Physical Activity and Children

Review 1:

DESCRIPTIVE EPIDEMIOLOGY

Draft 4

11 July, 2007

NICE Public Health Collaborating Centre – Physical Activity

Contents

Executive summary

The health benefits of physical activity for children

- Physical activity has small but significant physical health benefits for children, notably prevention of overweight and obesity and type II diabetes, and improvements in skeletal health.

- Physical activity has moderate psychological health benefits for children, particularly for self-esteem, but also for depression.

- There is limited evidence that childhood physical activity directly affects health in adulthood

- However, health indicators such as obesity do track from childhood to adulthood, therefore childhood physical activity may have an indirect influence on adult health.

- There is little evidence for the differential effect of physical activity on childhood health by gender, age or ethnicity.

How active are children and young people?

- Surveys show that high proportions of children are active at recommended levels. There is, however, a significant minority of children who take little or no physical activity.

- Inactivity is highest among young girls (from around age 10).

- Provision of PE and sport in schools has been increasing while active travel to school has declined.

- Levels of sport and exercise are lower among lower socio-economic groups and people from black and minority ethnic groups.

Does physical activity 'track' from childhood to adulthood?

- Physical activity tracks within childhood at moderate levels.
- Tracking from childhood/adolescence into adulthood is small. It is difficult to determine whether this is due to a true effect or is attributable to measurement problems.
- Tracking is likely to be strengthened by increasing the quality of the physical activity experience.
- Sedentary behaviours may track better than physically active behaviours, but more research is needed.

Conclusions

- There is a strong rationale for promoting physical activity among children and adolescents.
- Specific population sub-groups in which levels of activity are low include young girls (aged 10+), children from lower socio-economic groups, children from black and minority ethnic groups, and overweight and obese children.
- Data on the provision of PE and sport in school has shown that this mode of activity is generally increasing, and this trend should be encouraged. However, a higher priority might be given to active travel to school, which has been declining for many years.
- There is very little evidence available to quantify trends in levels of active play. However, review level evidence for a decline in natural play, and access to natural environments, suggest that this might also be a mode of activity that would benefit from being prioritised.

1. Introduction

1.1. Background to the NICE programme on children and physical activity

The National Institute for Health and Clinical Excellence ('NICE' or 'the Institute') has been asked by the Department of Health (DH) to develop guidance on a public health programme aimed at promoting physical activity, play and sport for pre-school and school age children in family, pre-school, school and community settings.

This guidance will provide recommendations for good practice, based on the best available evidence of effectiveness, including cost effectiveness. It is aimed at professionals with public health as part of their remit working within the NHS, local authorities and the wider public, private, voluntary and community sectors. It will also be relevant to parents and professional carers.

The guidance will support implementation of the preventive aspects of national service frameworks (NSFs) and a number of related policy documents[1]. It has been commissioned in response to growing concerns over low levels of physical activity in children and young people, and the potential impact on current and future health.

---

[1] See Children and Physical Activity scope for full details: http://guidance.nice.org.uk/page.aspx?o=410813

1.2. Background to this review

This is the first of a series of reviews commissioned to provide background evidence for the development of public health guidance. Future reviews will

- identify the individual, social and environmental factors associated with children's physical activity and summarise the directions and strength of these associations
- investigate the views of children about the barriers and facilitators to participation in physical activity
- review the effectiveness and cost effectiveness of specific approaches to promoting physical activity in children.

This initial review provides the context for the later reviews by describing the evidence on the descriptive epidemiology of physical activity in children. Descriptive epidemiology focuses on identifying and reporting both the pattern and frequency of health events in a population (Mausner & Kramer, 1985).

1.3. Purpose of the review

The purpose of the review is to define patterns of physical activity in children of different populations and ages in England and to determine the impact of physical activity on short and long term health, and other outcomes.

The review will help identify populations or developmental stages in which physical activity is low and therefore of concern. This will help to develop the conceptual model for the children and physical activity programme, and focus and prioritise the direction of the reviews that follow. It will also feed into the development of the economic model.

This review will:

- explore the prevalence and patterns of different types of physical activity in pre-school and school children;
- identify populations of children or developmental stages in which PA is low and therefore of concern;
- describe the relationship between children's physical activity behaviours and their physical activity levels as adults;
- describe the benefits of childhood physical activity and
- describe the health outcomes (mortality and morbidity) and other outcomes associated with lack of physical activity as a child.

In this review the term 'children' will generally be used, and will include all pre school and school aged children up to age 18 years. Where studies include children beyond this age (for example surveys looking at young people aged 16-24), we may include findings relevant to 16-18 year olds, as appropriate.

2. Methodology

2.1. Sources of evidence

This review synthesises evidence from key reports and studies in the literature. Tailored searches of the literature were conducted for each topic in the report, and the search strategies are outlined separately in each chapter.

2.2. Review team

This review has been carried out by a team from the Public Health Collaborating Centre (CC) for Physical Activity[2]. The Collaborating Centre is an alliance between the British Heart Foundation Health Promotion Research Group (University of Oxford) and the British Heart Foundation National Centre for Physical Activity and Health (Loughborough University).

---

[2] Lead authors Prof Stuart Biddle and Nick Cavill.

Reference (Sections 1 and 2)

Mausner JS, Kramer S. Epidemiology: An introductory text (2nd Edition). Philadelphia, PA: Saunders, 1985.

3. The health benefits of physical activity for children

3.1. Summary

- Physical activity has small, or small-to-moderate, but significant health benefits for children, notably prevention of overweight and obesity and type II diabetes, and improvements in skeletal health.

- There is limited evidence that childhood physical activity directly affects health in adulthood.

- However, health indicators such as obesity do track from childhood to adulthood, therefore childhood physical activity may have an indirect influence on adult health.

- There is little evidence for the differential effect of physical activity on childhood health by gender, age or ethnicity.

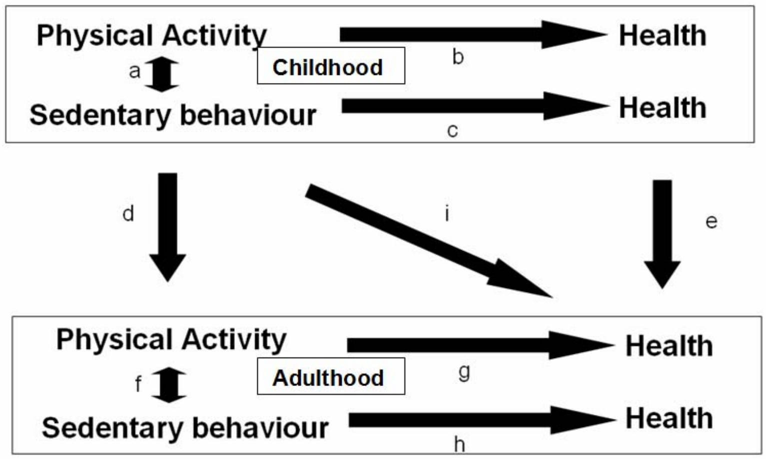
3.2. Introduction

This section[3] will describe the benefits of childhood physical activity and the health and related outcomes (mortality and morbidity) associated with lack of physical activity as a child or adolescent. In Section 4, we will review the links between physical activity in childhood and adolescence and health outcomes in adulthood. Figure 1 depicts a schematic for viewing these various links.

[3] This section is based on previous reviews undertaken at Loughborough University, specifically Biddle et al. (Biddle SJH, Gorely T, Stensel DJ. Health-enhancing physical activity and sedentary behaviour in children and adolescents. Journal of Sports Sciences 2004b; 22: 679-701.) and Stensel et al. (Stensel DJ, Gorely T, Biddle SJH. Physical (in)activity and youth health outcomes. In: Smith AL and Biddle SJH, editors. Youth physical activity and inactivity: Challenges and solutions. Champaign, Il: Human Kinetics, in press.). The contributions of Dr David Stensel and Dr Trish Gorely are gratefully acknowledged. Research assistance from Andy Atkin and Natalie Pearson (Loughborough University) is also acknowledged with thanks.

Figure 1.

Linkages between behaviours in childhood and behaviours and health outcomes in both childhood and adulthood



With reference to Figure 1, physical activity and sedentary behaviours may both need investigating, although the evidence concerning the latter is significantly smaller than for physical activity. Sedentary behaviours may have independent associations with health in childhood and adulthood, although the evidence base beyond TV viewing is very small, and the whole field is replete with difficulties (Biddle et al., 2004a; Bryant et al., 2007). Nevertheless, links between these two clusters of behaviour in childhood (link ‘a’) and in adulthood (link ‘f’) are important. Comments have been provided on link ‘c’ where evidence is available but for the purposes of the present review, we have focussed mainly on:

- The links between physical activity and health outcomes in childhood/adolescence (link ‘b’)
- The links between physical activity in childhood and health outcomes in adulthood (link ‘i’)
- The links between physical activity in childhood and physical activity in adulthood (link ‘d’).

In judging evidence, we have used criteria based on strength and category of evidence. For strength of evidence we provide verbal descriptors of ‘small’, 'moderate' and 'large' by generally adopting the conventions of Cohen's *d* effect size (small=0.3; moderate=0.5; large=0.8) and Cohen's criteria for strength of effect for correlations (0.1=small; 0.3=moderate; 0.5=large) (Cohen, 1988). We adopted four levels, or categories, of evidence consistent with conventions used elsewhere (Bouchard and Blair, 1999; National Institute for Health and Clinical Excellence, 2007). Notwithstanding the debate concerning using RCTs as the gold standard, and their appropriateness, or lack thereof, for some types of research questions, we have adopted criteria based on the following: category A (major RCTs or meta-analyses of substantial number of trials); category B (smaller RCTs or meta-analyses of fewer trials); category C (observational studies); category D (expert opinion) (see Table 1).

Search strategies for locating papers on health outcomes of physical activity of children were limited to papers published from 2001. Databases used were PubMed, and Metalib (including Web of Science, Sportdiscus, Psychinfo, Zetoc, Physical Education Index, and Articlefirst). This was conducted with a search of our own files, and limited searches on Google / Google scholar.

3.3. Relationships between childhood physical activity and childhood health

3.3.1. Obesity

Obesity prevalence in children and adolescents is increasing in the UK (Bundred et al., 2001; Chinn and Rona, 2001; Stamatakis et al., 2005) and other developed countries, and national guidelines have now been published on obesity (National Audit Office, 2001; National Institute for Health and Clinical Excellence & National Collaborating Centre for Primary Care, 2006; National Institutes of Health and National Heart Lung and Blood Institute, 1998). In the majority of studies obesity is defined according to age- and sex-specific percentile guidelines for body mass index (BMI: dividing weight in kilograms by height in meters squared – kg/m^2), such as those developed by Cole, Bellizzi, Flegal, and

Dietz (2000). Data from the Health Survey for England suggests that for children aged 2-10 years, 17% are obese, a figure rising to 31% for overweight (including obese). The same figures for those aged 11-15 years are 21% and 35% respectively. There are significant ethnic differences, with higher BMIs, compared to white children, in Black Caribbean, Black African, and Asian children (Swanton and Frost, 2007).

