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Health-enhancing physical activity and sedentary behaviour in children and adolescents

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We provide a wide-ranging review of health-related physical activity in children and adolescents using a behavioural epidemiology framework. In contrast to many other reviews, we highlight issues associated with true sedentary behaviours alongside physically active behaviours. Specifically, we review the evidence concerning the links between physical activity and cardiovascular disease, overweight and obesity, psychosocial measures, type II diabetes, and skeletal health. Although the evidence is unconvincing at times, several factors lead to the conclusion that promoting physical activity in youth is desirable. A review of the prevalence of physical activity and sedentary behaviours shows that many young people are active, but this declines with age. A substantial number are not adequately active for health benefits and current trends in juvenile obesity are a cause for concern. Prevalence data on sedentary behaviours are less extensive but suggest that total media use by young people has not changed greatly in recent years. Most children and adolescents do not exceed recommended daily hours of TV viewing. Physical activity is unrelated to TV viewing. We also identified the key determinants of physical activity in this age group, highlighting demographic, biological, psychological, behavioural, social and environmental determinants. Interventions were considered for school, family and community environments. Finally, policy recommendations are offered for the education, governmental, sport and recreation, health, and mass media sectors.

Keywords: determinants, exercise, health, interventions, physical activity, policy, sedentary behaviour, young people.

Introduction

This paper reviews the interrelationships between physical activity and health in young people using a behavioural epidemiology framework. Despite the difficulties in demonstrating clear links between activity and health in youth at times, often due to the length of time needed for disease endpoints to materialize from sedentary living, it is widely thought that a greater understanding of physical activity in this age group is necessary. With rising levels of obesity in children and adolescents, and declining levels of some aspects of physical activity (e.g. personal transport), alongside an array of tempting sedentary pursuits, it appears opportune to provide this wide-ranging review. Specifically, we review the evidence for a link between physical activity and various markers of health in youth. Second,

we consider prevalence estimates of physical activity and sedentary behaviours in youth as these may not be the opposite sides of the same coin. Third, we review key determinants of physical activity in youth, again making a distinction between physical activity and sedentary behaviours. Fourth, we consider research on interventions designed to change physical activity behaviours in youth. Finally, implications for health policy are discussed with particular reference to the UK.

We adopt the behavioural epidemiology framework advocated by Sallis and Owen (1999). Behavioural epidemiology considers the link between behaviours and health and disease, such as why some people are physically active and others are not. In relation to physical activity, this framework has five main phases:

- 1 To establish the link between physical activity and health.
- 2 To develop methods for the accurate assessment of physical activity.

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- 3 To identify factors that are associated with different levels of physical activity.
- 4 To evaluate interventions designed to promote physical activity.
- 5 To translate findings from research into practice.

We will address phases 1, 3, 4 and 5 in the context of children and adolescents. For more detailed information on phase 2, see Welk (2002) and Welk *et al.* (2000).

Establishing the link between physical activity and health in youth

This section, reflecting phase 1 of the behavioural epidemiology framework, will examine the evidence relating to the following two issues: (1) Does physical activity in childhood and adolescence influence health in childhood and adolescence? (2) Does physical activity in childhood and adolescence influence health in adulthood? These issues will be examined with reference to studies of both disease and disease risk factors. The evidence will be assessed for five main outcomes: cardiovascular disease, overweight/obesity, psychosocial outcomes, type II diabetes and skeletal health. Although there is emerging evidence to suggest that physical activity in adulthood may prevent certain forms of cancer (Hardman, 2001), this topic has only recently begun to be addressed in children (Culos-Reed, 2002) and will not be explored further here.

Cardiovascular disease

Although cardiovascular disease (CVD) becomes evident in middle-age and beyond, the development of the disease begins in childhood and adolescence (McGill *et al.*, 2000). Moreover, data from the Bogalusa Heart Study indicates that CVD risk factors track from childhood into adulthood (Nicklas *et al.*, 2002). It is therefore logical to attempt to limit the development of CVD as early as possible, particularly in children and adolescents who exhibit CVD risk factors such as elevated cholesterol and blood pressure. Randomized controlled trials (RCTs) in adults have demonstrated that exercise has a beneficial influence on lipids/lipoproteins (Kraus *et al.*, 2002) and blood pressure (Whelton *et al.*, 2002). Although there are no RCTs in adults for cardiovascular disease, large-scale prospective studies continue to support a protective role of exercise (Manson *et al.*, 2002; Tanasescu *et al.*, 2002).

In children and adolescents, the evidence is much less robust. In their review of the effects of physical activity on blood lipids in adolescents, Armstrong and Simons-Morton (1994) concluded that cross-sectional studies indicate a beneficial effect of exercise but that

the results of longitudinal studies are 'unimpressive'. Another review of the influence of physical activity on blood pressure concluded that exercise might be of benefit for hypertensive adolescents, although it would not normalize blood pressure in such individuals (Alpert and Wilmore, 1994). More recently, Riddoch (1998) stated that physical activity has only weak associations with serum lipid and lipoprotein concentrations and with blood pressure in young people, and Tolfrey *et al.* (2000) concluded that the majority of longitudinal investigations 'suggest that imposed regular exercise has little, if any, influence on the lipoprotein levels of children and adolescents' (p. 100).

Although the evidence to date is not convincing, it is too early to discount a role for exercise in influencing CVD risk in children. It is clear from the reviews that many of the studies in this area lack 'rigour' (Armstrong and Simons-Morton, 1994). Methodological weaknesses include small sample size, inadequate exercise training volume and a lack of control individuals (Tolfrey *et al.*, 2000). Thus, the hypothesis that physical activity modifies CVD risk in children and adolescents has not been adequately tested. Moreover, it is possible that most children and adolescents have normal lipid/lipoprotein and blood pressure profiles that are not amenable to change through exercise (Despres *et al.*, 1990). If this is the case, then it may be more fruitful to focus on groups of children and adolescents who exhibit unfavourable CVD risk factor profiles. This suggestion is supported by the findings from a recent randomized intervention study demonstrating a beneficial effect of physical training on lipids and lipoproteins in a group of obese adolescents. In this study, the participants with the least favourable baseline lipid and lipoprotein concentrations exhibited the most beneficial changes (Kang *et al.*, 2002).

Some studies have examined the influence of physical activity and physical fitness in adolescence on CVD risk factors later in life. Five such studies were published recently: the Amsterdam Growth and Health Longitudinal Study (Twisk *et al.*, 2002b), the Muscatine Study (Janz *et al.*, 2002), the Northern Ireland Young Hearts Project (Boreham *et al.*, 2002), the Danish Youth and Sports Study (Hasselstrøm *et al.*, 2002) and the Leuven Longitudinal Study on Lifestyle, Fitness and Health (Lefevre *et al.*, 2002). The findings of these studies suggest that high physical fitness during adolescence and young adulthood is related to a 'healthy' CVD risk profile later in life, but that physical activity levels do not influence CVD risk in later life (Twisk *et al.*, 2002a). Moreover, in a recent review of this topic, Rowland (2001) concluded that there is no direct proof that activity in childhood provides protection from CVD in adulthood.

These findings could be interpreted in several ways. The lack of association between physical activity and CVD risk may be due to a difficulty in accurately measuring physical activity. On the other hand, the relationship between physical fitness and CVD risk may be a reflection of genetic predisposition for low levels of fitness and increased CVD risk in susceptible individuals independent of physical activity. These issues can only be addressed by future longitudinal studies that include frequent and accurate assessments of physical activity in youth and longer follow-up periods extending well into middle age and thus beyond the clinical horizon for CVD. In the meantime, the evidence suggests that from the point of view of future health status, it may be better to focus on physical fitness rather than physical activity in youth. However, greater energy expenditure may be more important for some health status measures, such as obesity. In addition, behavioural scientists might argue that a focus on the behaviour of physical activity is more appropriate for health behaviour change and maintenance than the outcome of physical fitness.

