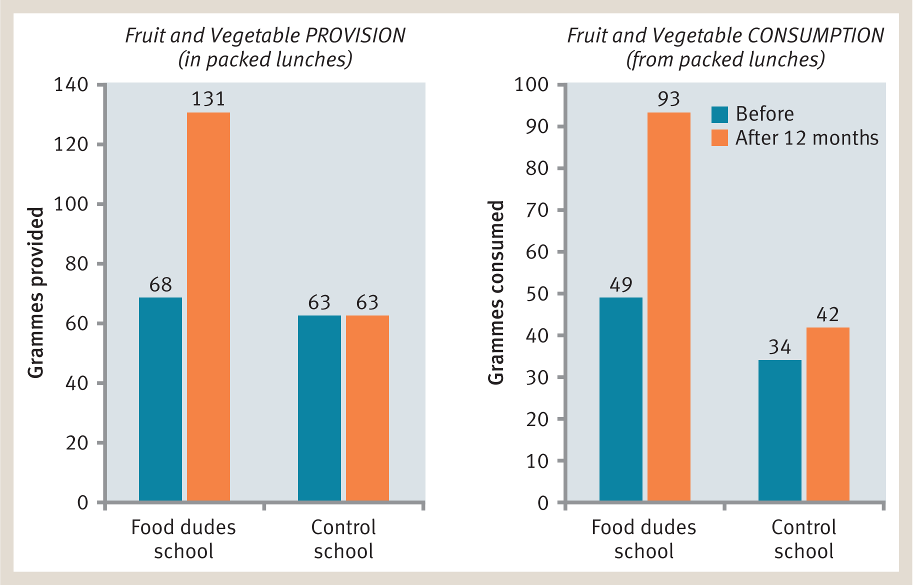

Figure 4.1 Ireland experimental evaluation

Source: Horne et al. (2009), reprinted by permission from Macmillan Publishers Ltd

guarantee healthy food choices in young people, as described in the next chapter where wider sociocognitive influences are described.

Given the challenge of increasing fruit and vegetable intake, ISSUES below raises the question of whether supplementing a person's diet with antioxidant vitamins (e.g. vitamins A, C and E; beta-carotene; folic acid) has benefits in terms of reducing disease risk.

Exercise

Physical inactivity has been identified by the World Health Organization as the fourth leading risk factor for global mortality. As we will describe here, regular exercise (physical activity) in contrast is generally considered as health-protective, reducing an individual's risk of developing diseases such as cardiovascular and coronary heart disease, type 2 diabetes mellitus, osteoporosis and obesity, and some forms of cancer, including colorectal and breast cancer (Department of Health 2004; Warburton et al. 2010; World Health Organization 2014: http://www.who.int/mediacentre/factsheets/fs385/).

As a result, most countries have guidelines as to what is considered the appropriate amount of exercise to gain health benefits.

Recommendations to exercise

Specific recommendations regarding physical activity for adults (aged 18–64 years) suggest at least 30 minutes of moderate intensity exercise on at least five days of each week (or as an alternative to this, 150 minutes of moderate exercise, 75 minutes of high-intensity exercise) and for children and young people (aged 5–17 years) the recommendations are higher, suggesting at least 60 minutes of at least moderate to vigorous intensity exercise a day, every day (e.g. World Health Organization 2010; Department of Health 2011). Within these guidelines are also recommendations for at least 2 exercise days to include muscles strengthening exercise (3 times a week for children), and for adults, the aerobic exercise should be done in bouts of 10 minutes plus duration. For those over 65 years of age, the WHO guidelines are the same as for younger adults although specific recommendations include balance-enhancing exercise for those with limited mobility. The aim of such guidelines is to set minimum activity targets with the

ISSUES

Do vitamins protect us from disease?