Many studies indicate that overweight and obesity are associated with a variety of health risks both in youth as well as adulthood (British Medical Association, 2005), and childhood obesity is a risk factor for adult obesity (i.e., it has been shown to track) (Bouchard, 2000). The Chief Medical Officer's Report on physical activity (Department of Health, 2004) states that obese children are more likely to have certain cardiovascular risk factors, higher incidence of premature atherosclerosis and greater insulin resistance. Such children often have lower levels of physical fitness and less positive mental health than their non-obese counterparts. However, given the difficulty of measuring overweight and obesity in children, the potential confounding with growth and maturation, and the time interval between the development of obesity and likely disease endpoints, the association between childhood obesity and health is complex (Hardman and Stensel, 2003).

BMI is often the measure of choice for population-level assessment. However, it is recognised that BMI is not a direct measure of adiposity. A more precise marker than BMI for the health risks associated with excess adiposity may be needed. For example, waist circumference is a marker of central body fat accumulation and has been linked to an increased risk of metabolic complications such as type 2 diabetes in men (Wang et al., 2005). Three cross-sectional surveys of waist circumference in British youth aged 11-16 years (McCarthy et al., 2003) showed very clear increases over a 20-year period, and greater increases than for BMI. The authors concluded that BMI is likely to be systematically underestimating the prevalence of obesity in British youth. However, NICE (National Institute for Health and Clinical Excellence & National

Collaborating Centre for Primary Care, 2006) recommend that BMI (adjusted for age and gender) be used as a practical estimate of overweight in children while waist circumference is not recommended as a routine measure. But they do say that waist circumference may be used to give additional information on the risk of health problems in the long term. Clearly, issues remain regarding the best way to measure body fat in children and adolescents and also the point at which excess body fat becomes detrimental to health in young people (Livingstone, 2000).

Notwithstanding these difficulties, many researchers believe that young people are getting fatter and that a change in physical activity levels is a major cause of this trend. For example, a recent study of ‘Old Order Amish’ children in Canada (Bassett et al., 2007), where lifestyles resemble those of Europe and North America over 150 years ago (such as no motorized transport or electronic labour-saving devices, and subsistence farming), showed both children and adolescents to have very high step counts compared with data in other studies investigating youth in settings akin to current society. Moreover, only 7.2% of these Amish youth were overweight (in comparison with 31-35% in England) and 1.4% were obese (17-21% in England).

Although some cross-sectional studies have found an inverse association between physical activity levels and BMI or body fatness in children and adolescents, the associations are often weak or inconsistent. For example, a very extensive HBSC (Health Behaviour in School-Aged Children) study gathered cross-sectional data from 137,593 young people aged 10-16 years in 34 countries (Janssen et al., 2005). The authors concluded that there was a significant negative relationship between physical activity and BMI in 88% of the countries. However, closer inspection shows great variability in this relationship. For example, of the 10 countries showing the highest prevalence of obesity, the percentage of children meeting the typical physical activity recommendation of 60 mins of activity on at least 5 days of the week ranged from 26-50% (non-weighted M=33%). Of the 10 leanest countries, the range was 21-43% (M=36%).

Similarly, although 65% of all countries sampled showed a significant relationship between TV viewing and obesity, these relationships were small and inconsistent, supporting a recent meta-analysis (Marshall et al., 2004). For example, the 10 most obese countries in the HBSC study showed an average of 46% (range = 38-53) of young people watching 3 or more hours of TV per day, whereas this figure was higher (51%; range = 24-66) for the 10 leanest countries.

Small or inconsistent associations between physical activity and obesity in cross-sectional studies is often blamed on the imprecise nature of the measure of physical activity (usually self-report, such as in the HBSC study). However, a recent cross-sectional study in Northern Ireland (Rennie et al., 2005) examined physical activity levels in prepubescent children using doubly labelled water and heart rate monitoring and found no difference in activity levels in boys and girls at high risk of obesity, this being defined as one or both of their parents being obese, compared with children not at high risk of obesity. Moreover, data on nearly 2,000 9-10 and 15-16 year old youth from three regions of Europe showed very small, non significant, associations between objectively measured physical activity (accelerometry) and body fatness (Ekelund et al., 2006).

Prospective (longitudinal) studies provide stronger indications of cause and effect than cross-sectional studies, and these are discussed in the section concerning the relationships between childhood physical activity and adult health. To demonstrate that a lack of physical activity is causally related to overweight/obesity, well designed intervention trials are required and preferably randomized controlled trials (RCTs). Recent reviews have investigated the effectiveness of interventions to prevent overweight and obesity in children and adolescents (Campbell et al., 2005; Doak et al., 2006; Flodmark et al., 2006). School-based interventions (k=25) were reviewed by Doak and colleagues, although not all were RCTs. Nineteen of the 25 studies focused on both activity and diet, three on activity alone, one on television viewing, and two on diet. Seventeen out of the 25 studies (68%) were judged to be effective based on significant reductions in BMI or skinfolds for the intervention group. Four interventions were effective in reducing both BMI and skinfold measures. Two of these targeted reductions in television viewing and two targeted increased physical activity combined with diet. Importantly, one study that successfully reduced overweight also increased prevalence of underweight. Caution is needed in drawing conclusions about sedentary behaviour interventions, such as TV viewing, because this area is still in its infancy. Current research suggests that TV viewing does not displace physical activity and its relationship to body fatness in young people is very small (Ekelund et al., 2006; Marshall et al., 2004). In other words, TV itself may not be a significant issue in childhood obesity because, over time, it does not necessarily replace physical activity (Marshall et al., 2004; Sallis et al., 2000). However, in addition to considering the dietary component of TV viewing (e.g., influence of advertising, excessive snacking etc), clearly it is prudent to avoid excessive time on sedentary behaviours in general, and to find physically active alternatives where possible. Such sedentary behaviours should go beyond TV viewing, such as other screen-based media use, sedentary socialising, motorised transport, and sedentary hobbies. It is interesting to note that TV viewing has not increased in young people (Marshall et al., 2006; Sturm, 2005) alongside increases in obesity, and that boys watch more TV than girls (Marshall et al., 2006). Boys, however, show greater levels of physical activity and less obesity than girls (Caspersen et al., 2000; Swanton and Frost, 2007).

Flodmark and colleagues' (2006) review only studies with at least 12 months of follow-up. They identified 15 overweight/obesity prevention programmes with positive outcomes, 24 with neutral outcomes and none with negative results. Thus, 41% of the studies they examined, including 40% of the 33,852 youth studied, showed a positive effect. Flodmark et al. concluded that it is possible to prevent obesity in children and adolescents through limited, school-based programmes that combine healthy dietary habits and physical activity. The Cochrane review by Campbell et al (2005) found that there was "limited high quality data on the effectiveness of obesity prevention programs and no generalisable conclusions can be drawn" (p. 1). However, they did say that encouraging a reduction in sedentary behaviours and increase physical activity "may be fruitful" (p. 1).

The STRIP (Special Turku Coronary Risk Factor Intervention Project for Children) study conducted in Finland monitored the prevalence of overweight in children from age 7 months to 10 years (Hakanen et al., 2006). Children were placed into either an intervention group (*n*=540) or a control group (*n*=522) at 7 months of age. Parents and children in the intervention group received individualized advice on diet and physical activity biannually for 10 years. At the age of 10 years, 10.2% of the intervention girls were overweight compared with 18.8% of the control girls. No group differences were observed in overweight prevalence in the boys. Only three children in the intervention group were obese at some point in this study, whereas 14 control children were classified as obese during the study. It was concluded that dietary and activity guidance provided twice a year since infancy decreases the prevalence of overweight in school-aged girls.

Watts et al. (2005) highlight that there are very few RCTs investigating the efficacy of exercise training in obese children or adolescents and state that many existing studies have been poorly controlled and have not specifically stratified the independent effects of exercise versus dietary modification. This last point is also true of many of the studies which have focused on prevention. They conclude that although exercise training does not consistently decrease body weight or BMI, it is associated with beneficial changes in fat and lean body mass, stressing the importance of comprehensive assessment of body composition in future studies. Atlantis and co-workers (2006) conclude from their systematic review of 13 studies that 155-180 minutes of aerobic exercise per week at moderate-to-high intensity is effective for reducing body fat in overweight youth, but effects on body weight and central obesity are inconclusive. Such suggestions are higher than those currently recommended (Department of Health, 2004).

Overall, the majority of recent evidence appears to support a role for physical activity in overweight and obesity prevention in youth, although the evidence is in need of clarification and further development. Many of the difficulties may be due to measurement problems, as well as the potential influence of diverse factors, such as socio-economic status. Increasing physical activity and decreasing a range of sedentary behaviours may be an effective strategy in the management of overweight and obesity in children and adolescents, alongside appropriate nutritional intake (National Institute for Health and Clinical Excellence & National Collaborating Centre for Primary Care, 2006). Evidence on physical activity and obesity in childhood is probably best described as category B, with strength of effect rated conservatively as small, but with some evidence for small-to-moderate effects (see Table 1).

3.3.2. Type-2 Diabetes

Much of the concern over the increasing prevalence of overweight and obesity in young people is predicated on the associated health risks. In adults, the greatest health risk of obesity is type 2 diabetes which, in turn, increases the risk of cardiovascular disease. Studies have consistently demonstrated a dose-response association between obesity and risk of type 2 diabetes (Wang et al., 2005). Estimates suggest that approximately 4% of men and 3% of women are diagnosed annually with diabetes, 85% being for Type 2 diabetes. At least half of cases are estimated to be undiagnosed. Evidence for adults suggests that physical activity is associated with a reduced risk of type 2 diabetes (Hardman and Stensel, 2003).

Type 2 diabetes is also known as ‘adult onset diabetes’, but this is now an outdated term due to the emergence of type 2 diabetes in children and adolescents. Many believe that the emergence and increasing prevalence of type 2 diabetes in young people is linked with the increased prevalence of obesity in this age group. Aylin and colleagues (2005) report that among patients aged 18 years and younger, the admission rate for obesity in English hospitals increased 63.5% from 1996-7 to 2003-4, and the admission rate for diabetes rose 44.4%

during the same period. If the increases are genuine, rather than an artefact of improved identification, then they represent only a small proportion of affected individuals because not all will be referred.

Convincing evidence for a link between obesity and type 2 diabetes in young people is provided by a study examining the prevalence of impaired glucose tolerance, a marker for the risk of diabetes, in a group of severely obese children and adolescents (BMI > the 95^{th} percentile for age and sex) (Sinha et al., 2002). Impaired glucose tolerance was detected in 25% of 55 obese children and 21% of 112 obese adolescents. More recent cross-sectional studies confirm an association between excess adiposity and insulin resistance and poor glucose handling in children and adolescents (Khan et al., 2003; Viner et al., 2005).

Intervention trials have not been conducted to assess the effectiveness of physical activity in preventing type 2 diabetes in young people. However, physical activity and physical fitness are inversely related to insulin resistance (Kasa-Vubu et al., 2005) and positively associated with insulin sensitivity (Imperatore et al., 2006) in young people. Moreover, there is an extensive literature in adults demonstrating that exercise is effective in the prevention and management of type 2 diabetes (Bassuk and Manson, 2005; LaMonte et al., 2005). This evidence includes two randomized controlled trials (US Diabetes Prevention Program; Finnish Diabetes Prevention Study) demonstrating that lifestyle intervention is effective in reducing the incidence of type 2 diabetes in adults at high risk of developing the disease (Knowler et al., 2002; Tuomilehto et al., 2001). Therefore, evidence currently available suggests that it would be prudent to recommend physical activity to children and adolescents as one component of an overall lifestyle package aimed at preventing type 2 diabetes.