Overweight and obesity

Despite the lack of a standardized definition of obesity in children and adolescents, there is firm evidence that the prevalence of obesity is increasing in these groups in many countries around the world (Reilly and Dorosty, 1999; Chinn and Rona, 2001; Strauss and Pollack, 2001; Baur, 2002). This is a concern because obesity in youth is associated with a variety of conditions, including dyslipidaemia (Stensel *et al.*, 2001) and an increased risk of type II diabetes mellitus (Sinha *et al.*, 2002). Childhood obesity is also a strong predictor of obesity in adulthood (Whitaker *et al.*, 1997) and is associated with health problems in adulthood independent of adult weight status (Must *et al.*, 1992). Thus, efforts to prevent and manage obesity in youth should be taken seriously.

In adults (Jebb and Moore, 1999) and children (Steinbeck, 2001) there is evidence linking physical inactivity to the development of obesity. Most of this evidence is cross-sectional. There is a lack of evidence that physical inactivity precedes obesity in children and adolescents. Recent longitudinal studies have failed to demonstrate a firm link between low energy expenditure and obesity in children (Johnson *et al.*, 2000; Ekelund *et al.*, 2002; Salbe *et al.*, 2002a), although there is evidence to support such a link in adults (Weinsier *et al.*, 2002). Baseline adiposity appears to be the main determinant of subsequent fatness in longitudinal studies of obesity in youth (Johnson *et al.*, 2000; Salbe *et al.*, 2002b).

Despite the lack of firm evidence, there are good reasons for believing that physical inactivity is causally related to obesity in children. Changes to the gene pool are unlikely to explain the increased global prevalence of obesity and, in the absence of such changes, diet and exercise appear the most likely candidates (Goran and Treuth, 2001). There is evidence to suggest that children are expending significantly less energy today than their counterparts of 50 years ago (Durnin, 1992). Recent evidence also indicates that physical activity levels decline substantially during adolescence (Kimm *et al.*, 2002). Intervention studies are required to confirm or refute a role for physical inactivity in the development of childhood and adolescent obesity. In the absence of such studies, encouraging greater physical activity in children would seem a prudent step in attempting to stem the rising prevalence of obesity in youth.

Findings from studies examining the role of exercise training in the management of childhood obesity have been uninspiring. Intervention studies in the adolescent population show only a small (1–3% body fat) reduction in adiposity as a result of physical training. Longer programmes appear to be more effective than shorter programmes and lifestyle activities (e.g. walking to and from school) appear to have a more lasting influence than regimented activities (e.g. callisthenics or jogging) (Bar-Or and Baranowski, 1994). As with the other areas reviewed here, there is a shortage of controlled intervention studies examining the impact of exercise training on obesity in children and adolescents (Epstein *et al.*, 1996). Research indicates that exercise is likely to be most effective in ameliorating childhood and adolescent obesity when it is combined with appropriate dietary changes (Epstein *et al.*, 1998; Southern, 2001). The key to successful weight loss through exercise appears to be energy expenditure. In adults there is evidence that exercise alone can be effective in reducing adiposity provided that energy expenditure is sufficient (Ross *et al.*, 2000).

Psychosocial outcomes

There is widespread belief that physical activity is inherently 'good' for young people in respect of varied psychosocial outcomes. These include self-esteem, mood and cognitive functioning. A widely held view is that participation in sport is beneficial for moral behaviour. Despite such claims, the evidence is not always clear. While physical activity can enhance psychological well-being, the relationships are far from simple.

Mutrie and Parfitt (1998) reviewed literature on young people and mental, social and moral health. They concluded that physical activity can have positive

effects for mental health, most particularly for self-esteem, and those who are physically active are less likely to suffer from mental health problems. However, the evidence in this area is not extensive. Studies are largely cross-sectional, small-scale and lack measurement consistency. In addition, while physical activity may enhance psychological well-being, it is likely that the prevailing psychological climate and social interactions inherent in such settings will be more crucial than the physical activity itself. Unfortunately, such factors are rarely accounted for.

The literature on physical activity and psychological well-being in adults is extensive (Biddle *et al.*, 2000), and several meta-analytic reviews have been conducted (see Biddle and Mutrie, 2001). From these reviews, one can glean information pertaining to mental health effects of physical activity in youth. For example, a meta-analysis of exercise and anxiety reduction (Petrusello *et al.*, 1991) reported an effect size for those under 18 years of age of 0.20 for state anxiety ($K=21$, where K =number of effect sizes), 0.47 for trait anxiety ($K=3$) and 0.38 for psychophysiological indices of anxiety ($K=8$). These compare with effect sizes of 0.24, 0.34 and 0.56 for all ages, respectively, suggesting anxiety-reducing effects of exercise are slightly less for younger people. However, with few studies in some categories, this conclusion requires further testing. North *et al.* (1990) reported an effect size for exercise and reduced depression of 0.49 ($K=5$) for those under 18 years, compared with an overall effect size of 0.53 ($K=290$) across all ages.

Cross-sectional survey data support the results of meta-analyses. For example, Steptoe and Butler (1996) report, in a sample of over 5000 British adolescents, that emotional well-being is positively associated with participation in vigorous recreation and sport. Similar results were found by Hendry *et al.* (1989) in Scotland, also with a large cohort ($n=5862$).

The relationship between physical activity and cognitive – or academic – performance is unclear (Mutrie and Parfitt, 1998). A recent study showed no effects of a health-related physical education programme on academic achievement (Sallis *et al.*, 1999). Many studies are not well designed and where effects have been reported, these cannot be attributed solely to physical activity.

Type II diabetes

Type II diabetes has traditionally been considered as a disease that occurs in adulthood – hence the term adult-onset diabetes. In recent years, however, cases of type II diabetes have been reported in children and adolescents (Sinha *et al.*, 2002). Moreover, the prevalence of type II diabetes in children and adolescents has increased to

such an extent that some scientists are now talking of an ‘epidemic’ of diabetes in the young (Rosenbloom *et al.*, 1999; Rocchini, 2002). Until recently, the reported cases of type II diabetes in children and adolescents were restricted to minority groups in the USA such as Pima Indians, African Americans and Mexican Americans, and to Japanese children (Rosenbloom *et al.*, 1999). Last year, however, four cases of type II diabetes were reported in white adolescents aged 13–15 years from England (Drake *et al.*, 2002).

The emergence of type II diabetes in children and adolescents is very likely related to the increased prevalence of childhood obesity (Rocchini, 2002). A recent study from the USA has documented the prevalence of impaired glucose tolerance in obese children for the first time (Sinha *et al.*, 2002). Impaired glucose tolerance was found in 25% of 55 obese children aged 4–10 years and in 21% of 112 obese adolescents aged 11–18 years. Moreover, follow-up analysis was performed in two 6-year-old children found to have impaired glucose tolerance. Both children subsequently developed type II diabetes, one at age 8 and the other at age 11. These findings are a great cause for concern bearing in mind the increasing prevalence of childhood obesity in many countries worldwide, including the UK.

At present there are no intervention trials examining the role of exercise in preventing type II diabetes in children or adolescents. Recently, however, two RCTs have been conducted to assess the role of lifestyle intervention in preventing type II diabetes in adults. These are the Finnish Diabetes Prevention Study (Tuomilehto *et al.*, 2001) and the Diabetes Prevention Program in the USA (Diabetes Prevention Program Research Group, 2002). Exercise was a major component of the lifestyle intervention in both of these studies and both found such an intervention to be effective in preventing type II diabetes. There is evidence that exercise can improve glycaemic control in insulin-resistant offspring of diabetic parents (Perseghin *et al.*, 1996) and in adults with type II diabetes (Boulé *et al.*, 2001). Therefore, exercise should be helpful in the prevention and treatment of type II diabetes in children, although evidence to support this statement is not currently available.

Skeletal health

In the UK, osteoporosis affects one in three women and one in twelve men over the age of 50 and results in 70,000 hip fractures, 50,000 wrist fractures and 40,000 spinal fractures annually (National Osteoporosis Society Online, 2002). Osteoporosis is largely associated with ageing and its prevalence may be expected to increase in the future because people are living longer.

Peak bone mass is predominantly under genetic control but there are environmental influences, including diet and physical activity (Ralston, 1997). Therefore, physical activity in childhood and adolescence may be a means of maximizing bone development, thus preventing osteoporosis later in life.