Research has suggested that a lack of vitamins A, C and E, beta-carotene and folic acid in a person's diet plays a role in blood vessel changes that potentially contribute to heart disease, and low beta-carotene has been linked with certain cancers. Beta-carotene is a form of vitamin A found in the cell wall of carrots and sweet potatoes, and we now understand that cooking these vegetables releases this more easily for absorption than eating them raw (see Bardia et al. 2008, for a systematic review and meta-analysis). Such associations are attributed to the antioxidant properties of these vitamins (i.e. they reduce the oxidated products of metabolism which can cause cell damage). Additionally, vitamins C and E have anti-inflammatory effects, and both inflammation and oxidation have been linked with cognitive decline and progression towards dementia. Naturally, such findings stimulate media and public interest, and taking vitamin supplements as a means of protecting one's health became commonplace in the USA and more recently across Europe. Vitamin supplementation has become a growth industry – just look at the shelves of your local supermarkets or pharmacist.

However, what is the evidence base as to their effectiveness? Do supplements work in the same way as when contained naturally in the foods we eat? The United States Preventive Services Task Force (USPSTF: an expert group formed to review research evidence in order to make informed health recommendations) conducted two large-scale reviews of studies of vitamin supplements, one in relation to reduced risk of cardiovascular disease (USPSTF 2003) and the other in relation to reduced risk of breast, lung, colon and prostate cancer (Morris and Carson 2003). They found that in terms of subsequent development of disease, even well-designed randomised controlled trials comparing vitamin supplements with an identical-looking placebo pill were inconclusive in their findings. Worryingly, they find 'compelling evidence' of an increase in lung cancer risk and subsequent death in smokers who take beta-carotene supplements. However, Bardia et al. (2008) concluded from their review of 12 randomised trials (9 with high methodological quality, overall related to 104,196 individuals) that even this evidence regarding mortality is limited because not all trials analysed mortality data by whether their sample smoked or not!

Furthermore, the stronger claims of associations between vitamin supplements and reduced disease risk come from more poorly designed and poorly controlled studies. For example, **observational studies** reporting an association between reduced breast cancer incidence and vitamin A intake generally failed to control for other relevant behaviours, such as general diet or levels of physical activity. Similarly, the reduced colon cancer risk reported amongst those taking folic acid supplements came from retrospective reports of those already diagnosed with colorectal cancer, rather than a prospective follow-up of initially healthy individuals.

Consistent with the USPSTF report, Bardia et al.'s review concludes that there was no effect of antioxidant supplementation in relation to primary cancer incidence and mortality. In making recommendations for vitamin usage, the USPSTF concluded that, with the exception of advising against smokers taking beta-carotene supplements, there was little evidence of vitamin supplements causing harm, BUT neither was their conclusive evidence of benefits in terms of reduced risk of heart disease or many forms of cancer.

Further study is, however, justified. As Bardia notes, these vitamins consist of several antioxidant components and also micro- and macro-nutrients, and studies so far focused on different compounds taken in

observational studies
research studies which evaluate the effects of an intervention (or a treatment) without comparison to a control group and thus such studies are more limited in their conclusions than randomised controlled trials.

differing amounts, rather than the interactions between components (for example, between selenium and lycopene).

In terms of vitamin C and E supplements and their potential in halting cognitive decline, the evidence is more preliminary. Well-designed randomised controlled trials (comparing vitamins with a placebo) are still required (Haan 2003). One study has pointed to beneficial effects of vitamins C and E on the verbal fluency and verbal memory scores of healthy elderly women (the loss of which are implicated in the development of dementia) (Grodstein et al. 2003). However, the benefits were found only when the two vitamins were taken together and not for either one taken alone, which raises interesting questions about interactions as noted above.