The evidence base on physical activity and type 2 diabetes in children suggests that the evidence is at category C with a moderate strength of effect.

3.3.3. Cardiovascular disease

Unlike type 2 diabetes, there is no indication that clinical signs and symptoms of cardiovascular disease (CVD) are occurring regularly in children and adolescents. Nevertheless, there is considerable evidence to show that CVD has its origins in childhood and that obesity in childhood is associated with traditional CVD risk factors such as hypertension and dyslipidaemia (British Medical Association, 2005). Overweight and obesity in youth are also associated with the insulin resistance (metabolic) syndrome. This is a clustering of risk factors, including dyslipidaemia (high triglycerides and low HDL cholesterol), central obesity, hypertension, and impaired glucose regulation (diabetes) (Alberti et al., 2005; Ferreira et al., 2007; Hardman and Stensel, 2003). One recent study suggests that one third of obese children and adolescents have the insulin resistance syndrome (Viner et al., 2005) and a review paper has suggested that physical activity may have a positive impact on this syndrome in school-aged youth (Strong et al., 2005). However, the syndrome remains a topic of debate as to whether individual or clustered risk factors should be targeted (Grundy, 2006; Khunti and Davies, 2005; Reaven, 2006).

In adults there is substantial evidence that high levels of physical activity and/or physical fitness protect against CVD (Hardman and Stensel, 2003). The relationship between physical activity/fitness and CVD is more difficult to establish in young people because CVD does not typically occur until adulthood (Boreham and Riddock, 2001). Very long follow-up periods would be required to provide definitive evidence of a link between physical activity/fitness in childhood and subsequent risk of CVD. Therefore, most studies of young people have examined the relationship between physical activity/fitness and risk factors for CVD rather than disease endpoints. A limitation here is that CVD risk factors are not always predictive of disease endpoints. Nevertheless, studies examining physical activity/fitness and CVD risk in young people are important in identifying the strength and direction of any likely association and several recent studies are suggestive of a protective role of physical activity/fitness.

A notable example of a cross-sectional study linking physical activity with CVD risk in children is The European Youth Heart Study (Andersen et al., 2006). This study involved 1,732 randomly selected 9 and 15-year-old school children from Denmark, Estonia and Portugal. Physical activity was measured using accelerometers and CVD risk was assessed using a composite risk factor score from measurements of systolic blood pressure, triglyceride, total cholesterol/high density lipoprotein cholesterol ratio, insulin resistance, sum of four skinfolds, and aerobic fitness. Participants were divided into quintiles according to physical activity levels and those in the lowest three quintiles for physical activity were found to have a higher CVD risk factor score compared with those in the most active quintile. The authors concluded that physical activity guidelines for children and adolescents should be higher than the current international guidelines of at least 60 mins per day of at least moderate intensity physical activity to prevent a clustering of CVD risk factors. Their recommendation is for 88 mins for 15 year olds and 116 mins for 9 year olds. In a commentary on this paper, Weiss and Raz (2006) noted that the inverse association between physical activity and CVD risk observed in The European Youth Heart Study was independent of the degree of adiposity and was similar for lean and overweight children, suggesting physical inactivity is an independent CVD risk factor in young people. In addition to studies linking physical activity with CVD risk, aerobic fitness (physical work capacity at a heart rate of 150 beats/min) is independently associated with CVD risk factors in young people (Eisenmann et al., 2005).

A recent study has demonstrated that a multifactorial intervention, involving exercise, nutrition education, and behaviour therapy, is effective in improving CVD risk factors in obese children (Reinehr et al., 2006). However, there remains a lack of firm evidence from RCTs to show that physical activity is effective in modifying CVD risk factors in young people.

It appears that the conclusion of the CMO’s Report (Department of Health, 2004) remains valid. That is, the association between CVD risk factors and youth physical activity is weak (small). We assess the evidence as category C.

3.3.4. Skeletal health

Childhood and adolescence is a crucial period for bone development. According to Vicente-Rodriguez (2006), the prepubertal human skeleton is sensitive to mechanical stimulation elicited by physical activity. To attain peak bone mass, children should be physically active prior to and throughout puberty. Indeed, in the English consensus reviews on physical activity and young people (Biddle et al., 1998), Riddoch (1998) concluded that weight bearing activities for young people may be beneficial for skeletal health. This led to the secondary recommendation for National physical activity guidelines for children and adolescents stating that “at least twice a week, (physical activity) should help to enhance and maintain muscular strength, flexibility, and bone health” (Cavill et al., 2001). This recommended was repeated in the CMO Report (Department of Health, 2004).

Two aspects of skeletal or bone health can be considered. First, given the dangers of osteoporosis, it is agreed that achieving optimal peak bone mass/bone mineral density is important. To this end, research needs to identify whether physical activity positively influences bone health in this way. Second, if peak bone mass has been optimised, does it reduce the incidence of bone fracture?

There are two new systematic reviews that address these issues. First, Hind and Burrows (2007) reviewed controlled trials that investigated whether weight-bearing physical activity in young people affected bone mineral accrual. The review addressed only healthy people aged less than 18 years where the primary outcome measure was DXA-derived bone mineral density or bone mineral content. For prepubertal children, 6 of 9 trials reported positive effects of exercise on bone mass, with effects ranging from 0.9-4.9%. Some studies had a risk of bias.

For early pubertal children, Hind and Burrows’ (2007) review showed positive effects in all 8 studies. Success over a 6-month period ranged from 1.1-5.5%. Again, some studies had high risk of bias. For pubertal children, only 5 studies were included, and 2 reported positive effects ranging from 0.3-1.9%. Four of the studies had high risk of bias.

In summary, Hind and Burrows (2007) concluded that positive effects are shown for prepubertal children, with stronger effects for those in the early pubertal stage of development. They state that this stage may be particularly good for bone development especially when accompanied by sufficient calcium intake. They report that that it is estimated that about 30% of adult bone mass is accrued at this stage, and this is similar to the amount of bone lost during the postmenopausal years (Bailey, 1997). There may therefore be this ‘window of opportunity’ for bone development in early puberty providing an optimal period for bone to respond to exercise. For pubertal children, however, research suggests that the effects are less pronounced than for those in early puberty. Hind and Burrows conclude that this may be due to poor study design as much as maturational effects.

The American College of Sports Medicine (2004) have published a position stand on Physical Activity and Bone Health. Guidelines for mode of activity target impact activities such as gymnastics, plyometrics (jumping and bounding-type activities), and moderate intensity resistance training. Participation in sports that involve running and jumping (e.g., football, basketball) is believed to be of benefit, however a lack of scientific evidence is acknowledged. Intensity should be high in terms of bone-loading forces, however for safety reasons it is recommended that resistance training be at less than 60% of 1-repetition maximum (1RM), although this is likely to be age-dependent. The recommended frequency of such activities is at least three days/week with a duration of 10-20 minutes per bout and 2 times per day or more may be more effective.

The second area of bone health for young people is fracture risk. In a recent meta-analysis (Clark et al., 2006b), 10 case-control studies were analysed, 8 of which were amenable to meta-analytic aggregation. Results showed that there is an association between low bone mass and incident of bone fracture in children below the age of 17 years. Effect size (SMD) was significant but small at -0.32

(95% CI = -0.43 to -0.21). The same researchers also reported an 89% increased risk of fracture per standard deviation decrease in size-adjusted bone mass in a 24-month follow-up of 6,213 10 year old children in SW England (Clark et al., 2006a).

In summary, skeletal health appears to be clearly associated with physical activity in children. This is for effects on bone mineral density and reduced risk of fracture. For bone mineral density, the evidence appears to be category B with moderate effects , whereas for fractures it is category C/B with small effects.

3.3.5. Mental health

Mental illness is a serious public health issue. It accounted for almost 11% of the global burden of disease in 1990 and this is expected to rise to 15% by 2020, which would make it the leading disease burden (Biddle and Mutrie, in press). The prevalence of mental illness in the UK is 230 per 1000 referrals to primary care services and data from social trends analysis in the year 2000 showed that 1 in 6 adults living in the UK reported some kind of neurotic disorder such as depression, anxiety or a phobia, in the week prior to the interview (Office of National Statistics, 2005).

Mental illness, suicide, depression, eating disorders, and anxiety are some of the conditions that affect young people in disproportionate rates in comparison to many other populations groups (Viner and Booy, 2005). Moreover, there is widespread belief that physical activity is inherently ‘good’ for young people in respect of varied psychosocial outcomes, such as self-esteem and cognitive functioning. The majority of studies in this area are cross-sectional and therefore causality cannot be established because the temporal relationship between exposure and outcome has not been demonstrated with any reliability. Thus, though there is evidence that physical activity can enhance psychological well-being, such an outcome may not be inevitable (Lagerberg, 2005).

The effect of physical activity on mental health in children and adolescents has received significantly less attention than in adult populations. Where it has been investigated the work has primarily focused on depression, anxiety and self-concept/self-esteem and there is relatively little work examining other important aspects of mental health such as stress and emotional distress (Strong et al., 2005).

Depression

Depressive disorders have been identified throughout the lifespan with an estimated 1% of 5-16 year olds in the UK (Green et al., 2005) suffering depression and up to 13% of boys and 19% of girls suffering “serious mental health problems” (Viner and Booy, 2005). Those experiencing depression can face significant disability as a result (Mutrie, 2000). Evidence from adult studies demonstrates that physical activity is inversely associated with symptoms of depression (Craft and Landers, 1998; North et al., 1990) and there is some evidence that this relationship is causal (Mutrie, 2000). There is, however, much less evidence for this relationship in children and adolescents. In two early meta-analyses of the field, a moderate effect, similar to that found in adults, was reported for physical activity on depression in adolescents (Calfas and Taylor, 1994; North et al., 1990). However, each meta-analysis only included five studies.

Cross-sectional surveys also show an inverse relationship between physical activity participation and depression (Strong et al., 2005). Tomson et al. (2003) reported an elevated risk of depressive symptoms among 933 8- to 12-year olds children classified as inactive (2.8 to 3.4 times higher risk) and among children not meeting criterion-referenced standards for health-related fitness (1.5 to 4 times higher risk) compared with their contemporaries who were considered active/fit. A recent cross-sectional study of 13-34 year-olds in the US showed that the risk of nearly lethal suicide attempts was five times lower for those who had been physically active in the past month (Simon et al., 2004).

The majority of work in this area is limited because it is usually cross-sectional in nature, fails to adjust for confounding factors (e.g., sex, socio-economic status), and employs measures of depression that do not have established validity for adolescent populations. In a recent 2-year longitudinal study that attempted to overcome some of these limitations, Motl and colleagues (2004) demonstrated that changes in self-reported frequency of physical activity were inversely associated with changes in depressive symptoms even after controlling for confounding factors of sex, socio-economic status, smoking behaviour, alcohol consumption, and the value participants placed on their health, appearance and achievement. Although this study does not establish the direction of causality, it does provide stronger evidence for a relationship between physical activity and depressive symptoms in adolescents than evidence from cross-sectional studies.