Intervention trials have shown that weight-bearing activity (any activity done standing up, such as walking, jumping and weight lifting) is effective in increasing bone mineral density in children and adolescents (Bass, 2000; French *et al.*, 2000; MacKelvie *et al.*, 2002). The most consistent findings are for the femoral neck, total bone mineral density and lumbar spine (French *et al.*, 2000). Increases in bone mineral density due to exercise in children and adolescents have ranged from 2 to 30% (Bass, 2000), although increases of between 5 and 15% are more typical (Boreham and Riddoch, 2001).

Approximately one-quarter of final adult bone is accumulated during the two years surrounding peak bone velocity (at approximately 12.5 years in girls and 13.5–14.0 years in boys), and this is similar to the amount of bone lost during the post-menopausal years (Bailey, 1997). In view of this, MacKelvie and colleagues (2002) have speculated that there may be a 'window of opportunity' for bone development in early puberty providing an optimal period for bone to respond to exercise. Alternatively, Bass (2000) has proposed that the pre-pubertal years may provide the best opportunity for exercise-induced bone development, owing to the optimal amounts of growth hormone at this time. There is currently insufficient evidence to confirm or refute either of these suggestions.

There are no longitudinal studies to demonstrate that gains in bone mineral density during childhood and adolescence are maintained into adulthood or that such gains reduce fracture risk in later life (MacKelvie *et al.*, 2002). Retrospective studies are available suggesting a persistent effect of exercise on bone mineral density in previously elite, retired ballet dancers (Kahn *et al.*, 1998) and gymnasts (Bass *et al.*, 1998). Conversely, a study of male soccer players who had been retired for 35 years did not detect any differences in bone mineral density and fracture risk compared with controls (Karlsson *et al.*, 2000).

Long-term follow-up studies are required to determine whether bone mineral density gains attained through exercise interventions in childhood and adolescence are maintained into adulthood or whether the interventions merely accelerate the achievement of a predetermined bone mass (MacKelvie *et al.*, 2002). Future research is also required to determine if exercise in youth influences bone structure, and thus bone strength, independently of changes in bone density (Bass, 2000).

Health outcomes: conclusions

In a previous review, Riddoch (1998) concluded that 'no single study, or set of studies, provides definitive evidence for a meaningful health gain through being an active child' (p. 30). This conclusion remains valid. There is some evidence that high levels of physical activity in childhood and adolescence can benefit CVD risk factors, adiposity and bone health, but in many studies the relationships are weak to moderate. Moreover, there are no convincing studies linking health in adulthood with childhood activity patterns. There is, however, evidence to link infectious and non-infectious disease in childhood with poor health in adulthood (Blackwell *et al.*, 2001). Thus, it is plausible that activity that influences adiposity, bone health or CVD risk in childhood could influence health in adulthood.

One possible reason why many studies have been unable to detect health benefits from physical activity in youth is a lack of accuracy in the assessment of physical activity combined with a lack of sensitivity in health risk markers (Fox and Riddoch, 2000; Molnar and Livingstone, 2000). For example, it is unlikely that some markers of health outcomes of inactivity will be sufficiently clear until early or late adulthood, even though inactivity in youth may be a precursor to such effects. It is also clear that the study designs used in many investigations are insufficient to provide sound evidence of the benefits of physical activity in childhood and adolescence. In particular, cross-sectional and retrospective studies, although informative, cannot provide proof of causality. Rigorous, well-controlled intervention trials are required to further assess the effects of physical activity and exercise in youth on youth health status. Large-scale longitudinal studies spanning childhood, adolescence and adulthood are needed to determine with confidence whether or not physical activity in youth benefits future health status. Clearly, it will be some time before such evidence is available.

In the absence of definitive data we must make conclusions based on expert reading of the available evidence of the health benefits of physical activity in youth. There have been large increases in the prevalence of obesity in children and adolescents in recent years. Associated with this has been the emergence of type II diabetes in these groups. In adults there is convincing evidence linking physical inactivity with the development of both obesity and type II diabetes. Moreover, both physical activity and physical fitness are independent risk factors for CVD and all-cause mortality in adults (Erikssen, 2001). In light of such evidence, it is unlikely that physical activity will not provide some benefit to children and adolescents and it

would appear prudent to encourage physical activity in such groups.

Prevalence of physical activity and sedentary behaviours¹

Previous reviews (Armstrong and Van Mechelen, 1998; Stone *et al.*, 1998) of physical activity participation studies conducted in Europe, Australia and North America during the late 1980s and early 1990s have concluded that at least 50% of children and adolescents are insufficiently active for health. Although definitions of physical activity varied across the reviewed studies, in general sufficient activity was defined in line with the activity guidelines suggested by the US Surgeon General (Department of Health and Human Services & Centers for Disease Control and Prevention, 1996), National Association for Sport and Physical Education (NASPE, 1998) and the Health Education Authority in England (Biddle *et al.*, 1998b). Furthermore, these reviews have shown that girls are less active than boys, but the age-related decline in activity levels has not been consistently reported. Although it is often stated that the decline is more pronounced in girls, a recent symposium showed the opposite (Sallis, 2000; Telama and Yang, 2000; Van Mechelen *et al.*, 2000). This may be due to greater initial levels of activity in boys, although the inconsistency of conclusions may be the result of the time points studied. Certainly, the findings showing boys to be more active than girls as well as the steep decline across the period of adolescence are robust and appear to hold across westernized countries despite measurement and methodological differences.

Several nationally representative studies have now been published. A recent large pan-European survey of approximately 1300 11-, 13- and 15-year-olds in each of 25 European nations (World Health Organization, 2000) found that patterns of involvement were similar across countries and that about 65% of boys and 47% of girls participate in vigorous exercise two or more times per week and about 80% of boys and 63% of girls participate in vigorous exercise for two or more hours per week. Vigorous exercise was defined as at least slow jogging that made you 'out of breath and a little sweaty'. Data were also collected in Canada and the USA as part of this survey and the findings were similar to the other data. Differences between the sexes noted in previous reviews continue to be found in all countries. These results are somewhat encouraging, as they show relatively good levels of participation in vigorous exercise, but data for participation in moderate exercise

were not collected, so it is not possible to comment on the proportion of individuals who are sufficiently active. The 1992 US National Health Interview Survey–Youth Risk Behavior Survey (NHIS-YRBS) conducted with 10,645 Americans aged 12–21 years found that around 12% of young males and 15% of young females had not participated in vigorous or moderate physical activity during the previous week, and the prevalence of inactivity increased with age. In contrast, approximately 60% of young males and 49% of young females had participated in vigorous activity on three or more days during the previous week (Department of Health and Human Services & Centers for Disease Control and Prevention, 1996).

In the 1995 school-based US Youth Risk Behavior Survey (YRBS) of 10,904 students in grades 9–12 (15–18 years of age), 7% of males and 14% of females reported no vigorous or moderate physical activity in the preceding week but 76% of males and 57% of females had participated in vigorous physical activity on at least three days in the previous week (Department of Health and Human Services & Centers for Disease Control and Prevention, 1996). Vigorous activity was defined as exercise or sports participation that makes you sweat or breathe hard for at least 20 min. A national survey in New Zealand (Sport & Recreation New Zealand (SPARC), 2002) showed that only about 30% of young people were insufficiently active for health (defined as less than 2.5 h of sport or active leisure in the previous week), suggesting that in some countries at least, participation rates, while not ideal, are better.

While the more recent results can be viewed as encouraging, it remains a concern that a sizeable proportion of young people continue to have what might be described as an 'inactive' lifestyle. It must also be remembered that it is problematic to compare across both surveys and time, as different measures of physical activity have been employed and the criteria for 'sufficient' activity has changed as the focus has moved from physical activity for aerobic fitness to physical activity for health. While the practicalities of large studies often necessitate the use of self-report measures of recent participation, the limitations of this approach should not be ignored (e.g. potential for self-report bias, errors in recall, gaining an accurate picture of habitual activity; Snel and Twisk, 2001).

A frequent assumption in both the academic and popular media is that young people today are less active than in previous generations. However, there is insufficient direct data at both the behavioural (e.g. participation rates) and physiological (e.g. aerobic fitness) level to argue convincingly in favour of this assumption (Sallis *et al.*, 1992; Cavill *et al.*, 2001), although personal transport patterns are changing and

¹ The contribution to this section of Dr Simon Marshall, San Diego State University, is gratefully acknowledged.

energy expenditure appears to have declined in children (Durnin, 1992). For example, male teenagers now cycle half the distance they did 20 years ago, while 20% of motorized traffic during the immediate pre-school period is involved with transporting children to school. This reflects a dramatic decline in physically active transport to school and a general decline in children's walking and cycling (DiGiuseppi *et al.*, 1997). We believe this requires greater emphasis in future discussions of young people's physical activity patterns.