More recent evidence is less encouraging, however. Plassman et al. (2010) reviewed 127 observational studies, 22 randomised controlled trials and 16 systematic reviews in terms of a range of factors associated with cognitive decline, including the nutritional factors addressed here. They found insufficient evidence to support such an association, although nutritonal data were examined in only 7 of the studies reviewed. It may be that effects are confined to specific populations. For example, in women with pre-existing cardiovascular disease or cardiovascular disease risk factors, overall antioxidant supplementation did not slow cognitive change over a 5-year period, but an effect of vitamin C or beta-carotene intake was found among a sub-group who had low dietary intake levels (Kang et al. 2009). Given that cognitive decline and dementias are increasingly prevalent in an ageing society, more rigorous and focused studies with less varied populations are justified.

Overall, therefore, current research no longer supports the taking of antioxidant supplements, except perhaps where natural food sources are lacking. Eating a healthy diet with these vitamins contained within the foodstuffs and maintaining a healthy body weight is more relevant to reducing disease risk than relying on supplements.

potential to reduce the incidence of the diseases described above, including obesity, as well as improving general well-being. Guidelines are not intended to be set so high as to be beyond the reach of the average individual, and certainly the advice for a previously inactive individual is to build up their exercise levels gradually, rather than making dramatic changes to the frequency or intensity of exercise performance. Furthermore, where a pre-existing health complaint exists, plans to become more active should first be discussed with a medical professional.

In spite of obvious health benefits and active campaigning on the part of public health authorities to encourage people of all ages to become more active, exercise levels in some parts of Europe (as elsewhere) remain low.

Levels of exercise

There is some suggestion that levels of childhood activity influence adult health and disease risk although there is need for more longitudinal research to confirm the pathways through which any effects occur (Hallal et al. 2006; Mattocks et al. 2008). It may be that active youngsters maintain activity in adulthood, but it may also be that active youngsters' lifestyles vary in other (healthy) ways as they grow older – whichever explanation it may be, there is certainly no harm in setting down patterns of healthy behaviour early.

Less than half of the British adult population carry out some form of exercise at least once a month, and a similar percentage fail to exercise to current recommended levels, with percentages dropping with age. This pattern is not only evident in Britain: for example, Table 4.1 shows the prevalence of insufficient physical activity ranges from 71.9 per cent in Malta, through to 26 per cent in Hungary. Gender and age differences have also been reported, with women generally more inactive than men, and older women less active than younger women (e.g. Stephenson et al. 2000). Data on the behaviour of the 'very old' (i.e. 85+) are limited as many surveys simply compare people who are under 65 years of age with those aged over 65. In older populations exercise behaviour is likely to be influenced by factors such as current health status and physical functioning, access to facilities, and even personal safety

Table 4.1 Prevalence of insufficient physical activity in adults – Top and bottom 10 European countries

	European Country	Prevalence of insufficient physical activity (%)
1.	Malta	71.9
2.	Serbia	68.3
3.	United Kingdom	63.3
4.	Turkey	56
5.	Italy	54.7
6.	Ireland	53.2
7.	Portugal	51
8.	Spain	50.2
9.	Luxembourg	47.7
10.	Norway, Spain	44.2
	European Country	**Prevalence of insufficient physical activity (%)**
1.	Greece	15.6
2.	Estonia	17.2
3.	Netherlands	18.2
4.	Ukraine	18.4
5.	Russian Federation	20.8
6.	Slovakia	22.2
7.	Georgia	22.3
8.	Lithuania	22.6
9.	Cyprus	25.0
10.	Hungary	26.0

Source: WHO (2010).

concerns (in terms of walking alone, or of accidents at the gym). However, a person's lifespan (longevity) may be predicted by the extent to which a person is physically active as we describe in the next section.