Larun and colleagues (2006) conducted a systematic review of exercise interventions on depression in young people up to the age of 20 years. Five trials were located that investigated whether vigorous exercise conferred benefits over no intervention. They found a significant moderate effect (SMD of -0.66, CI -1.25 to -0.08) but noted that the trials were of low quality and highly varied in respect of methodological characteristics, such as sampling and measurement. When comparing vigorous with low intensity exercise, only two trials were located and these showed no significant effect, a result repeated for two trials investigating children receiving psychological treatment. When comparing exercise with psychosocial interventions, Larun et al. found only two trials, and no significant effect was evident. This was also the case for one trial involving children receiving psychological treatment. In summary, exercise over no intervention appears to be beneficial for reduced depression, but the evidence base is weak. Evidence is category C with moderate strength of effect.

Anxiety

Active adults report fewer symptoms of anxiety than inactive adults (Department of Health, 2004; Taylor, 2000) and there is some evidence that this is also true for young people. For example, a meta-analysis of exercise and anxiety reduction (Petruzzello et al., 1991) reported an effect size for those under 18 years of age of -0.20 for state anxiety (K=21; K=number of effect sizes), -0.47 for trait anxiety (K=3), and -0.38 for psychophysiological indices of anxiety (K=8). These are best described as small effects. In a recent narrative review on the outcomes of physical activity in school-age youth, Strong and colleagues (2005) concluded that cross-sectional studies show a weak negative association between physical activity and anxiety, and that quasi-experimental studies show strong negative associations between physical activity and measures of anxiety. However, in both these reviews there were few studies in some categories.

Larun et al. (2006) conducted a systematic review of exercise interventions on anxiety in young people up to the age of 20 years. Six trials were located that investigated whether vigorous exercise conferred benefits over no intervention. They found a non-significant trend (SMD of -0.48, CI -0.97 to 0.01; a small-to-moderate effect). As for their data on depression, the studies on anxiety were of low quality and highly varied in respect of methodological characteristics. When comparing vigorous with low intensity exercise, only three trials were located and these showed no significant effect. When comparing exercise with psychosocial interventions, Larun et al. found only two trials, and no significant effect was evident. No trials were located that involved children receiving psychological treatment. In summary, exercise over no intervention may be beneficial for reduced anxiety, but the evidence base is weak. Evidence is category C with small strength of effect.

Self-esteem

Self-esteem reflects the degree to which an individual values themselves and is widely viewed as a key indicator of positive mental health and well-being (Fox, 2000). Early reviews concluded that physical activity is associated with the development of self-esteem in young people (Calfas and Taylor, 1994; Gruber, 1986; Mutrie and Parfitt, 1998), and this is a commonly held view by politicians, teachers and others working with children and young people.

A recent meta-analysis (Ekeland et al., 2004) examined whether exercise interventions improved global self-esteem among children and young people aged 3-20 years of age. The results showed that in the 8 trials of an exercise alone intervention versus a no-intervention control there was a small-to-moderate effect in favour of the intervention group (SMD = 0.49, 95% CI = 0.16 to 0.81). Duration of the intervention (<10 weeks vs. >10 weeks) did not seem to affect the outcome. Comparisons were also made between interventions with healthy children and with children at risk of defined problems. Significant findings were only found for the latter group (SMD = 0.49, 95% CI 0.17 to 0.82). Most of the trials were of small scale and short duration. No follow-up results were given so the sustainability of changes could not be assessed. Only one of the trials was considered to be of high methodological quality, but it demonstrated the strongest effects.

A further 4 trials compared the effects of exercise as part of a comprehensive intervention package against no-intervention control groups and showed a moderate positive effect on self esteem in favour of the intervention (SMD = 0.51, 95% CI 0.15 - 0.88). The size of this effect increased when the only study with healthy participants was excluded (SMD = 0.64, 95% CI 0.22 – 1.06). There appeared to be an effect for study quality, with studies of moderate bias yielding non-significant effects but those of high bias yielding significant results (there were no comprehensive intervention studies with low bias). The authors also noted that the effects of exercise may be underestimated, as across both sections of the review all the studies used “usual activity” as the control treatment and therefore comparisons are not necessarily between exercise and no physical activity.

Some mental health problems have been identified with exercise, such as eating disorders or dependence on exercise (addiction). However, studies are nearly all with adults. For example, Polivy (1994) reviewed 11 studies on addiction to exercise and concluded that exercise could be a compulsive behaviour for some individuals. This is likely to be unhealthy due to increased risk of injury, fatigue, illness and psychological ill-health. However, the prevalence of exercise dependence is not known and is likely to be very small (Szabo, 2000). Links to self-esteem may be likely but further research is required on young people.

In summary, exercise can lead to improvements in self-esteem, at least in the short term and among at-risk youth. However, there is a paucity of good quality research in this area. Moreover, global measures of self-esteem can be affected by many factors beyond physical activity. Hence, measures of physical aspects of the self, such as body image or physical self-worth, important indices of psychological health in their own right, might be better targets for intervention. Evidence is best described as category C with moderate strength of effect.

Cognitive function

There has been significant interest in the relationship between physical activity and cognitive performance and academic achievement in young people. A recent meta-analysis (Sibley and Etnier, 2003) attempted to bring consensus to a conflicting and previously inconclusive body of literature. From 44 studies, it was concluded that there is a significant positive relationship (effect size = 0.32; ‘small’) between physical activity and cognitive functioning in young people (ages 4-18 years). Moderator analyses showed that this holds for all participants (healthy participants, those with mental impairments, and those with physical disabilities) and all ages. The findings were qualified by the authors because of lack of control for confounding variables, the relatively small number of peer-reviewed true experimental designs (K=9, 20%) and measurement issues, particularly of the dependent measure of cognitive functioning. Nevertheless, Sibley and Etnier concluded that, from a conservative standpoint, time spent in physical activity will not hurt cognitive performance and may actually improve it.

Kirkendall (1986) concluded that a modest positive relationship existed between motor performance and intellectual performance in children and that this relationship was strongest in the early stages of development. Intervention techniques for learning disabled children have also been investigated but a meta-analysis of 180 studies (Kavale and Mattson, 1983) showed no positive effect on academic, cognitive or perceptual motor performance from perceptual-motor training on children whose average IQ was 88 at the age of 8 years. In an experimental study, MacMahon and Gross (1987) found no effect on academic performance for a group of boys with learning disabilities who were given a 20-week vigorous aerobic exercise programme.

Claims that exercise for children helps them perform better academically have been used in support of daily physical education programmes (Dwyer et al., 1983; Pollatschek and O'Hagan, 1989), although a review by Shephard (1997) led him to conclude that “daily programs of physical education should not be introduced with the expectation that they will lead to major gains in academic performance” (p. 123). Indeed, a recent school-based RCT found that increased physical activity maintained rather than enhanced academic performance (Ahamed et al., 2007).

Many studies in this area have tended to be uncontrolled and open to positive expectancy effects. However, in a recent study of neurocognitive function in children using EEG and cognitive tests, Hillman et al. (2005) demonstrated that children with higher physical fitness also had faster neurocognitive processing, and better indices of memory and attention. Moreover, a recent cross-sectional American study showed a positive association between physical fitness and academic achievement (Castelli et al., 2007). This requires further testing with the uncoupling of effects for fitness and physical activity.

In conclusion, cognitive function may be positively influenced by physical activity in young people. However, many of the studies have low methodological quality. Evidence is category C with small strength of effect.

In summarising physical activity and mental health, physical activity is likely to have positive psychosocial outcomes for young people. The effects appear strongest for self-esteem (at least in the short term), and those who are physically active appear less likely to suffer from mental health problems and may have enhanced cognitive functioning. Evidence on depression is also promising but remains an underdeveloped area of enquiry. Although all participants are likely to gain significant benefits, the beneficial effects are likely to be greater in those who have poorer mental health at baseline. However, the evidence 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 possible that the prevailing psychological climate and social interactions inherent in such settings will also be crucial. Unfortunately, such factors are rarely accounted for.

3.3.6. Summary of relationships between childhood physical activity and childhood health

For many of the reasons already stated, detecting clear health outcomes of physical activity for children is not easy. Nevertheless, there is enough evidence to show that physical activity is an important health behaviour for children. The evidence is summarised in Table 1.

Table 1. Summary of evidence of the relationships between childhood physical activity and childhood health (see pp. 10-11 for details).

Health-related outcome	Strength of evidence (effect)	Category of evidence	Comments
Obesity	Small	B	The strength of evidence borders on small or small-to-moderate, so a conservative estimate is 'small'.
Type 2 diabetes	Moderate	C	
CVD risk factors	Small	C	
Skeletal health:			
a) bone mineral accrual	Moderate	B	
b) bone fracture	Small	C/B	
Mental health:			
a) depression	Moderate	C	
b) anxiety	Small	C	
c) self-esteem	Moderate	C	
d) cognitive functioning	Small	C	

3.4. Relationships between childhood physical activity and adult health

The previous element of this review addressed relationships between physical activity in childhood and adolescence and associated health outcomes during the same developmental period. A more difficult research exercise is to demonstrate relationships between physical activity in young people and health outcomes as an adult. This is path 'i' in Figure 1.

3.4.1. Obesity

It seems logical to think that being active as a young person may help attenuate the usual gains in body fatness during adulthood. Evidence for this is suggestive but not conclusive. A systematic review of childhood predictors of adult obesity (Parsons et al., 1999) concluded that there was "inconsistent but suggestive evidence for a protective effect of activity in childhood on later fatness" (p. S1). Similar conclusions were drawn by Wareham (2007).

Three longitudinal studies merit consideration. In an American study (Kimm et al., 2005), changes in self-reported habitual physical activity were examined in relation to changes in BMI and skinfold thickness in 1,152 black and 1,135 white females who were followed from ages 9/10 to 18/19 years. There was the well-known pronounced decline in physical activity during the transition from childhood to young adulthood while BMI and sum of skinfolds increased during this period. However, those classified as active during adolescence experienced smaller gains in BMI and skinfolds than those classified as inactive, even after adjusting for energy intake.

In the Cardiovascular Risk in Young Finns Longitudinal Study (Yang et al., 2006), 1,319 boys and girls aged 9-18 years were followed-up for 21 years. Adult obesity was associated with adult physical activity and adolescent obesity, and showed only an indirect effect for adolescent physical activity acting through youth obesity. In a study of a British cohort from births in March 1958 (Parsons et al., 2005), a trend was found for more activity in adolescence and early adulthood to predict a gain in BMI over a 30 year period. However, these trends were often quite complex. For example, physical activity at age 11 years had no effect on BMI in later life, whereas females showing higher activity at 16 years did show slower BMI gains as they aged. Results for males were inconsistent. However, the validity of the assessment of physical activity was not easy to judge, with only a few self-report items used in assessing use of facilities and playing sport.

3.4.2. Type-2 Diabetes

Given the recency with which the research community has been investigating the increase in type-2 diabetes in young people, it is not surprising that we believe that there are no data concerning the relationship between physical activity in young people and type-2 diabetes in adulthood.

3.4.3. Cardiovascular disease

In section 3.3, we showed evidence that cardiovascular disease (CVD) has its origins in childhood and that obesity in childhood is associated with traditional CVD risk factors such as hypertension. Overweight and obesity in youth are also associated with the insulin resistance (metabolic) syndrome. Long-term follow-up studies investigating adolescent physical activity and adult CVD outcomes are rare. In a review by Hallal and colleagues (2006), it was concluded that little relationship is evident for CVD risk factors, although measurement problems may partly explain this.