Another way of attempting to address the question of whether young people are less active than in previous generations is to examine the prevalence, incidence and secular trends in actual sedentary behaviours (e.g. TV viewing, computer use, 'hanging out') in young people. If these have increased, then, in line with the 'displacement hypothesis', there may be less time for physical activity (British Heart Foundation, 2000). The displacement hypothesis suggests that sedentary pursuits, such as TV viewing, will displace more active pursuits.

Estimates of total media use among western adolescents are approximately 40 h per week, or around 5 h per day (Robinson and Killen, 1995; Stanger, 1997, 1998; Roberts *et al.*, 1999; Stanger and Gridina, 1999; Woodard and Gridina, 2000). Of this, approximately 2½ to 3 h per day appears devoted to TV viewing (A.C. Nielson Company, 1990; Kimm *et al.*, 1996; Stanger, 1997, 1998; Gordon-Larsen *et al.*, 1999; Roberts *et al.*, 1999; Stanger and Gridina, 1999; Woodard and Gridina, 2000). Incidence and prevalence estimates of other media use in North American youth aged 6–17 years suggest they spend approximately 0.91 h per day watching videos, 0.84 h per day reading books, 0.63 h per day playing video games, 0.77 h per day using the computer/internet, 0.52 h per day talking on the telephone and 0.35 h per day reading magazines and newspapers (Stanger, 1997, 1998; Stanger and Gridina, 1999; Woodard and Gridina, 2000). Comparable data outside of the USA are lacking. However, two cross-national studies of youth age 11–15 years in Europe and Canada have found that approximately 30% of boys and 10% of girls play video games for more than 4 h per week and 23% of boys and 16% of girls watch videotapes for more than 4 h per week (World Health Organization, 1996, 2000).

Prevalence estimates from North America suggest that approximately 23% of girls and 29% of boys aged 8–16 years watch TV more than 4 h per day (Andersen *et al.*, 1998). Similar estimates are evident in European countries (25% and 31% of girls and boys aged 11–15 years, respectively) (World Health Organization, 1996, 2000). Together, these trends suggest that less than one-third of adolescents watch television for more than 4 h per day, a level twice that recommended by the American Academy of Pediatrics (1986).

As with physical activity, secular data on sedentary behaviours are limited. However, early studies on TV viewing (Himmelweit *et al.*, 1958; Schramm *et al.*, 1961; Lyle and Hoffman, 1972; Greenberg, 1976) revealed that previous generations of young people (11- to 17-year-olds in the 1960s and 1970s) watched TV for approximately 3.1 h per day, a figure remarkably consistent with current estimates. One study by Schramm *et al.* (1961) revealed that 11- and 17-year-olds in the late 1950s spent approximately 37 and 36 h per week, respectively, engaged with mass media (e.g. TV, radio, vinyl records, comic books) outside of school times and homework. This compares with more recent estimates of 37 h per week of total media use (Roberts *et al.*, 1999). Thus, while the content of media has changed, the absolute volume appears remarkably stable, possibly suggesting a maximum time that young people can devote to it. These secular data, while limited by measurement issues and scope, suggest that the sedentary behaviours frequently blamed for keeping young people from being active (Sallis *et al.*, 1992) are not more prevalent than in previous generations, and while they are undeniably popular pastimes among youth, are unlikely to be displacing physical activity. In fact, there is recent evidence that there is time for both in the lives of young people (Marshall *et al.*, 2002a,b). A recent survey by Sport England showed no change in the number of hours of weekly TV viewing for young people between 1999 and 2002, but there was a slight increase in hours devoted to sport and exercise (Sport England, 2003).

Determinants and correlates

Phase 3 of the behavioural epidemiology framework seeks to identify factors that are associated with participation in physical activity. Typically, this is referred to as the study of physical activity determinants or correlates. The term 'determinants' has been adopted by many writers in the field and it refers to 'reproducible associations that are potentially causal' (Buckworth and Dishman, 2002, p. 191), rather than necessarily causal effects.

Many reviews exist on the determinants of physical activity across the lifespan (Biddle and Mutrie, 2001), including reviews on children and youth (De Bourdeauhuij, 1998), but the most comprehensive and systematic is that of Sallis *et al.* (2000b). We will discuss the key determinants of young people's physical activity by focussing on the key findings from this review. Where possible, a distinction will be made between children (less than 13 years of age) and adolescents (13–18 years). We adopt an ecological approach (Sallis and Owen, 1996, 1999) by considering determinants from

multiple environments, including intra-personal (e.g. psychological), inter-personal (e.g. social) and physical environments. We only refer to data from industrialized countries because other settings (e.g. developing countries) are likely to have different patterns of physical activity, and hence different determinants to that in the UK. Following a summary of findings on physical activity, we then address sedentary behaviours.

Determinants of physical activity

Sallis *et al.* (2000b) reviewed all studies published on children and youth between 1970 and 1998 where determinants were tested for their association with a measure of physical activity. Studies with a primary emphasis on sport participation were excluded, which is a weakness given the importance of sport as a component of young people's physical activity. For example, Vilhjalmsson and Kristjansdottir (2003) have shown that for a nationally representative sample of Icelandic youth, membership in and withdrawal from sport programmes were significant factors in explaining differences in physical activity between the sexes.

Sallis *et al.* (2000b) considered a variable to be associated with physical activity if such a link was statistically significant. This could include small effect sizes for large samples and exclude moderate or large effects for small samples. In addition, they included any variable that had been the subject of at least three studies and reported a consistent association where the majority of studies supported the expected association. For children aged 4–12 years, 54 studies were reviewed, with 76% being cross-sectional and 80% from the USA. For adolescents aged 13–18 years, 54 studies were reviewed, with most being cross-sectional (83%) and from the USA (68%).

Demographic and biological variables

Results from Sallis *et al.* (2000b) for demographic and biological variables in children suggested that greater physical activity was associated with being male and, surprisingly, having an overweight parent. This difference between the sexes is a highly consistent finding (Wold and Hendry, 1998; Van Mechelen *et al.*, 2000; Vilhjalmsson and Kristjansdottir, 2003). Inconsistent findings were reported for age and body weight/fatness, while socio-economic status and ethnicity were unrelated to physical activity in this age group. For adolescents, greater physical activity was found for boys than girls and for non-Hispanic whites than all other ethnic groups. Less physical activity was associated with increasing age. Body weight/fatness was inconsistently associated and socio-economic status was unrelated to physical activity. Recent qualitative research (Mulvihill

et al., 2000) suggests that body weight *per se* may be less important than perceptions of body image and self-presentation in physical activity settings.

The finding of Sallis *et al.* (2000b) that socio-economic status is not consistently related to physical activity is surprising and contradicts evidence from other sources. For example, Wold and Hendry (1998) report on the social inequalities in participation that are likely to be reproduced across generations. This social reproduction may be accounted for through the social position of parents and their level of physical activity, as well as the link between education and access to sports clubs. As McElroy (2002) states, the primary significance of socio-economic status (or 'social class') is that it determines life choices.

Psychological variables

For children, less physical activity was associated with greater perceived barriers, while greater activity was related to intentions and preferences for physical activity. For adolescents, only achievement orientation, perceived competence and intention to be active were positively associated, and depression negatively associated, with physical activity. Although not always supported by Sallis *et al.* (2000b), a consensus statement from England (Biddle *et al.*, 1998b; Cavill *et al.*, 2001) suggested that activity may also be related to perceptions of enjoyment, self-efficacy, competence, control and autonomy, positive attitudes towards activity, and a perception of few barriers and many benefits. However, much of this research is cross-sectional using self-report measures of unknown validity. Better research designs are required.