While a greater percentage of younger adults (16 to 24 years) appear to meet current recommended physical activity levels compared with older adults, the prevalence of inactivity is high in child samples. For example, a World Health Organization study of 162,000 young people aged 11, 13 and 15 in 35 countries across Europe and North America found that only 35 per cent of 15-year-old boys and only 22 per cent of girls engage in at least one hour of moderate or heavier exercise five days a week, with huge geographical as well as gender differences (www.euro.who.int) (see Figure 4.2). In relation to even younger children, the Millenium Cohort study which is tracking the health of over 6,000 UK children born between 2000 and 2002 have recently reported (Griffiths et al. 2013) that when aged 7 years old, fewer than half were engaging in recommended levels of activity, with girls again less active than boys (38 per cent vs. 63 per cent meeting guidelines). Many large-scale studies have reported similar gender differences, maintained through adolescence. Cultural differences have also been reported amongst both adults and children. For example, Bangladeshi, Pakistani and Indian (South Asian) participants are significantly less active than white participants (adults aged over 55 living in the UK in the Health Survey for England, Williams et al. 2011; adults screened for type 2 diabetes, Yates et al. 2010; and children aged 7, Griffiths et al. 2013). That ethnic variations in physical activity exist points also to wider influences on activity which have been described in Chapter 2 ☛ i.e. that of socio-economic inequalities in terms of access to sports and leisure facilities, and social inclusion for those of BME status, at least in the UK.

What are the physical health benefits of exercise?

We use the term 'exercise' broadly here, encompassing both planned physical activity such as going swimming or to the gym for an exercise 'class' and that which is simply physical activity generated by body movement in the pursuit of one's daily life such as going shopping, or walking the dog. The majority of research studies in this domain have focused on the presence of purposeful exercise. However, exercise does not have to be structured and formal; there is clear evidence from a meta-analysis of randomised controlled trials that simply regular walking can reduce the risk of cardiovascular disease, particularly among older people (Murphy et al. 2007).

An early pointer towards the benefits of moderate to high levels of exercise came from a longitudinal study of the lifestyles of 17,000 former graduates of Harvard University where significantly more deaths occurred between 1962 and 1978 among those who reported leading a sedentary life. Those who exercised the equivalent of 30–35 miles (48–56km) running/walking a week faced half the risk of premature death of those who exercised the equivalent of five miles (8km) or less per week. Moderate exercisers were defined as exercising the equivalent of 20 miles (32km) per week, and these individuals also showed health benefits in that on average they lived two years longer than the low-exercise group (<5 mile equivalent) (Paffenbarger et al. 1986). In a similar vein Hakim and colleagues (Hakim et al. 1998) followed a cohort of 61–81-year-old men over a period