In the Amsterdam Growth and Health Longitudinal Study, Ferreira et al. (2005) studied adolescents aged 13 years and followed up with measures at aged 36 years. Participants were classified as to whether they demonstrated the metabolic syndrome. Those that did, in comparison to others, showed a more marked increase in body fatness and energy intake, while showing lower levels of fitness and vigorous (‘hard’) physical activities. On the other hand, they also showed increases in light-to-moderate activity and decreased alcohol intake.

A longitudinal study conducted by Hancox and colleagues (2004) addressed the issue from the point of view of sedentary rather than active behaviours. Mean hours of television viewed per weekday from the ages of 5 to 15 years were positively associated with prevalence of overweight and CVD risk at age 26 years, as indicated by elevated total cholesterol concentration, smoking and poor fitness levels. One difficulty in interpreting such evidence is that a consistent finding in young people in that TV viewing is largely unrelated to levels of physical activity (Marshall et al., 2004). Nevertheless, for some people, TV viewing may be indicative of high levels of sedentary behaviour and may also be associated with poor or excessive nutritional intake.

3.4.4. Skeletal health

There were no longitudinal studies to convincingly demonstrate that gains in bone mineral density achieved in 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 to controls (Karlsson et al., 2000). It is not possible to say whether this discrepancy reflects a gender or activity difference.

Long term follow-up studies are required to determine whether bone mineral density gains attained via 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). In summary, it remains to be determined if there are carry over effects from childhood to adulthood with respect to skeletal health.

3.4.5. Mental health

The effect of physical activity on mental health in children and adolescents has received significantly less attention than in adult populations, as we reported earlier. Indeed, most of the studies on young people are cross-sectional and there are no studies that we are aware of that track young people longitudinally from adolescence into adulthood in this area.

There are eight prospective studies that show a low level of activity at some preceding date (2-30 years) is associated with clinically defined depression at a later date (Biddle and Mutrie, in press). However, all but one of these follow participants as adults. The only longitudinal study on adolescents tracks them during this age period and not into adulthood (Motl et al., 2004). All have good design features in that physical activity was adequately measured and depression clinically defined. These studies suggest that inactivity precedes depression. This helps to refute the ‘reverse causation’ proposal. This states that the association found in cross sectional data is merely showing that depressed people choose to be inactive. However, as highlighted, we cannot demonstrate this from baseline data on adolescents.

We are not aware of any prospective study where physical activity in young people has been assessed and used to predict other adult mental health outcomes, such as anxiety and self-esteem.

In summarising the effects of childhood physical activity on adult health outcomes, all evidence is category C or even D, with strength of effects, where known, being small.

3.5. Discussion

The relationship between physical activity and health in children is often quite weak (Riddoch, 1998). This is due to many factors, including the difficulty of measuring physical activity in this age group, and the weak indicators of many disease end points at this stage of life. In addition, many children are already active, thus reducing variability in the behaviour required to show strong relationships at the population level. Therefore, it should not be expected that relationships will be strong. Of course, detecting relationships between childhood physical activity and adult health is even more difficult and the evidence base is still quite small.

The strongest evidence for the role of physical activity in physical health promotion among young people appears to be in the prevention of overweight and obesity and in enhancing skeletal health. Increasing physical activity and decreasing a range of sedentary behaviours may be an effective strategy in the management of overweight and obesity in children and adolescents, alongside appropriate nutritional intake. Physical activity should also be encouraged among children and adolescents as one component of an overall lifestyle package aimed at preventing type 2 diabetes. Physical activity has positive effects on skeletal health, with stronger effects for those in the early pubertal stage of development, an age that may represent a ‘window of opportunity’ for bone development.

Physical activity is likely to have positive psychosocial outcomes for young people. The effects appear strongest for self-esteem (at least in the short term), and to a certain extent depression, and those who are physically active appear less likely to suffer from mental health problems and may have enhanced cognitive functioning. Beneficial effects are likely to be greater in those who have poorer mental health at baseline. Of course, the quality of the physical activity experience may be equally or more important for psychological well-being than the quantity of activity.

3.6. Conclusions: health benefits

- Physical activity has small but significant physical health benefits for children, notably prevention of overweight and obesity and type II diabetes, and improvements in skeletal health.

- Physical activity has moderate psychological health benefits for children, particularly for self-esteem, but also for depression.

- There is limited evidence that childhood physical activity directly affects health in adulthood

- However, health indicators such as obesity do track from childhood to adulthood, therefore childhood physical activity may have an indirect influence on adult health.

- There is little evidence for the differential effect of physical activity on childhood health by gender, age or ethnicity.

References (section 3)

Ahamed Y, MacDonald H, Reed K, Naylor P-J, Liu-Ambrose T, McKay H. School-based physical activitydoes not compromise children's academic performance. Medicine and Science in Sports and Exercise 2007; 39: 371-376.

Alberti KGMM, Zimmet PZ, Shaw JE, for the IDF Epidemiology Task Force Consensus Group. The metabolic syndrome: A new worldwide definition. The Lancet 2005; 366: 1059-1062.

American College of Sports Medicine. Physical activity and bone: Position stand. Medicine and Science in Sports and Exercise 2004; 36: 1985-1996.

Andersen LB, Harro M, Sardinha LB, Froberg K, Ekelund U, Brage S, et al. Physical activity and clustered cardiovascular risk in children: A cross-sectional study (The European Youth Heart Study). The Lancet 2006; 368: 299-304.

Atlantis E, Barnes EH, Singh MAF. Efficacy of exercise for treating overweight in children and adolescents: A systematic review. International Journal of Obesity 2006; 30: 1027-1040.

Aylin P, Williams S, Bottle A. Obesity and type 2 diabetes in children, 1996-7 to 2003-4. British Medical Journal 2005; 331: 1167.

Bailey DA. The Saskatchewan Pediatric Bone Mineral Accrual Study: Bone mineral acquisition during the growing years. International Journal of Sports Medicine 1997; 18 (Supplement): S191-S194.

Bass S, Pearce G, Bradney M, Hendrich E, Delmas PD, Harding A, et al. Exercise before puberty may confer residual benefits in bone density in adulthood: Studies in active prepubertal and retired female gymnasts. Journal of Bone Mineral Research 1998; 13: 500-507.

Bassett DR, Tremblay MS, Eslinger DW, Copeland JL, Barnes JD, Huntingdon GE. Physical activity and body mass index of children in an old order Amish community. Medicine and Science in Sports and Exercise 2007; 39: 410-415.

Bassuk SS, Manson JE. Epidemiological evidence for the role of physical activity in reducing the risk of type 2 diabetes and cardiovascular disease. Journal of Applied Physiology 2005; 99: 1193-1204.

Biddle SJH, Gorely T, Marshall SJ, Murdey I, Cameron N. Physical activity and sedentary behaviours in youth: Issues and controversies. Journal of the Royal Society for the Promotion of Health 2004a; 124: 29-33.

Biddle SJH, Gorely T, Stensel DJ. Health-enhancing physical activity and sedentary behaviour in children and adolescents. Journal of Sports Sciences 2004b; 22: 679-701.

Biddle SJH, Mutrie N. Psychology of physical activity: Determinants, well-being and interventions (2nd Edition). London: Routledge, in press.

Biddle SJH, Sallis JF, Cavill N, editors. Young and active? Young people and health-enhancing physical activity: Evidence and implications. London: Health Education Authority, 1998.

Boreham C, Riddock C. The physical activity, fitness and health of children. Journal of Sports Sciences 2001; 19: 915-929.

Bouchard C. Introduction. In: Bouchard C, editor. Physical activity and obesity. Champaign, IL: Human Kinetics, 2000: 3-19.

Bouchard C, Blair SN. Introductory comments for the consensus on physical activity and obesity. Medicine and Science in Sports and Exercise 1999; 31: S498-S501.

British Medical Association. Preventing childhood obesity. London: British Medical Association Board of Science, 2005.

Bryant MJ, Lucove JC, Evenson KR, Marshall S. Measurement of television viewing in children and adolescents: A systematic review. Obesity Reviews 2007; 8: 197-209.

Bundred P, Kitchiner D, Buchan I. Prevalence of overweight and obesity children between 1989 and 1998: Population based series of cross-sectional studies. British Medical Journal 2001; 322: http:/bmj.com/cgi/content/full/322/7282/326.

Calfas KJ, Taylor WC. Effects of physical activity on psychological variables in adolescents. Pediatric Exercise Science 1994; 6: 406-423.

Campbell K, Waters E, O'Meara S, Kelly S, Summerbell C. Interventions for preventing obesity in children. The Cochrane Database of Systematic Reviews 2005; 2: No: CD001871. DOI: 10.1002/14651858.

Caspersen CJ, Pereira MA, Curran KM. Changes in physical activity patterns in the United States, by sex and cross-sectional age. Medicine and Science in Sports and Exercise 2000; 32: 1601-1609.

Castelli DM, Hillman CH, Buck SM, Erwin HE. Physical fitness and academic achievement in third- and fifth-grade students. Journal of Sport & Exercise Psychology 2007; 29: 239-252.

Cavill N, Biddle SJH, Sallis JF. Health-enhancing physical activity for young people: Statement of the United Kingdom Expert Consensus Conference. Pediatric Exercise Science 2001; 13: 12-25.

Chinn S, Rona RJ. Prevalence and trends in overweight and obesity in three cross-sectional studies of British children, 1974-94. British Medical Journal 2001; 322: 24-26.

Clark EM, Ness AR, Bishop NJ, Tobias JH. Association between bone mass and fractures in children: A prospective cohort study. Journal of Bone and Mineral Research 2006a; 21: 1489-1495.

Clark EM, Tobias JH, Ness AR. Association between bone density and fractures in children: A systematic review and meta-analysis. Pediatrics 2006b; 117: e291-e297.

Cohen J. Statistical power analysis for the behavioral sciences. Hillsdale, NJ: Erlbaum, 1988.

Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: International survey. British Medical Journal 2000; 320: 1240-1243.

Craft LL, Landers DM. The effect of exercise on clinical depression and depression resulting from mental illness: A meta-analysis. Journal of Sport & Exercise Psychology 1998; 20: 339-357.

Department of Health. At least five a week: Evidence on the impact of physical activity and its relationship to health. A report from the Chief Medical Officer. London: Author, 2004.

Doak CM, Visscher TLS, Renders CM, Seidell JC. The prevention of overweight and obesity in children and adolescents: A review of intervention programmes. Obesity Reviews 2006; 7: 111-136.

Dwyer T, Coonan WE, Leitch DR, Hetzel BS, Baghurst RA. An investigation of the effects of daily physical activity on the health of primary school students in South Australia. International Journal of Epidemiology 1983; 12: 308-313.

Eisenmann JC, Katzmarzyk PT, Perusse L, Tremblay A, Després J-P, Bouchard C. Aerobic fitness, body mass index, and CVD risk factors among adolescents: The Québec family study. International Journal of Obesity 2005; 29: 1077-1083.

Ekeland E, Heian F, Hagen KB, Abbott J, Nordheim LV. Exercise to improve self-esteem in children and young people. The Cochrane Database of Systematic Reviews 2004: Issue 1. Art.No.:CD003683. DOI:10.1002/14651858. CD003683.pub2.

Ekelund U, Brage S, Froberg K, Harro M, Anderssen SA, Sardinha LB, et al. TV viewing and physical activity are independently associated with metabolic risk in children: The European Youth Heart Study. PLoS Medicine 2006; 2: 2449-2456.