For young people, qualitative research (Mulvihill *et al.*, 2000) has shown that many barriers emerge during the time of transition to secondary school. For example, greater embarrassment and self-consciousness concerning their bodies, especially for girls, and perceived time pressure from homework were barriers to physical activity. Conversely, young people reported being motivated for physical activity by feelings of well-being, enjoyment and possible weight control. Indeed, the apparent 'moral panic' often portrayed in the popular media when young people and physical activity are discussed is not apparent from motivational profiles of a national sample of English teenagers (Wang and Biddle, 2001). Specifically, of 2510 students aged 12–15 years, under one-third were classified as 'poorly motivated' (16.8%) or 'amotivated' (14%), while 43.6% had clearly positive motivational profiles. The amotivated group was characterized by low perceptions of competence and physical self-worth and had feelings that sport ability cannot easily be developed. In addition, they were motivated largely through extrinsic factors, such as

teacher pressure, and felt that there was little point in participating. Twice as many girls than boys were members of this group.

Behavioural variables

For children, Sallis *et al.* (2000b) found that only healthy diet and previous physical activity had consistent positive associations with activity, whereas for adolescents it was sensation seeking, previous activity and participation in community sports. The latter confirms our earlier point that Sallis *et al.* may have been too restrictive in not reviewing studies where sport was the primary focus. No consistent association was found between physical activity and sedentary behaviours in children (e.g. TV viewing), but time in sedentary pursuits in adolescents after school and at weekends was inversely related to physical activity. More will be said on this later when we specifically address inactivity.

Social variables

No social variables were clearly associated with childhood physical activity (Sallis *et al.*, 2000b). For example, only 38% of 29 studies showed an association between parental and child physical activity, a result supported by data on adolescents. However, for the latter age group, parental support was positively associated with activity. McElroy (2002) states that results on parental modelling effects are mixed but that positive links may be created through parents instilling perceptions of competence in their children. The role of parents in youth physical activity requires greater scrutiny.

Sallis *et al.* (2000b) found that sibling physical activity was consistently associated for adolescents, whereas other social factors (e.g. peer modelling, perceived peer support) were not. A review by Wold and Hendry (1998) provides support for the view that some peer influence is likely, arguing for a link via friendship patterns. This is supported by the qualitative findings of Mulvihill *et al.* (2000).

One theoretical model that has received a great deal of attention is that of the Theory of Planned Behaviour, and its predecessor the Theory of Reasoned Action (Ajzen, 2001). In applying this model to physical activity, behaviour is predicted by intentions, which are, in turn, predicted by attitudes, subjective norms and perceived behavioural control. In the context of social factors, the variable of subjective norms is important because it reflects the normative beliefs of significant others and the extent to which people wish to comply with such social pressure and influence. In a recent meta-analysis of studies using the Theory of Planned Behaviour for both adults and youth, Hagger *et*

al. (2002) found that subjective norm was a small but significant predictor of physical activity intentions and that this was not moderated by age. However, attitudes, perceived behavioural control, self-efficacy and past behaviour were all stronger influences.

Physical environment variables

For children, Sallis *et al.* (2000b) found that access to facilities and programmes, as well as time spent outside, were consistently associated with greater physical activity. For adolescents, the general variable of 'opportunities to exercise' was associated with activity. Physical environment variables are likely to increase in importance as our built environment, in particular, develops at a pace. This can have significant effects on our physical activity and can create what might be referred to as 'activity toxic environments', in which personal transport is less likely to involve much energy expenditure (Haines *et al.*, 2000). Indeed, less than 9% of 7- to 8-year-olds now travel to school unaccompanied by an adult, compared with 80% in the early 1970s. This has been attributed to parental fear of traffic (Davis, 1999; see also Jones and Davis, 2001). As stated by Frank and Engelke (2002), 'the relative costs and benefits of the locational and travel choices that are currently available have resulted in a built environment designed to accommodate the car – at the measurable expense of the ability to move about under human power' (p. 8).

Determinants of sedentary behaviours²

Young people – indeed all people – face an array of opportunities for sedentary behaviour in their day-to-day lives. Many children and youth find these behaviours more reinforcing than physically active alternatives (Epstein *et al.*, 1991; Vara and Epstein, 1993). Although recent studies have attempted to understand the factors that influence physical activity habits of children and adolescents, as reviewed, few have focused on factors that mediate actual patterns of inactivity. This is surprising because it would appear self-evident that we need to understand the appeal of inactivity in addition to the level of appeal that physical activity might have.

Understanding why and how young people engage in sedentary behaviour will provide more leverage for intervention efforts designed to encourage lifestyles that are more physically active. However, we know very little about the underlying biological, psychosocial and behavioural mechanisms underlying habitual sedentari-ness in young people. Existing data are largely

² The contribution to this section of Dr Simon Marshall, San Diego State University, is gratefully acknowledged.

descriptive and the mechanisms by which sedentary behaviours contribute to negative health outcomes, particularly obesity, are not well understood. One of the problems in this field is that sedentary behaviour itself is rarely assessed. Instead, 'activity absence' is measured. For example, many studies assess how much physical activity young people do, and then simply classify people into groups based on such scores. One group might be labelled 'inactive' or 'sedentary', but we know nothing about what they actually do. Equally, assessment can be made of sedentary pursuits, such as TV viewing, and on this basis people might be classified as 'inactive'. Activity and inactivity, therefore, are viewed as opposite sides of the same coin (Owen *et al.*, 2000). Indeed, a so-called 'displacement hypothesis' has support in the popular and professional literature (British Heart Foundation, 2000) by assuming that inactive behaviours must necessarily prevent more active ones. Logical though this may sound, evidence suggests this to be false when individual sedentary behaviours are concerned. We concur with Owen *et al.* (2000): 'although sedentary behaviour may arguably be conceptualised as no more than the other side of the physical activity coin, we see it as a class of behaviours that can coexist with and also compete with physical activity' (p. 156). Our own research (Marshall *et al.*, 2002b) has shown this through very small positive correlations between selected sedentary behaviours (e.g. TV viewing, video games) and physical activity in youth, suggesting that there is time for both (see Fig. 1). Using cluster analysis, we found that three clusters each for boys and girls reflected an interaction between physical activity and a profile of sedentary behaviours. For example, 40% of boys featured in a 'techno-active' cluster, characterized by higher than average TV and video game use but also above average physical activity.

Research is required that identifies determinants of such patterns of behaviour. What these early findings on

sedentary behaviours suggest is that determinants for physical activity are likely to be different from those for sedentary behaviours. This assumption is based on data showing little correlation between individual sedentary behaviours and physical activity (Marshall *et al.*, 2002b; Sallis *et al.*, 2000b) and signs that physically active behaviours are more likely to occur at different times of the day than TV viewing and other sedentary pursuits (Marshall *et al.*, 2002a). Of course, continued involvement in sedentary pursuits across the day will eventually preclude active behaviours, but our key point is that certain sedentary pursuits often 'blamed' for inactive lifestyles, such as TV viewing, appear uncorrelated with physical activity.

Interventions promoting physical activity

Phase 4 of the behavioural epidemiology framework seeks to evaluate interventions designed to promote physical activity. Typically in child and adolescent populations, these interventions have been school-based because of the large number of young people that can be reached through schools and the associated health and physical education (PE) curricula (Sallis *et al.*, 1992; Almond and Harris, 1998). There is increasing recognition of the importance of family and community level interventions, particularly as the majority of young peoples' activity occurs outside of school hours, and physical education alone is unlikely to provide sufficient activity for significant health benefits to be accrued. Family level interventions are viewed as important because of the influence of family environment, particularly parental support in adolescence (Sallis *et al.*, 2000a), on physical activity patterns (Sallis, 1998). At the community level, agencies such as general practitioners and community youth organizations have the potential to further influence the attitudes and behaviour of young people. Few intervention studies have included more than one of these levels. Evidence at each of these levels will be reviewed.