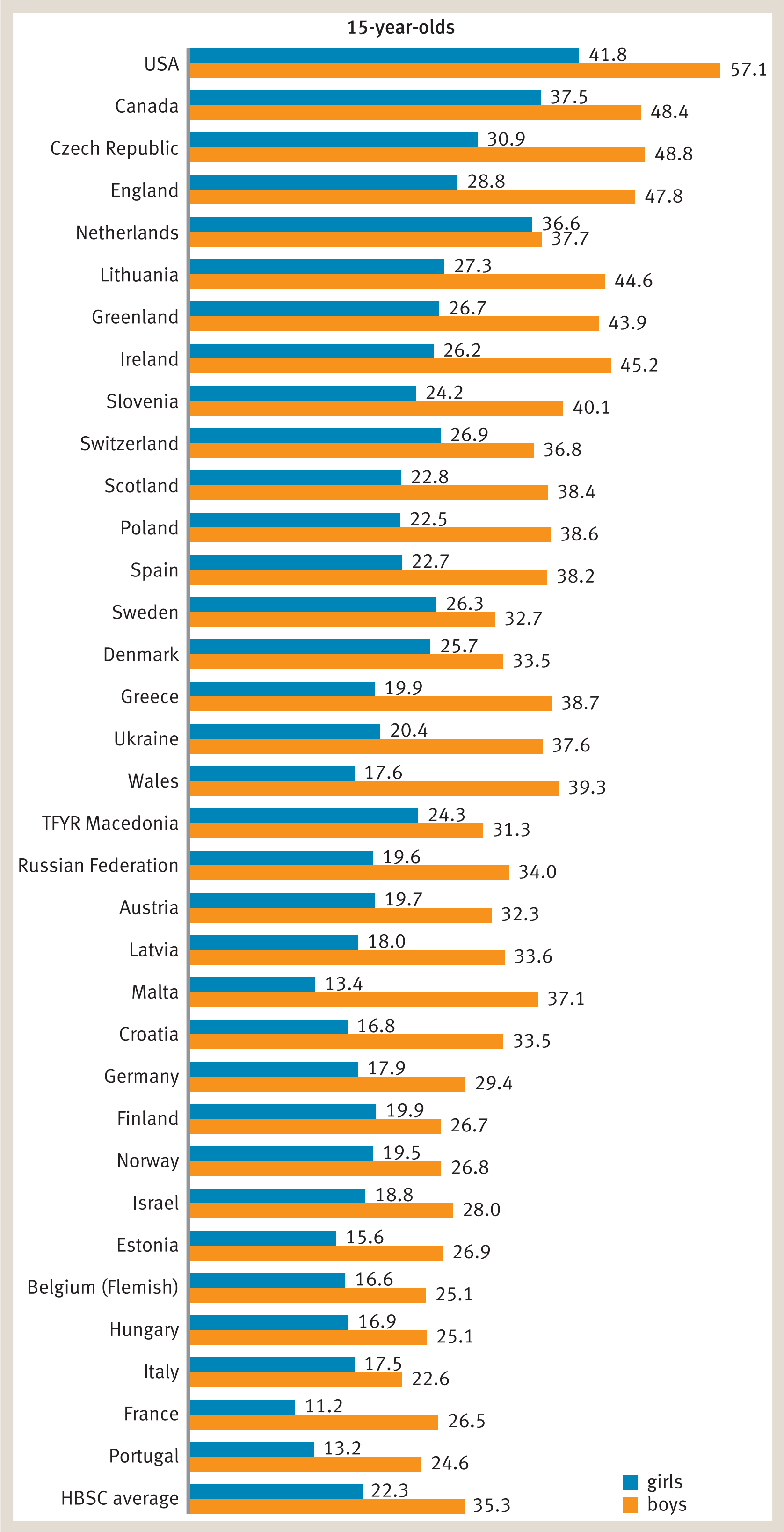

Figure 4.2 Proportion of 15-year-olds across a selection of 35 countries who engage in recommended exercise level, (at least an hour of moderate or high-intensity activity on five days per week)

Source: WHO (2004)

of 12 years and monitored the amount of walking they did. Men who walked more than two miles (3.2km) a day lived significantly longer than those who walked less (21.5 per cent died over the 12 years, compared with 43 per cent). Furthermore, the incidence of cancer and heart disease was also lower among those who walked more, even when controlling for other common risk factors such as alcohol consumption and blood pressure. All men who participated in this study were non-smokers, therefore this did not need to be controlled for; however, this otherwise careful study did not control for an individual's dietary behaviour, which may also play a role in the findings.

There is strong evidence that regular exercise is also protective against the development of osteoporosis, a disease characterised by a reduction in bone density due to calcium loss, which leads to brittle bones, a loss of bone strength and an increased risk of fractures (UK Department of Health 2004). It is estimated that, in the UK, someone experiences a bone fracture due to osteoporotic bones every two minutes, and that one in two women and one in five men over the age of 50 will have this condition (National Osteoporosis Society 2014). Regular exercise, particularly low-impact exercise or weight-bearing exercise such as walking and dancing, helps in the laying down of calcium in the bones, which helps to prevent bone thinning and fractures. Exercise is therefore not just important to bone development in the young but is also important for maintaining peak levels of bone density during adulthood. Additional benefits to muscle strength, coordination and balance can be gained from resistance-strengthening exercise, which in turn can benefit older individuals by reducing the risk of falls and subsequent bone fractures.