Ferreira I, Boreham CA, Twisk JWR, Gallagher AM, Young IS, Murray LJ, et al. Clustering of metabolic syndrome risk factors and arterial stiffness in young adults: the Northern Ireland Young Hearts project. Journal of Hypertension 2007; 25: 1009-1020.

Ferreira I, Twisk JWR, van Mechelen W, Kemper HCG, Stehouwer CDA. Development of fatness, fitness and lifestyle from adolescence to the age of 36 years. Archives of Internal Medicine 2005; 165: 42-48.

Flodmark CE, Marcus C, Britton M. Interventions to prevent obesity in children and adolescents: A systematic literature review. International Journal of Obesity 2006; 30: 579-589.

Fox KR. The effects of exercise on self-perceptions and self-esteem. In: Biddle SJH, Fox KR and Boutcher SH, editors. Physical activity and psychological well-being. London: Routledge, 2000: 88-117.

Green H, McGinnity A, Meltzer H, Ford T, Goodman R. Mental health of children and young people in Great Britain 2004. Basingstoke: Palgrave MacMillan, 2005.

Gruber JJ. Physical activity and self-esteem development in children: A meta-analysis. In: Stull GA and Eckert HM, editors. Effects of physical activity on children. Champaign, IL: Human Kinetics, 1986: 30-48.

Grundy SM. Does a diagnosis of metabolic syndrome have value in clinical practice? American Journal of Clinical Nutrition 2006; 83: 1248-1251.

Hakanen M, Lagström H, Kaitosaari T, Niinikoski H, Näntö-Salonen K, Jokinen E. Development of overweight in an atherosclerosis prevention trial starting in early childhood: The STRIP study. International Journal of Obesity 2006; 30: 618-626.

Hallal PC, Victora CG, Azevedo MR, Wells JCK. Adolescent physical activity and health: A review. Sports Medicine 2006; 36: 1019-1030.

Hancox RJ, Milne BJ, Poulton R. Association between child and adolescent television viewing and adult health: A longitudinal birth cohort study. The Lancet 2004; 364: 257-262.

Hardman AE, Stensel DJ. Physical activity and health: The evidence explained. London: Routledge, 2003.

Hillman CH, Castelli DM, Buck SM. Aerobic fitness and neurocognitive function in healthy preadolescent children. Medicine and Science in Sports and Exercise 2005; 37: 1967-1974.

Hind K, Burrows M. Weight-bearing exercise and bone mineral accrual in children and adolescents: A review of controlled trials. Bone 2007; 40: 14-27.

Imperatore G, Cheng YJ, Williams DE, Fulton J, Gregg EW. Physical activity, cardiovascular fitness, and insulin sensitivity among U.S. adolescents: The National Health and Nutrition Examination Survey, 1999–2002. Diabetes Care 2006; 29: 1567-1572.

Janssen I, Katzmarzyk PT, Boyce WF, Vereecken C, Mulvihill C, Roberts C, et al. Comparison of overweight and obesity prevalence in school-aged youth from 34 countries and their relationships with physical activity and dietary patterns. Obesity Reviews 2005; 6: 123-132.

Kahn KM, Bennell KL, Hopper JL, Flicker L, Nowson CA, Sherwin AJ, et al. Self-reported ballet classes undertaken at age 10 and 12 years and hip bone mineral density in later life. Osteoporosis International 1998; 8: 165-173.

Karlsson MK, Linden C, Karlsson C, Johnell O, Obrant K, Seeman E. Exercise during growth and bone mineral density and fractures in old age. Lancet 2000; 355: 469-470.

Kasa-Vubu JZ, Lee CC, Rosenthal A, Singer K, Halter JB. Cardiovascular fitness and exercise as determinants of insulin resistance in postpubertal adolescent females. Journal of Clinical Endocrinology and Metabolism 2005; 90: 849-854.

Kavale K, Mattson PD. 'One jumped off the balance beam': Meta-analysis of perceptual-motor training. Journal of Learning Disabilities 1983; 16: 165-173.

Khan F, Green FC, Forsyth JS, Greene SA, Morris AD, Belch JJF. Impaired microvascular function in normal children: Effects of adiposity and poor glucose handling. Journal of Physiology 2003; 551: 705-711.

Khunti K, Davies M. Metabolic syndrome. British Medical Journal 2005; 331: 1153-1154.

Kimm SYS, Glynn NW, Obarzanek E, Kriska AM, Daniels SR, Barton BA. Relation between changes in physical activity and body-mass index during adolescence: A multicentre longitudinal centre. The Lancet 2005; 366: 301-307.

Kirkendall DR. Effects of physical activity on intellectual development and academic performance. In: Stull GA and Eckert HM, editors. Effects of physical activity on children. Champaign, IL: Human Kinetics & American Academy of Physical Education, 1986: 49-63.

Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. The New England Journal of Medicine 2002; 346: 393-403.

Lagerberg D. Physical activity and mental health in schoolchildren: A complicated relationship. Acta Paediatrica 2005; 94: 1699-1701.

LaMonte MJ, Blair SN, Church TS. Physical activity and diabetes prevention. Journal of Applied Physiology 2005; 99: 1205-1213.

Larun L, Nordheim LV, Ekeland E, Hagen KB, Heian F. Exercise in prevention and treatment of anxiety and depression among children and young people. Cochrane Database of Systematic Reviews 2006: Issue 3. Art.No.:CD004691. DOI:10.1002/14651858. CD004691.pub2.

Livingstone B. Epidemiology of childhood obesity in Europe. European Journal of Pediatrics 2000; 159: S14-S34.

MacKelvie KJ, Khan KM, McKay HA. Is there a critical period for bone response to weight-bearing exercise in children and adolescents? A systematic review. British Journal of Sports Medicine 2002; 36: 250-257.

MacMahon JR, Gross RT. Physical and psychological effects of aerobic exercise in boys with learning difficulties. Developmental and Behavioral Pediatrics 1987; 8: 274-277.

Marshall SJ, Biddle SJH, Gorely T, Cameron N, Murdey I. Relationships between media use, body fatness and physical activity in children and youth: A meta-analysis. International Journal of Obesity 2004; 28: 1238-1246.

Marshall SJ, Gorely T, Biddle SJH. A descriptive epidemiology of screen-based media use in youth: A review and critique. Journal of Adolescence 2006; 29: 333-349.

McCarthy HD, Ellis SM, Cole TJ. Central overweight and obesity in British youth aged 11-16 years: Cross sectional surveys of waist circumference. British Medical Journal 2003; 326: 624-627.

Motl RW, Birnbaum AS, Kubik MY, Dishman RK. Naturally occurring changes in physical activity are inversely related to depressive symptoms during early adolescence. Psychosomatic Medicine 2004; 66(3): 336-342.

Mutrie N. The relationship between physical activity and clinically defined depression. In: Biddle SJH, Fox KR and Boutcher SH, editors. Physical activity and psychological well-being. London: Routledge, 2000: 46-62.

Mutrie N, Parfitt G. Physical activity and its link with mental, social and moral health in young people. In: Biddle SJH, Sallis JF and Cavill N, editors. Young and active? Young people and health-enhancing physical activity: Evidence and implications. London: Health Education Authority, 1998: 49-68.

National Audit Office. Tackling of obesity. London: The Stationery Office, 2001.

National Institute for Health and Clinical Excellence. The guidelines manual. London: Author www.nice.org.uk, 2007.

National Institute for Health and Clinical Excellence & National Collaborating Centre for Primary Care. Obesity: The prevention, identification, assessment and management of overweight and obesity in adults and children: http://guidance.nice.org.uk/CG43/guidance, 2006.

National Institutes of Health and National Heart Lung and Blood Institute. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: The evidence report. Obesity Research 1998; 6: 51S-209S.

North TC, McCullagh P, Tran ZV. Effect of exercise on depression. Exercise and Sport Sciences Reviews 1990; 18: 379-415.

Office of National Statistics. Social Trends 2005; 35.

Parsons TJ, Manor O, Power C. Physical activity and change in body mass index from adolescence to mid-adulthood in the 1958 British cohort study. International Journal of Epidemiology 2005; 35: 197-204.

Parsons TJ, Power C, Logan S, Summerbell CD. Childhood predictors of adult obesity: A systematic review. International Journal of Obesity 1999; 23: S1-S107.

Petruzzello SJ, Landers DM, Hatfield BD, Kubitz KA, Salazar W. A meta-analysis on the anxiety-reducing effects of acute and chronic exercise: Outcomes and mechanisms. Sports Medicine 1991; 11: 143-182.

Polivy J. Physical activity, fitness, and compulsive behaviors. In: Bouchard C, Shephard RJ and Stephens. T, editors. Physical activity, fitness, and health. Champaign, IL: Human Kinetics, 1994: 883-897.

Pollatschek JL, O'Hagan FJ. An investigation of the psycho-physical influences of a quality daily physical education programme. Health Education Research: Theory and Practice 1989; 4: 341-350.

Reaven GM. The metabolic syndrome: Is this diagnosis necessary? American Journal of Clinical Nutrition 2006; 83: 1237-1247.

Reinehr T, de Sousa G, Toschke AM, Andler W. Long-term follow-up of cardiovascular disease risk factors in children after an obesity intervention. American Journal of Clinical Nutrition 2006; 84: 490-496.

Rennie KL, Livingstone MBE, Wells JCK, McGloin A, Coward WA, Prentice AM, et al. Association of physical activity with body-composition indexes in children aged 6-8 y at varied risk of obesity. American Journal of Clinical Nutrition 2005; 82: 13-20.

Riddoch C. Relationships between physical activity and physical health in young people. In: Biddle S, Sallis J and Cavill N, editors. Young and active? Young people and health-enhancing physical activity: Evidence and implications. London: Health Education Authority, 1998: 17-48.

Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. Medicine and Science in Sports and Exercise 2000; 32: 963-975.

Shephard RJ. Curricular physical activity and academic performance. Pediatric Exercise Science 1997; 9: 113-126.

Sibley BA, Etnier JL. The relationship between physical activity and cognition in children: A meta-analysis. Pediatric Exercise Science 2003; 15: 243-256.

Simon TR, Powell KE, Swann AC. Involvement in physical activity and risk for nearly lethal suicide attempts. American Journal of Preventive Medicine 2004; 27: 310-315.

Sinha R, Fisch G, Teague B, Tamborlane WV, Banyas B, Allen K, et al. Prevalence of impaired glucose tolerance among children and adolescents with marked obesity. The New England Journal of Medicine 2002; 346: 802-810.

Stamatakis E, Primatesta P, Chinn S, Rona RJ, Falascheti E. Overweight and obesity trends from 1974 to 2003 in English children: What is the role of socioeconomic factors? Archives of Disease in Childhood 2005; 90: 999-1004.

Stensel DJ, Gorely T, Biddle SJH. Youth health outcomes. In: Smith AL and Biddle SJH, editors. Youth physical activity and sedentary behaviour: Challenges and solutions. Champaign, Il: Human Kinetics, 2008.

Strong WB, Malina RM, Blimkie CJ, Daniels SR, Dishman RK, Gutin B, et al. Evidence based physical activity for school-age youth. Journal of Pediatrics 2005; 146: 732-737.

Sturm R. Childhood obesity: What we can learn from existing data on societal trends, Part 1. Preventing Chronic Disease [serial online] 2005; 2, January: http://www.cdc.gov/pcd/issues/2005/jan/04_0038.htm.