When considering intervention effectiveness, it is necessary to first decide the outcome variable on which ratings of effectiveness will be based. For example, effectiveness could be gauged in terms of physiological changes (e.g. aerobic fitness), cognitive changes (e.g. knowledge), affective changes (e.g. attitudes) or behavioural changes (e.g. changes in amount of physical activity). While arguably change at all these levels is important, it has been suggested that because the health benefits of physical activity in youth are transitory, it is most important to establish patterns of regular participation in youth that can be carried into adulthood and, therefore, effectiveness should be gauged on both short- and long-term behavioural changes (Pate *et al.*, 2000;

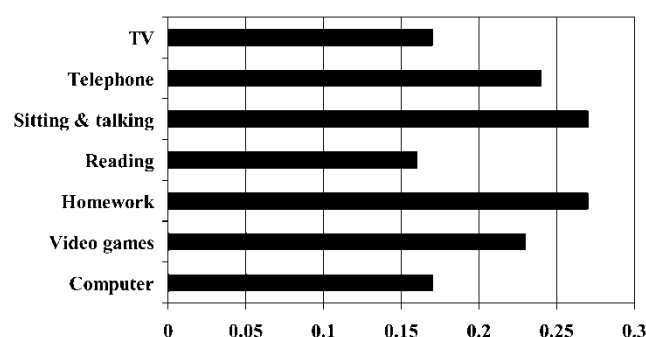


Fig. 1. Polychoric correlations between seven sedentary behaviours and a composite measure of physical activity, showing zero-to-small positive associations (data from Marshall *et al.*, 2002b).

Richter *et al.*, 2000; Sallis *et al.*, 1992). Thus behavioural changes will be prioritized in this review and other changes will be highlighted only briefly. This section builds on reviews by Almond and Harris (1998), Sallis (1998) and Stone *et al.* (1998).

School-based interventions

A review by Almond and Harris (1998) on the effectiveness of interventions based within the PE curriculum showed that most intervention studies that achieved positive results involved non-standard PE programmes that included additional PE time, the sustainability of which is questionable. The work reviewed was criticized for involving largely short-term interventions with few longitudinal designs. Perhaps more crucially these authors concluded that the extant literature did little to improve understanding of what kinds of programmes or what aspects of programmes bring about health gains or valued outcomes.

Physical education is an important site for physical activity accrual, particularly as young people go through adolescence (McKenzie *et al.*, 2000), but it does not provide sufficient activity for students to achieve recommended levels of activity; therefore, the influence of PE-based interventions on extra-curricular activity levels should also be evaluated. Stone *et al.* (1998) reviewed studies that had physical activity behaviour as an outcome variable and found that while school-based programmes might increase physical activity during physical education, they had limited success in improving participation in out-of-school physical activity. This finding highlights the difficulty of using school programmes to achieve change in behaviour outside of school hours. It is unrealistic to expect schools to be able to facilitate such changes without the support of families and communities (Wechsler *et al.*, 2000). Students spend only some of their time in schools and must return every evening and weekends to environments that may send powerful alternative messages to what they receive at school (Resnicow *et al.*, 1996). It is critical, therefore, that interventions are designed to integrate changes across multiple levels and sites and that they are evaluated to determine the relative influence of each component (e.g. the Child and Adolescent Trial for Cardiovascular Health (CATCH): Luepker *et al.*, 1996; Sports Play and Active Recreation for Kids (SPARK): Sallis *et al.*, 1997).

The role of the environment in influencing behaviour has been recognized. However, aside from changes to the PE curriculum, the effects of other school environment influences on physical activity behaviour have not received significant research attention (Wechsler *et al.*, 2000). Wechsler and colleagues reviewed research examining four potentially influential school environ-

mental factors for physical activity: break (recess) periods, intramural sports and physical activity programmes, facilities that support physical activity, and psychosocial support for physical activity. These authors demonstrated that limited data on the contribution of these factors to the physical activity levels of young people are available and while a logical argument can be made for their potential influence, research investigating how and in what circumstances these environmental factors operate is required. The results of the Middle-School Physical Activity and Nutrition project (M-SPAN: McKenzie, 2001) should provide some initial insight into this issue. The M-SPAN project investigated whether school environmental changes can lead to improved physical activity and dietary habits of middle school children.

A recent study by Stratton (2000) examined the effects of changing playground markings on the activity levels of primary aged (5–7 yrs) children during break times. Results showed that playground markings had a significant and positive effect on physical activity levels, but changes in a control group demonstrated that other factors also influenced behaviour during the intervention period, such as availability of skipping ropes and balls, and increased time allowed in the playground. While this study was limited by sample size, its results highlight the importance of investigating multiple environmental influences within one study. Understanding how individual school environmental factors interact to influence behaviour will also be important, as it is likely that environmental interventions will be most effective when they are integrated across several factors, deliver a unified message and are supported by all levels of school administration (Wechsler *et al.*, 2000). To get the clearest understanding of these influences and interactions, it is probable that case studies will be most effective, as the in-depth data derived from such an approach might allow greater elucidation of what works, in what situation and why.

Family interventions

Sallis (1998) argues that family interventions are important because of the many potential avenues for parental and sibling influence (e.g. modelling, social support, transportation). However, his review demonstrates that the effectiveness of family level interventions is generally poor for healthy populations but more effective among low-fit or obese populations. Where family level interventions have been included within multi-level interventions, the specific effect of the family-based intervention has been limited. For example, the CATCH intervention included a home/family component designed to reinforce the classroom intervention curriculum. Nader *et al.* (1996) evaluated the

family component and concluded that it resulted in improved knowledge and attitudinal effects but did not influence behaviour change beyond that achieved through the school-based component. There was some evidence of a dose-response effect, with families demonstrating greater parental involvement showing the most change. The authors argued that the lack of specific behaviour change may result from the low intensity of the home-based intervention. They also noted a differential effect for gender and ethnicity, suggesting that family interventions may need to be more specifically targeted along these dimensions. There is a need to know more about the family as a unit for intervention and it is likely that this will be best gained through qualitative work because it is likely that different family members will view the same event in different ways. This may require in-depth qualitative exploration.

Community interventions

The majority of interventions have been at the school or family level; however, there is increasing recognition that involvement of the community at all levels is important for interventions to be effective (Sallis, 1998; Pate *et al.*, 2000). It seems logical that young people are more likely to adopt healthy physical activity habits if they receive consistent messages across a variety of community settings and from a variety of sources. However, few studies have examined community interventions for young people and those that have been conducted have produced equivocal results (see reviews by Stone *et al.*, 1998; Pate *et al.*, 2000). For example, the two studies reviewed by Pate *et al.* were the Class of 1989 and Minnesota Heart Health Program Study and the Active Winners Study. The first of these, which includes both school and community intervention components, showed that physical activity declined over time in both the intervention and the control group but the decline was smaller in the intervention group. However, the intervention group in the Active Winners programme showed no significant changes in physical activity or physical fitness relative to a control group, although the girls in the intervention group had significantly increased intentions to exercise. Despite the equivocal results, Pate *et al.* (2000) concluded that there is some evidence for the feasibility of community approaches.

Although there are examples of physical activity interventions for adults delivered through primary health care that show modest positive effects (e.g. Calfas *et al.*, 1996), this vehicle has not been widely employed with youth populations (Sallis *et al.*, 2000a). The only published example that could be found with non-clinical populations was the initial evaluation of the

Patient Centered Assessment and Counseling for Exercise plus Nutrition (PACE+) programme (Patrick *et al.*, 2001). In PACE+, 117 adolescents from four paediatric and adolescent medicine clinics were recruited into the programme. All participants completed a computerized assessment of their physical activity and nutrition behaviour and received counselling from their health care provider. Participants were then randomly assigned to one of four groups for follow-up contact over the next 4 months: no further contact, frequent mail, infrequent mail and telephone, or frequent mail and telephone. Post-intervention surveys to all participants were then administered by telephone interviews. Results showed that PACE+ participants improved their moderate but not vigorous physical activity participation over time. No effect for follow-up condition was noted. The authors acknowledge that these findings are limited due to the lack of a control group (a randomized trial of PACE+ is now underway), but suggest that despite this the initial findings support the feasibility of using primary care settings to change moderate-intensity physical activity behaviour in youth.

Intervention considerations

For interventions to be critically evaluated, they require clearly defined and measurable goals that are based on the best available evidence defining valued outcomes. In experimental intervention research, the use of random assignment and control groups is necessary. Where qualitative approaches are employed, sufficient detail and description must be given to ensure the usefulness and transferability of results. Longitudinal studies are required so that the effects of changes as a young person on adult behaviour can be elucidated. For example, is the goal of preparation for a physically active life achieved? Interventions are likely to be most successful when they consistently target the same behaviour across a number of sites in which an individual engages.