Even amongst overweight individuals with a body mass index (BMI, see Chapter 3 ☛) of 25.0 or more – being of moderate or high 'fitness' can significantly reduce overall mortality and heart attack incidence compared to overweight individuals who are also of 'low' fitness. Being 'fat' does not inevitably mean being 'unfit' and fitness may protect against negative effects of being overweight.

In general, therefore, regular exercise is an accepted means of reducing one's risk of developing a range of serious health conditions. Once a relationship between behaviour and a health outcome has been established, it is important to ask 'how' this relationship operates. In terms of exercise and reduced heart disease risk, it appears that regular performance of exercise:

- strengthens the heart muscles;
- increases cardiac and respiratory efficiency
- tends to reduce blood pressure;
- reduces the tendency of a person to accumulate body fat.

Photo 4.2 Public Health England's Change4Life initiative has become one of the most instantly recognisable brands in health improvement.

Source: Department of Health.

In addition to reducing risk of disease, exercise has benefits for those already with disease: for example, increasing muscular strength, function and quality of life, reducing fatigue and the side effects of cancer treatments (Cramp and Daniel 2008; Perna et al. 2008) and reducing fatigue in those with Chronic Fatigue Syndrome (White et al. 2011). However, as found amongst healthy individuals, a range of factors will predict whether clinical populations will engage in sufficient physical activity to reap the benefits (see 'Why do people exercise' below).

Exercise helps to maintain the balance between energy intake and energy output and works to protect physical health in a variety of ways. A 'dose–response' relationship is seen to exist in relation to reduced risk of cardiovascular disease, type 2 diabetes and some forms of cancer, whereby the greater the level (frequency and intensity) of exercise, the greater the benefits. There is some note of caution in relation to this dose–response association, however: extreme exercise dependence is sometimes associated with a poor body image and with other compulsive disorders including eating disorders (e.g. Hamer and Karageorghis 2007; Cook and Hausenblas 2008), and there is also the risk of injury and musculoskeletal damage (see later).

The psychological benefits of exercise

Exercise and mood

Exercise has been associated with psychological benefits in terms of elevated mood among clinical populations such as those suffering from depression (Craft and Landers 1998) and amongst some specific populations, for example the elderly (Sjösten and Kivelä 2006). Such findings, often from non-controlled, correlational studies, have contributed to recommendations that exercise be included as a treatment for depression, for example the National Service Framework for Mental Health (Donaghy and Durward 2000) and NICE (NICE 2007). There is much support for this. For example, a recent meta-analysis of data obtained from 23 randomised controlled trials where exercise was provided as an intervention to those with depression (compared to a control intervention or no treatment) found a large clinical benefit of exercise in terms of reduced depressive symptomatology. However, it is important to note that this effect reduced to a moderate and non-significant effect when the three most robust studies were meta-analysed, and exercise in these studies did no better than cognitive therapies (Mead et al. 2009), highlighting a need to draw conclusions from well-controlled, prospective studies rather than single correlational studies.

Regular exercise has also been associated with reduced anxiety and depression and improved self-esteem or body-image amongst non-clinical populations (Hausenblas and Fallon 2006; Lox et al. 2006). Single episodes or limited-frequency aerobic exercise appear beneficial also in terms of elevated mood, self-esteem and **prosocial behaviour** (Biddle et al. 2000; UK DoH 2005; Lox et al. 2006). These psychological benefits of exercise have been attributed to various biological mechanisms, including:

- exercise-induced release of the body's own natural opiates – endorphins – into the bloodstream, which produce a 'natural high' and act as a painkiller, and reductions in the stress hormone, cortisol (Duclos et al. 2003) (Chapter 12 ☛);
- stimulation of the release of **catecholamines** such as **noradrenaline** and **adrenaline**, which counter any stress response and enhance mood (Chapters 8 and 12 ☛);
- muscle relaxation, which reduces feelings of tension.

