommendation on physical activity has been that adults should participate in a minimum of 30 minutes of activity of at least moderate intensity on five or more days of the week. The proportion achieving this level has increased over recent years to 40% of men and 28% of women in 2006, but nevertheless a majority of adults are still insufficiently active (Information Centre 2008). Progress has also been slow in the US, with only 33% of adults sufficiently active in 2003, compared with 32% in 1997: a small positive is that the prevalence of walking has improved somewhat over these years. In Australia, the proportion of those aged 15 and over reporting sedentary or low exercise levels has not changed significantly over the last ten years (69% in 1995, 69% in 2001 and 70% in 2004–5) (Australian Bureau of Statistics 2006).

In summary, it is clear that the prevalence of physical inactivity remains high in developed countries. In rapidly growing cities of the developing world, inactivity is an even greater problem. The WHO Global Strategy on Diet, Physical Activity and Health summarizes the available data thus: 'More than 60% of the world population is inactive or insufficiently active to gain health benefits' (WHO 2008b).

NATIONAL SURVEYS OF FITNESS

Three countries, Canada (1981 and 1988), England (1992) and the US (1999–2000 and 2001–2002) have published representative national surveys of fitness. In the Canadian survey, more than 20,000 participants completed a battery of tests. Cardiorespiratory fitness was assessed on the basis of the heart rate response to a standard step test, and participants were allocated to one of three fitness levels: 'an undesirable personal fitness level'; 'the minimum personal fitness level'; or 'a satisfactory personal fitness level'. This approach reflected the original purpose of the step test (to give individuals a means to monitor changes in their own fitness), but it made it difficult to relate the data to epidemiological findings. Average values for maximal oxygen uptake were predicted, without direct measurement of respiratory gases, and found to correspond quite closely with 'world averages' (Shephard 1986). The latter were not drawn from representative samples, however, and the prediction of $\dot{V}O_2$max from the step test data was fraught with problems. Repeat measurements were made in 1988 on most of a 20% subset of the original sample, but results have not been widely disseminated.

The English National Fitness Survey used a graded treadmill test to estimate $\dot{V}O_2$max from measurements of oxygen uptake and heart rate in a much smaller, but still representative, sample (858 men, 883 women). These values were reported by age and sex, but researchers used functional criteria as the main outcome measures (did people have suffi-

cient aerobic capacity or muscle strength to carry out everyday tasks without fatigue?). For example, it was determined that nearly one-third of men and two-thirds of women would find it difficult to sustain a walking pace of about 4.8 km h^{-1} (3 mile h^{-1}) up a 1-in-20 (5%) slope for more than a few minutes (Sports Council and Health Education Authority 1992). The proportion of men who could not do this rose sharply with age, that is, from 4% of 16–24-year-olds to 81% of 65–74-year-olds. Equivalent figures for women rose from 34% to 92%. These findings strongly suggest that the prevalence of low fitness was widespread in England. To the authors' knowledge, there are no plans to update these data.

The American data derives from the National Health and Nutrition Examination Survey (NHANES) and also comprises predicted values for maximal oxygen uptake, based on heart rate responses to a submaximal treadmill test. Analysis revealed low fitness in adults of non-Hispanic black race, particularly among women (Duncan *et al.* 2005). Uniquely, NHANES also obtained data for young people aged 12 to 19 years. Fitness was lower among overweight individuals but unrelated to race/ethnicity (Pate *et al.* 2006).

DEFINITIONS OF KEY TERMS

Disease is relatively easy to define, either according to aetiology (e.g. tuberculosis is caused by a bacterium, *Mycobacterium tuberculosis*) or in terms of symptoms (e.g. the term asthma describes a disease characterized by fits of laboured breathing). Defining health is more problematic. Is health merely the 'other side of the coin', that is, the absence of disease? Somehow this fails to capture the essence of our everyday use of the term health as encapsulated in phrases such as 'picture of health' and 'rude health'. Something wider is needed. The most ambitious definition is probably that proposed by the WHO (1946): 'Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.' This definition, although criticized because of the difficulty of defining and measuring well-being, remains an ideal. It is helpful in the context of this book because physical activity contributes more to health than just helping to prevent disease.

Finally – a note on our use of the terms 'physical activity' and 'exercise'. We have adopted the definitions that have acquired currency over recent years (Howley 2001). Thus physical activity is 'any bodily movement produced by contraction of skeletal muscle that substantially increases energy expenditure'. Hence the title of this book is broad – *physical activity* and health. Exercise (or exercise training) is defined as 'a subcategory of leisure-time physical activity in which planned, structured and repetitive bodily movements are performed to improve or maintain one or more components of physical fitness'. However, the distinction between physical activity and exercise is sometimes neither helpful nor necessary, so there are occasions in the text where these terms are used more loosely.

SUMMARY

- The modern history of exercise science began after the Second World War, when epidemiologists began the scientific study of the role of exercise in protection against heart disease.

- An epidemic of obesity in adults and children is leading to an increase in obesity-related diseases.
- In many countries, developed and developing, less than one-third of young people are sufficiently active to benefit their present and future health.
- Improvements in life expectancy for both men and women mean that the total number of older people world-wide is increasing, changing the age structure of populations. This means more age-related disease and an increased number of frail elderly people.
- The findings of representative surveys of physical activity levels generally have two features in common: a rapid decline in activity levels with increasing age; and higher levels of activity in men than in women.
- A decline in physical activity appears to follow in the wake of economic growth, so that the prevalence of inactivity world-wide may be expected to rise as the economies of developing countries progress.
- The National Fitness Survey for England determined that nearly one-third of men and two-thirds of women would find it difficult to sustain a walking pace of about 4.8 km h^{-1} (3 mile h^{-1}) up a 1-in-20 (5%) slope for more than a few minutes.

STUDY TASKS

1. Typical daily energy expenditure in western countries is estimated to have fallen by as much as 3,360 kJ (800 kcal) in the last 50 years. Is this a lot or a little? Explain your answer as fully as possible.
2. Why do the figures describing the prevalence of overweight and obese children give rise to so much concern?
3. In your opinion, what factors can be invoked to explain the low levels of physical activity in children and adolescents?
4. Why is the age structure of the population of a country such as New Zealand expected to change so much in the decades to come? What are the implications of this change for public health policy?
5. Basing your answer on Figure 1.6, describe and evaluate the public health importance of the data describing physical activity levels in England.
6. Which two countries have the best data on long-term changes in physical activity? What, in your opinion, is the value of making objective comparisons over time of physical activity in population levels?

NOTE

1. There are more women than men in the older age groups, and this proportion is expected to rise still further as the population ages. Thus the prevalence of osteoporosis will increase.

FURTHER READING

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