The content of intervention programmes must be carefully considered in light of the desired outcome. If this outcome is the oft-cited 'lifelong physical activity', then the provision of structured activity programmes must be questioned for how they prepare young people for adult activity, which is typically unstructured. Similarly, the content of PE intervention programmes and games-based curricula must also be reviewed in terms of this goal (Harris, 1997). Programmes aimed at promoting activity across the lifespan should focus on the development of activities and skills 'that promote generalization and maintenance of physical activity during youth and adolescence and enhance the probability of carryover to adulthood' (Sallis *et al.*, 1992, p. S255). This is not a new argument (Corbin *et al.*,

Table 1. Principles of ecological approaches to health behaviour change applied to physical activity in young people (based on Sallis and Owen, 1996).

Principle	Description	Examples of application to physical activity in young people
Multiple dimensions of influence on behaviour	In addition to intra- and inter-personal influences, ecological models include social, cultural and physical environments as important influences on health behaviours	Social 'acceptance' of physical activity in different cultural groups, such as Muslim girls, white working-class boys, young children, older adolescents, etc. Inhibitory physical environment for physical activity, such as dense traffic routes to school
Interactions of influences across dimensions	An ecological approach should address how the different types of determinants will interact to influence health behaviours	A research study testing the interaction between intra-personal beliefs concerning walking and the use and types of walking routes to school.
Multiple levels of environmental influences	Ecological models specify levels of influence, such as different types of environment (e.g. urban, climate)	The prevalence of physical activity at different times of the year when differing in daylight hours and the use of cycle paths to school Availability of open play spaces and perceptions of local safety and crime
Environments directly influence behaviours	Ecological models propose that environments influence health behaviours directly as well as indirectly through other factors such as individual beliefs	Physical activity will be directly influenced by local traffic conditions regardless of intra- or inter-personal differences

1987). Recent calls for the independent study of sedentary behaviours and their relationship with physical activity (Owen *et al.*, 2000; Marshall *et al.*, 2002b) suggest that once more is understood about these behaviours, interventions could be designed that specifically target the reduction of sedentary behaviours (in contrast to current interventions, which typically target an increase in physical activity). The effect of reducing sedentary behaviour on physical activity levels could then be evaluated. Although Epstein and colleagues have often claimed that behavioural economic research demonstrates that reducing sedentary time in children increases physical activity, this is mainly in obese children (Epstein and Roemmich, 2001). In addition, there is little evidence that individual sedentary behaviours compete with physical activity (Owen *et al.*, 2000; Marshall *et al.*, 2002b). This is clearly an area for further research.

The majority of physical activity interventions target the individual and ignore potentially important environmental factors. Little research has examined these effects among youth (Richter *et al.*, 2000; Wechsler *et al.*, 2000). However, the potential utility of this approach is worthy of further attention not least because it shifts the focus from individually oriented to population-based solutions (Richter *et al.*, 2000), thus potentially affecting more individuals. This argument

reinforces further the need to take a multi-faceted approach to interventions and examine how the individual and the environment interact to influence behaviour (Resnicow *et al.*, 1996).

Implications for health policy³

Phase 5 of the behavioural epidemiology framework is to translate findings from research into practice. However, few large-scale intervention trials exist, meaning that implications for policy and practice must draw on wider evidence, including cross-sectional studies and expert opinion. In addition, in adopting an ecological approach to the understanding of physical activity in young people (Sallis and Owen, 1996), we recognize the multiple influences on health-related physical activity. Policies governing incentives and resources for physical activity are part of the wider social-environmental factors of influence. Sallis and Owen (1996) specify some guiding principles of ecological approaches to health behaviour change (see Table 1). Successful interventions in physical activity

³ This section draws on the work of the *Young & Active?* project in which Stuart Biddle was academic coordinator with James F. Sallis (Biddle *et al.*, 1998b).

Table 2. Recommendations for policy initiatives in the education sector

Focus	Recommendation
Schools	Schools actively enabling young people of all ages to take part in physical activity for the recommended time, ^a both in the PE curriculum and at other times
School physical education	Physical education programmes should take into account both the perceived needs of young people and those expressed by young people themselves. In addition, school PE should neither be seen as the panacea for curing the 'ills of inactivity' nor should it be expected that all PE lessons are highly active. Skill learning may require varying approaches in this regard
Schools and school physical education	Schools should recognize the importance of health-related physical activity and exercise within the National Curriculum, and ensure that the requirements are fully implemented in practice. In addition, health-related exercise should take the form of an effectively planned, delivered and evaluated programme of study
Training (higher and further education)	Professional development, training and support services, including institutions of further and higher education, should provide appropriate training (including initial teacher and in-service training) that includes the teaching of health-related exercise
Schools	Schools should promote the concept of the health-promoting school, which includes the contribution of physical activity towards other health topics
Schools	Extra-curricular programmes should be designed to provide a broad range of health-enhancing activities to meet the needs of all young people
Schools and other agencies	Schools should form partnerships with other agencies to increase opportunities for participation in activity and to address inhibitory factors both in and out of school
Schools, universities and colleges	Schools, universities and colleges should ensure wider access to their facilities for all young people in their local community
Schools, local education authorities (LEAs), traffic authority, parents	Schools, LEAs and related agencies should encourage young people to walk or cycle by developing and enhancing safe travel routes to schools. Parents should be actively discouraged in driving their children to school where possible
Parents	Schools should develop programmes that involve parents and encourage them to support participation in physical activity
Schools and related local agencies	Schools and LEAs should work with planners and other agencies to develop safe and attractive environments that encourage young people to be physically active. These might include safe playgrounds, changing rooms and playing fields

^a According to current guidelines (Biddle *et al.*, 1998b).

will need to address this wider approach, difficult though this will be. Ecological approaches tend to be rather broad in orientation, making it difficult to identify key determinants or which aspects of an intervention were successful. Nevertheless, such an approach will capture the diversity of influences on physical activity and are therefore more appropriate for macro-level policy initiatives.

Biddle *et al.* (1998b) discuss a range of agencies at national and local level that have a vital role to play in promoting health-enhancing physical activity for young people. There is a need for greater coordination of effort across a broad range of partners. Programmes should be designed to meet the specific needs of young people, including those with disabilities, those from different ethnic groups and those from different socio-economic backgrounds. Detailed recommendations by Biddle *et al.* have been developed for several key sectors,

including the education sector, local authorities, organizations concerned with sport and recreation and/or young people (such as sports clubs, youth groups), health services, the media and government departments (Biddle *et al.*, 1998a).

Education

Those involved in the education of young people can make a major contribution to the establishment of lifetime habits of physical activity. To achieve this, schools and education authorities will need to work with a range of organizations – including local government, sport, leisure and recreation, the health services, traffic organizations, and environmental and voluntary groups – to develop local strategies to increase levels of physical activity of young people. Specific roles might include:

- the planning, delivery and support of the curriculum in health education and physical education in schools;
- the delivery of whole-school approaches to promoting physical activity within the context of 'healthy schools' initiatives;
- developing sustained links with providers in the local community.

Possible recommendations for action are listed in Table 2.

Local government

Local government agencies can play a vital role in the promotion of health-enhancing physical activity with young people. To achieve this, local departments will need to work in partnership with each other and also with a wide range of external organizations, including health services, traffic organizations, environmental and voluntary groups. Possible recommendations for action are listed in Table 3.

Sport and recreation organizations

These may be statutory or non-statutory bodies, including youth groups, clubs, church and religious organizations, sport and recreation bodies, consumer groups and private sector agencies. These organizations and agencies have the potential to access a variety of

groups who work with young people and provide opportunities for increased participation in physical activity at a local level. Possible recommendations for action are listed in Table 4.

Health services

Health professionals and those working in the health services are in a position to provide leadership in promoting physical activity to young people. This can be both in developing and implementing physical activity policies and through professional education and training. Health professionals can act as advocates for physical activity. Possible recommendations for action are listed in Table 5.

Mass media

The media has a key role to play in raising public and professional awareness of the benefits of physical activity for young people. Television and magazines might be particularly influential in reaching young people and impacting their perceptions. Positive role models are required for both girls and boys and all socio-economic and ethnic groups. Fortunately, it appears that physical activity, or at least 'sport', is increasingly popular among young people (Sport England, 2003) and the mass media has an important role in reinforcing this. Possible recommendations for action are listed in Table 6.