However, the relationship between exercise and positive mood states is not straightforward. Evidence exists of an inverse relationship between exercise intensity and adherence, whereby individuals are less likely to maintain intense exercise than moderate exercise, possibly because it is experienced as adversive (Brewer et al. 2000). This suggestion that, beyond a certain level, exercise may in fact be detrimental to mood was explored further by Hall et al. (2002) who examined the **affective** response of 30 volunteers to increasing levels of exercise intensity. Their results showed not only that intense exercise caused negative mood but also that the timing of mood assessments (pre- and post-exercise assessment, compared with

prosocial behaviour
behavioural acts that are positively valued by society and that may elicit positive social consequences.

catecholamines
these chemical substances are brain neurotransmitters and include adrenaline and noradrenaline.

noradrenaline
this **catecholamine** is a neurotransmitter found in the brain and in the **sympathetic nervous system**. Also known as norepinephrine.

adrenaline
a neurotransmitter and hormone secreted by the adrenal medulla that increases physiological activity in the body, including stimulation of heart action and an increase in blood pressure and metabolic rate. Also known as epinephrine.

sympathetic nervous system
the part of the autonomic nervous system involved in mobilising energy to activate and maintain arousal (e.g. increased heart rate).

repeated assessment during exercise) profoundly changed the nature of the relationship found. Studies measuring mood before exercise, and again after exercise has ended and the person has recovered, generally report positive affective responses. However, Hall and colleagues' data clearly show considerable mood deterioration as exercise intensity increases, with mood rising to more positive levels only on exercise completion. These authors propose that remembering the negative affective response experienced *during* exercise is likely to impair an individual's future adherence, and that this may explain why some studies report poor exercise adherence rates. Ekkekakis et al. (2008) replicated and extended these interesting findings, suggesting that methodological factors play a role in whether or not exercise is associated with positive mood. This is important as it highlights the need for researchers to consider both the timing of assessments and also that, because exercise is an event that typically takes time, a person's experience of it may also change over the course of its performance. Mood is a complex phenomenon!

Many other factors may combine with biological factors to influence the affective experience reported. Exercise may offer cognitive distraction or actual physical removal from life's problems, and as such provide a means of coping with stress. During exercise, a person may focus on aspects of the physical exertion or on the heart-rate monitor, they may distract themselves by listening to music or planning a holiday, or they may use the time to think through current stressors or demands and plan their coping responses (see Chapter 12 ☛). For others, the social support gained from exercising with friends plays an important role, particularly for females (Molloy et al. 2010). Even the exercise environment itself can play a role in mood outcomes, such as room temperature, the presence and type of music, and the presence of mirrors – the latter being associated with negative well-being (Martin Ginis et al. 2007).

For some individuals, self-image and self-esteem may be enhanced as a result of exercise contributing to weight loss and general fitness. Rightly or wrongly, we live in a society where trim figures are judged more positively (by others as well as by ourselves) than those that are considered to be overweight or unfit. However Mead and colleagues' (2009) meta-analysis found no significant linear relationship between the duration of exercise interventions and reduced depression (i.e. they did not find that longer exercise programmes showed greater reductions in depression), nor in fact was mood related to physical fitness in half of the trials analysed. This argues against concluding that mood benefits from increased *fitness*. However, the samples in this meta-analyses all fulfilled criteria for a depression diagnosis and so the findings may not generalise to those without this symptomatology.

> **affective**
> to do with affect or mood and emotions.