Swanton K, Frost M. Lightening the load: Tackling overweight and obesity - A toolkit for developing local strategies to tackle overweight and obesity in children and adults. London: National Heart Forum, 2007.

Szabo A. Physical activity as a source of psychological dysfunction. In: Biddle SJH, Fox KR and Boutcher SH, editors. Physical activity and psychological well-being. London: Routledge, 2000: 130-153.

Taylor AH. Physical activity, anxiety, and stress. In: Biddle SJH, Fox KR and Boutcher SH, editors. Physical activity and psychological well-being. London: Routledge, 2000: 10-45.

Tomson LM, Pangrazi RP, Friedman G, Hutchison N. Childhood depressive symptoms, physical activity and health related fitness. Journal of Sport & Exercise Psychology 2003; 25: 419-439.

Tuomilehto J, Lindström J, Eriksson JG, Valle TT, Hämäläinen H, Ilanne-Parikka P, et al. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. New England Journal of Medicine 2001; 344: 1343-1350.

Vicente-Rodriguez G. How does exercise affect bone development during growth? Sports Medicine 2006; 36: 561-569.

Viner RM, Booy R. ABC of adolescence: Epidemiology of health and illness. British Medical Journal 2005; 330: 411-414.

Viner RM, Segal TY, Lichtarowicz-Krynska E, Hindmarsh P. Prevalence of the insulin resistance syndrome in obesity. Archives of Disease in Childhood 2005; 90: 10-14.

Wang Y, Rimm EB, Stampfer MJ, Willett WC, Hu FB. Comparison of abdominal adiposity and overall obesity in predicting risk of type 2 diabetes among men. American Journal of Clinical Nutrition 2005; 81: 555-563.

Wareham N. Physical activity and obesity prevention. Obesity Reviews 2007; 8: 109-114.

Watts K, Jones TW, Davis EA, Green D. Exercise training in obese children and adolescents. Sports Medicine 2005; 35: 375-392.

Weiss R, Raz I. Focus on childhood fitness, not just fatness. The Lancet 2006; 368: 261-262.

Yang X, Telama R, Leskinen E, Mansikkaniemi K, Viikari J, Raitakari OT. Testing a model of physical activity and obesity tracking from youth to adulthood: the cardiovascular risk in young Finns study. International Journal of Obesity 2006; 31: 521-527.

4. How active are children and young people?

4.1. Summary

- Surveys show that high proportions of children are active at recommended levels.
- There is, however, a significant minority of children who take little or no physical activity
- Inactivity is highest among young girls (from around age 10)
- Provision of PE and sport in schools has been increasing while active travel to school has declined.
- Levels of sport and exercise are lower among lower socio-economic groups and people from black and minority ethnic groups.

4.2. Introduction

This chapter aims to describe the prevalence and patterns of different types of physical activity in pre-school and school children. This will help to identify populations of children or developmental stages in which physical activity is low and therefore of concern.

4.3. Methodology

Data for this chapter come from surveys of children and young people that have included questions on physical activity. As we are taking a broad definition of physical activity, we are therefore interested in surveys of sport, exercise, leisure pursuits, and transport.

To be included, surveys needed to have been conducted among a sample of children that was representative of the population of children/young people being studied. Data were included from studies conducted in England (as NICE guidance currently covers England only) but we did not exclude surveys which covered the whole of the UK as long as they included data from England.

We conducted a search of Medline to identify suitable studies but this produced very few surveys of interest, as the majority of survey data are published by government agencies and are therefore classified as ‘grey literature’. We therefore focused on web searches, and following up leads from the Collaborating Centre and discussion with experts. A key resource was a briefing paper on obesity produced by the NHS (Information Centre, 2006) and this was quoted extensively.

4.3.1. Limitations of methods and measures

Most data on the prevalence of physical activity come from interview or self-completion surveys. These commonly ask about level, frequency and duration of participation in separate activities, which are then combined into a composite measure of physical activity. There are several limitations to these assessments, notably difficulties of recall (particularly for activities in daily life such as walking), problems of classification of activity (such as ascribing an energy expenditure value to different types of activity), and variability in research tools used. However, most surveys use the same methodology across their samples, and over different years, so they can provide valuable ways to compare activity levels between groups and identify trends.

4.3.2. Recommended levels of physical activity

The current guidelines are that children should achieve a total of at least 60 minutes of at least moderate intensity physical activity each day. A secondary recommendation is that children should participate in physical activity of at least moderate intensity at least twice a week, to enhance and maintain muscular strength and flexibility and bone health. These stem from a review conducted by the Health Education Authority (Biddle et al., 1998) and endorsed by the Chief Medical Officer (Department of Health, 2004). There is also a Public Service Agreement target in place, shared by the Department for Education and Skills (DfES) and the Department for Culture, Media and Sport (DCMS) to enhance the take-up of sporting opportunities by 5 to 16 year olds so that the percentage of school children in England who spend a minimum of two hours each week on high quality PE and school sport within and beyond the curriculum increases from an estimated 25% in 2002 to 85% by 2008 (Department for Culture Media and Sport, 2005).

4.4. How active are children in England compared to other countries?

The Health Behaviour in School-Aged Children (HBSC) study gathered cross-sectional data from 137,593 young people aged 10-16 years in 34 countries (Janssen et al., 2005). This showed that children in England have relatively high levels of physical activity compared to other countries: England had 41.8% of children active for 60 minutes or more on five or more days a week, the sixth highest of the 34 countries surveyed.

4.5. Details of physical activity participation

The Health Survey for England (HSE) 2002 (Department of Health, 2003) provides the most recent and detailed data on levels of physical activity among young people, with a large enough sample of children to carry out a detailed analysis. Information from the HSE 2002 is presented on the participation in out of-school physical activity and the physical activity levels of children aged 2 to 15. The types of activity for which data were collected were sports and exercise (including dance), active play and walking. Children aged 8 and over were also asked questions about their participation in housework and gardening. Activity which was part of the school curriculum was excluded.

4.5.1. Achievement of thresholds

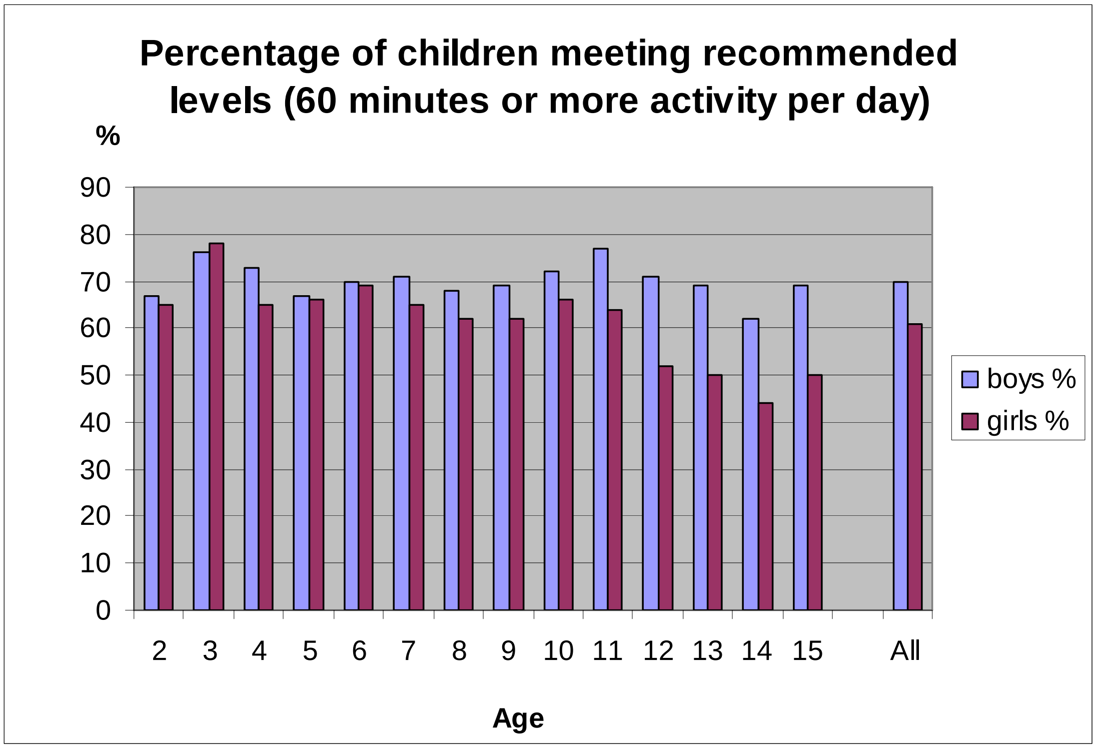
Data on physical activity levels among children are derived by summarising different types of activity into a frequency-duration scale, by taking account of the energy and time spent participating in physical activities, and the number of active days in the last week. In the HSE, the summary levels are divided between high, medium and low activity.

- High activity levels = 60 minutes of moderate intensity physical activity on 7 days in the last week (the recommended level)
- Medium activity levels = 30 to 59 minutes of moderate intensity physical activity on 7 days in the last week.
- Low activity levels = those that are active at a lower level or not active at all.

4.5.2. Age and sex

Overall, boys were more likely than girls to achieve the recommended levels of physical activity, lasting 60 minutes or more on 7 days a week (70% of boys compared with 61% of girls). Overall, participation rates declined with age among girls after age 10. By age 15, 50% of girls did 60 minutes physical activities on 7 days. In contrast, the percentage of 15 year old boys who did so remained high at 69%. See Figure 2.

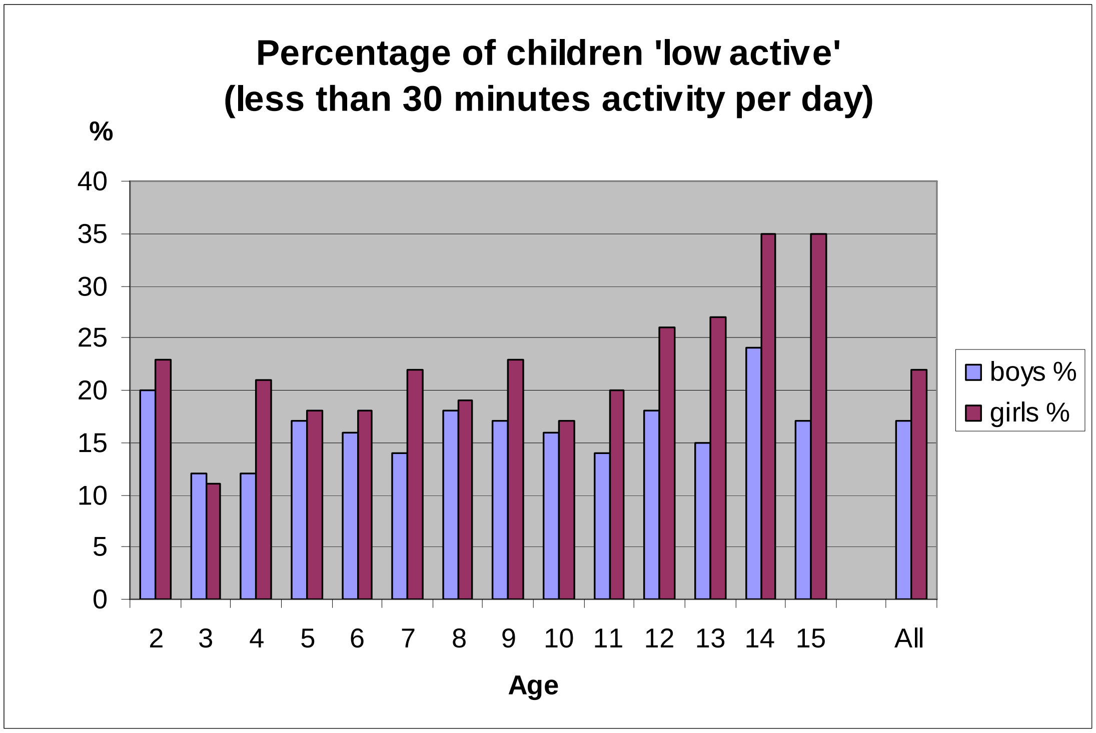
Figure 2.