Table 3. Recommendations for policy initiatives in the local government (local authority) sector

Focus	Recommendation
Parks and open spaces	Local authorities should provide a range of easily accessible, attractive and appropriate environments, including parks, open spaces and playgrounds, in which young people are encouraged to play safely
Leisure facilities	Local authorities should ensure that the contract specification for the management of local leisure facilities includes appropriate policies, prices and programming to encourage participation among young people, including those with low levels of participation in physical activity
Training	Local authorities should ensure that those who work with young people (including leaders, coaches, recreation, health, youth workers and other community personnel) are appropriately trained and qualified for their role as physical activity promoters; educating, motivating and confidence-building
Programmes and opportunities	Local authorities should design programmes to provide a broad range of health-enhancing physical activities for young people, e.g. dance, play and outdoor education
School playing fields	Local authorities should ensure the development of policies for the protection of school playing fields
Agency alliances	Local authorities are in a position to lead strategic alliances with education and health professionals in their area to promote physical activity to young people
Local partnerships	Local authorities should develop partnerships with non-statutory organizations that provide a broad range of physical activities for young people, e.g. sports and youth clubs, playgroups
Active travel routes to school	Local authorities should assist in the development of safe and attractive walking and cycling routes to schools within local authority development plans

Government departments

Government departments play a key role in promoting health-enhancing physical activity to young people (see Table 7). Their role relates to policy development, legal and fiscal legislation, and research.

Many of the recommendations given here were extensively discussed with key people working in each of these sectors as part of the *Young & Active?* project (Biddle *et al.*, 1998b), both through postal consultation on a draft policy framework and discussion meetings. These discussions focused on the practical implications

Table 4. Recommendations for policy initiatives in the sport and recreation sector

Focus	Recommendation
Training of staff	These organizations should ensure that those who work with young people are aware of the health benefits of physical activity for young people and, where appropriate, are trained and qualified in the delivery of health-enhancing physical activity
Range of activities	These organizations should ensure the inclusion of a broad range of health-enhancing physical activities for young people (e.g. sport, dance, play and outdoor education) in their programme of activities
Environments	Health, transport and environmental groups should work with planners and other agencies to develop safe and attractive environments that encourage young people to be physically active, such as safe playgrounds, walking and cycling routes
Funding agencies	Funding agencies should commission research into physical activity for young people and the effectiveness of interventions
Funding agencies	Funding agencies should provide resources for local interventions to improve the opportunities available for participation in physical activity by young people
Private sector agencies	Private sector agencies should develop appropriate policies, pricing and programming to encourage participation among young people, including those with low levels of participation in physical activity

Table 5. Recommendations for policy initiatives in the health services sector

Focus	Recommendation
Health policy	Health authorities, primary care trusts and other health agencies should develop and coordinate physical activity policies for young people and support local interventions and campaigns that target young people. Health agencies should develop policy agreements with health promotion units and local authorities on the promotion of physical activity for young people
Training	Health agencies should ensure that those who work with young people are aware of the health benefits of physical activity for young people and, where appropriate, are trained and qualified in the delivery of health-enhancing physical activity
Schemes and targeting	Health agencies, in partnership with local authorities, schools and other partners, should design school- and community-based physical activity schemes that target young people and their parents, and in particular those groups of young people who currently participate in low levels of physical activity
Information and opportunities	Health professionals, in partnership with local authorities, should provide information for young people and parents on local opportunities for participation in physical activity by young people, including safe and attractive play areas, walking and cycling routes, and sports and recreation programmes and facilities
Research	Health authorities should commission research to evaluate the effectiveness of local physical activity promotion interventions that target young people
Special needs	Health professionals, including those in primary health care teams, nurses and community health workers should target young people with specific needs, such as the overweight or obese, people with diabetes, asthma and mental health needs

Table 6. Recommendations for policy initiatives in the mass media

Focus	Recommendation
Positive images	All forms of media should be encouraged to provide positive and health-enhancing images of participation in a range of activities by young people, placing in perspective the relative dangers of traffic and 'stranger danger'
Accuracy of data	All forms of media should use accurate data to present the key issues relating to young people and physical activity
Local media	Local media, including press and radio, should publicize a range of opportunities for young people, including safe play areas, walking and cycling routes
Celebrities in the media	Media should use celebrities known to young people, including non-sport models, to promote regular physical activity to young people, avoiding the use of stereotypical images associated with physical activity that emphasize appearance, beauty and muscularity

Table 7. Recommendations for policy initiatives in the governmental sector^a

Focus	Recommendation
Inter-departmental coordination	Inter-departmental strategies and policies should be agreed that ensure a coordinated approach to the promotion of physical activity among young people
Funding	National Lottery funds, including capital costs, should be allocated to a range of initiatives targeting young people that promote and sustain physical activity (e.g. safe play, cycling and walking, sports facilities)
Education	The Department for Education should, through the review of the national curriculum, encourage the development of physical activity promoting policies in schools
Resources	The government should identify and provide human and financial resources to support physical activity policies that target young people
Environment and transport	The Department of Environment/Transport should work with interested parties to develop safe play, cycling and walking policies that target young people
Sport and recreation	The Department for Sport should adopt a broad approach towards sport and recreation policies for young people
Health initiatives	The Department of Health should consider the importance of schools and colleges in developing the plans for 'Healthy Living Centres' and 'Health Action Zones' ^b
Health and physical activity promotion	The Department of Health should expand its programme of physical activity promotion aimed at adults to include young people
Education and schools	The Department of Health, in conjunction with the Department for Education, should expand the programme of Health Promoting Schools, and include physical activity as a core topic area among the other health topics
Inter-departmental coordination	The Department of Health should establish a task force involving other government departments and other agencies to promote health-enhancing physical activity

^a Terms have been modified, where appropriate, to fit most national government structures.^b Terms specific to the UK government, referring to specific health initiatives through centres and communities.

of the experts' recommendations and the potential roles of key sectors and organizations. The recommendations, therefore, should be seen as realistic and feasible.

Conclusions

Using a behavioural epidemiological framework advocated by Sallis and Owen (1999), we have provided

a wide-ranging review of health-related physical activity in children and adolescents. In contrast to many other reviews, we have also highlighted issues associated with true sedentary behaviours alongside physically active behaviours. The following are our conclusions:

- physical activity may have a positive influence on reducing CVD risk in youth, although the evidence is

so far rather unconvincing and the key research questions have not been adequately tested;

- there is no direct evidence that physical activity in childhood provides protection from CVD in adulthood;
- there is evidence linking a lack of physical activity to obesity in youth, although most of the data are cross-sectional;
- physically active youth tend to show better mental health than their less active counterparts;
- the emergence of type II diabetes in youth is likely to be associated with the increased prevalence of obesity;
- weight-bearing activity appears beneficial for bone mineral density in young people;
- despite weak evidence in some areas, it is prudent to suggest that greater physical activity in youth is to be encouraged;
- boys are more active than girls and there is a steep decline in physical activity during the adolescent years;
- although many young people are 'active', and certainly more active than adults, there is a sizeable proportion who have physical activity levels less than those thought desirable for good health;
- there has been a decline in active travel by youth in recent years;
- total media use in leisure time for youth appears to have remained unchanged over recent decades, although the nature of this media use will have changed;
- for those watching TV, young people average about 2.5 h per day with just less than one-third having 'excessive' levels of 4 h or more each day;
- individual sedentary behaviours, such as TV viewing, are largely unrelated to physical activity, suggesting that there is time for both;
- consistent determinants or correlates of physical activity in children are male gender, fewer perceived barriers, stronger intentions and preferences for physical activity, having a healthy diet, previous physical activity, and access to programmes and facilities;
- consistent determinants or correlates of physical activity in adolescents are male gender, younger age, achievement orientation, higher perceived competence, stronger intention, less depression, greater sensation-seeking tendencies, previous physical activity, participation in community sports, parental support, sibling physical activity, and opportunities to exercise;
- there is potential to change young people's physical activity through interventions in schools, families and communities, with multi-level and environmental interventions holding greatest promise;
- family interventions have had limited success;
- few community interventions with young people exist and results have been equivocal;
- health policy needs to capture the diversity of influences on physical activity for young people and must take into account other policy environments, such as in education, local government, sport and recreation organizations, health services, the mass media and government departments.

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