Exercise and cognitive function

Exercise may have psychological benefits for those experiencing cognitive decline as a result of ageing or dementia. Cotman and Engesser-Cesar (2002) reported that physical activity was associated with delays in the age-related neuronal dysfunction and degeneration that underlies types of cognitive decline often associated with Alzheimer's disease, such as memory lapses and not paying attention. Physical activity may improve at least some aspects of cognitive funcion important for tasks of daily living (BHF National Centre for Physical Activity and Health 2007) by virtue of neuroprotective effects, although the evidence on this is relatively new. For example, reviewing evidence of the effects of exercise on those identified with mild cognitive impairment (MCI, defined as atypical cognitive decline given a person's age and educational level which confers risk for going on to develop dementia) Barber and colleagues conclude that the neurobiological and vascular processes (increased cerebral blood flow) attributed to exercise have some evidence base from anatomical studies using MRI brain scans, reasonable evidence from general population studies comparing cognitive decline in the active versus the inactive, and finally, encouraging but as yet limited evidence from randomised controlled trials of physical activity interventions (Barber et al. 2012).

In summary, regular physical activity is generally considered to be beneficial to physical and psychological health, and possibly even indirectly to survival, but, as with much behaviour, it may be that moderation is required.

IN THE SPOTLIGHT

Exercise, our genes and ageing

A great example of health research moving from the laboratory run by cell biologists to potentially the interface with patients and health behaviour change interventions is the growing body of work exploring the association between our DNA and ageing. Telomeres are protective caps, made up of a combination of DNA and protein, based on the ends of chromosomes that affect how quickly cells age. As they become shorter, and as their structural integrity weakens, the cells age (lose their DNA) and die quicker. Telomerase is an enzyme that is involved in the repair and lengthening of telomeres which maintains the ability of cells to reproduce and maintain their DNA. Evidence from several prospective studies, both in animals and in humans, have found reduced telomerase levels and shorter telomeres to be associated with a broad range of diseases, including many forms of cancer, infectious diseases, stroke, vascular dementia, cardiovascular disease, obesity, osteoporosis and diabetes, and increased overall mortality risk . Elizabeth Blackburn, a Nobel prize winning scientist, and colleagues at University of California San Francisco have conducted many longitudinal studies amongst the healthy and patient groups, in both younger and older populations. Summaries of this exciting avenue of work conducted by themselves and by others is also available in a lectures series available on YouTube, making this science widely accessible (see for example, https://www.youtube.com/watch?v=-INR1xZS5GY)

In trying to establish WHY there may be an association between telomere length and disease, or even survival, several behavioural and psychosocial factors have been found to be associated, including perceived stress (including caregiving stress, see Chapter 15 ☛) and health behaviours. One recent example is a pilot study by Ornish and colleagues (2013) which followed 35 men with early stage, localised prostate cancer over five years, ten of whom were asked to make lifestyle changes in terms of their exercise levels, diet, use of social support and stress management. Compared to the 25 not making lifestyle changes, blood samples taken at five years found that their telomere length *grew* by approximately 10 per cent, compared to approximately 3 per cent shortening in the control group. In addition, a linear relationship was seen between the extent of lifestyle change and the percentage increase in length. No significant association was found between lifestyle change and telemorase enzyme levels, however.

Although a relatively small-scale pilot study, this study, published in *Lancet Oncology*, is adding to an exciting avenue of current work and larger-scale trials are needed within both patient and non-patient populations to explore further the interacting effects of genes, our behaviour and ageing.

The negative consequences of exercise

Paradoxically, for some people a reliance on exercise develops to the extent that exercise becomes a compulsion, interfering with other aspects of one's life and producing dependence (evidenced by, for example, experience of withdrawal effects, guilt and irritability when exercise is omitted) (e.g. Ogden et al. 1997; Hausenblaus and Symons Downs 2002). Experimental studies have shown that depriving regular exercisers of exercise can lead to mood reduction and irritability (e.g. review by Biddle and Murtrie 1991), with positive mood restored when exercise is reinstated. As with eating disorders, it may be that exercise affords an element of control to those who feel aspects of their lives are uncontrollable. The long-term physical consequences of excessive exercising relate to muscle wastage and weight loss rather than to any specific disease; however, these findings are a reminder that moderate levels of behaviour – even behaviour considered health-protective – are better than extreme levels.