Source: Health Survey for England 2002. Department of Health.

Figure 3 shows the proportion of children who were classed as 'low active', that is, doing less than 30 minutes activity per day. There is a steep increase among girls after age 10, but levels of inactivity among boys remains at about 15-25%.

Figure 3.

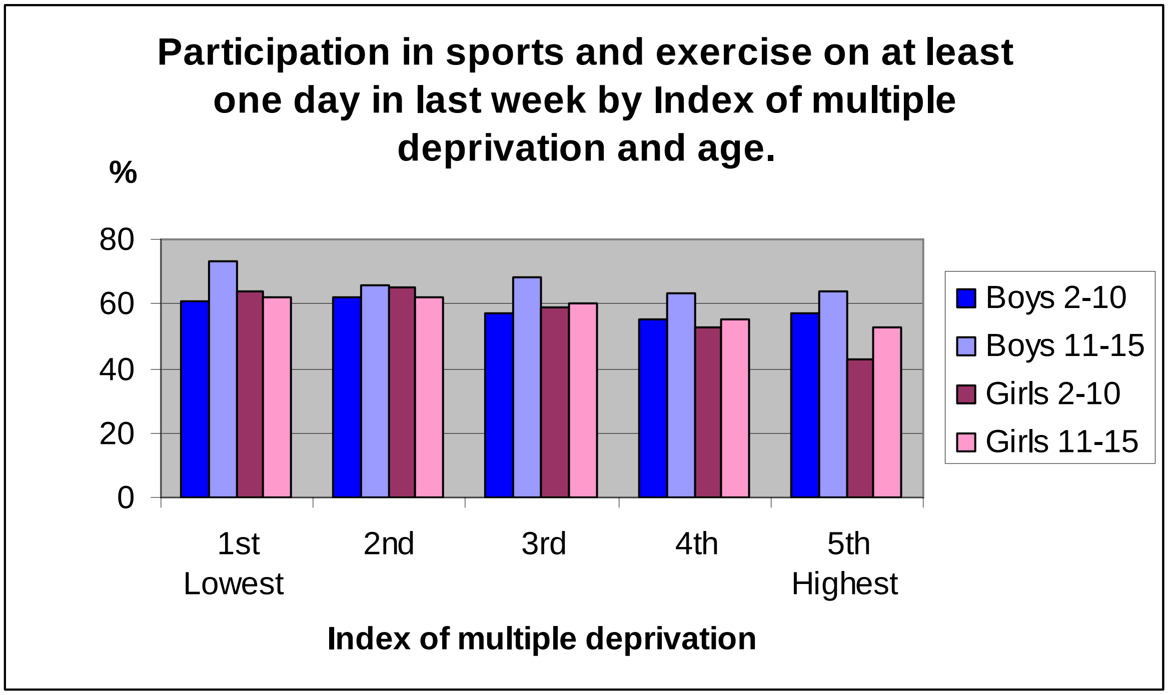


Source: Health Survey for England 2002. Department of Health.

4.5.3. Social class / education

Overall participation levels did not differ significantly when looking at household income quintiles and area deprivation, or NS-SEC (the standard definition of socio-economic status). However, when focusing on individual activities a pattern did emerge for sports and exercise. Participation in sports and exercise on at least one day increased with equivalised income and decreased with deprivation levels, especially among girls (Figure 4).

Fig 4.

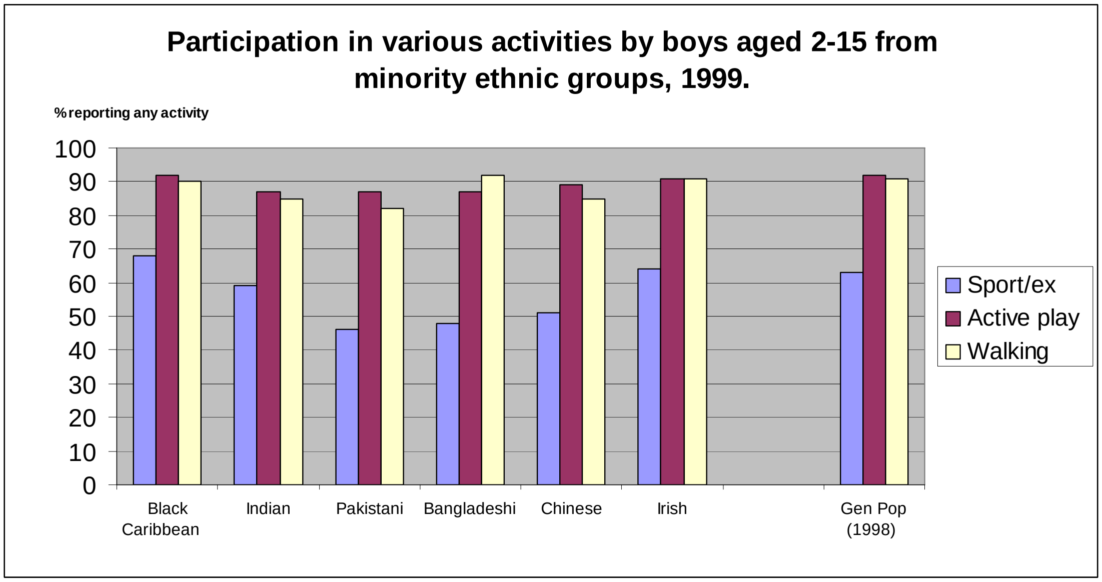


Source: Health Survey for England 2002. Department of Health.

4.5.4. Ethnic origin

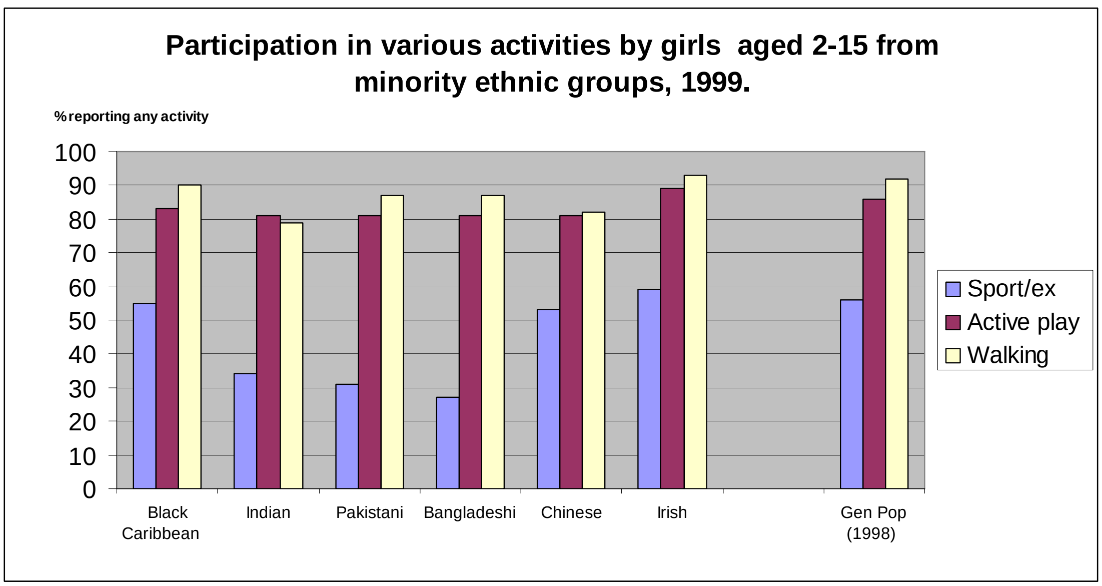
Figures 5 and 6 show participation in sports and exercise, active play and walking among boys and girls from the main minority ethnic groups in England (Black Caribbean, Indian, Pakistani, Bangladeshi, Chinese and Irish). This shows that there are few differences in physical activity participation by ethnic group. The largest differences were for sports and exercise, where Indian, Pakistani, Bangladeshi and Chinese children had lower rates than children in the general population.

Figure 5



Source: Health Survey for England 1999 – The Health of Minority Ethnic Groups.

Figure 6



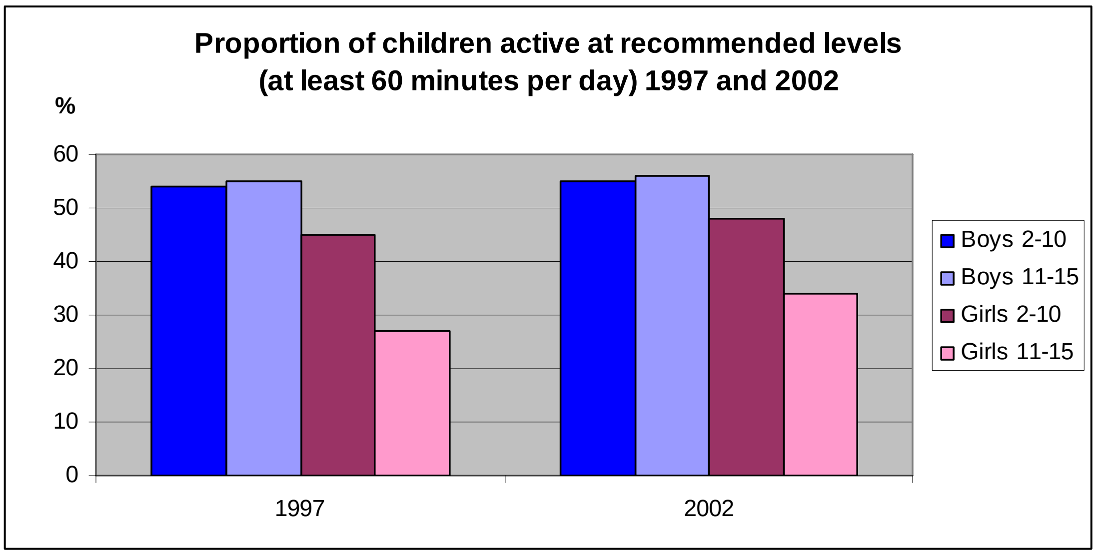
Source: Health Survey for England 1999 – The Health of Minority Ethnic Groups.

4.5.5. Trends in physical activity

The Health Survey for England has suffered considerable changes to the questionnaire over the years, making it difficult to measure trends. To make 2002 data more comparable with 1997 data, only activities that lasted at least 15 minutes were included in the trend analysis. In addition, all walking and housework and gardening sessions in 2002 were capped at 15 minutes to make the data more comparable with 1997. Even then, two time points do not constitute a trend so these should be treated with caution.

There are no significant differences in the proportions of boys and girls aged 2 to 10 and 11 to 15 meeting the physical activity target of at least 60 minutes of activity each day between 1997 and 2002 (Figure 7).

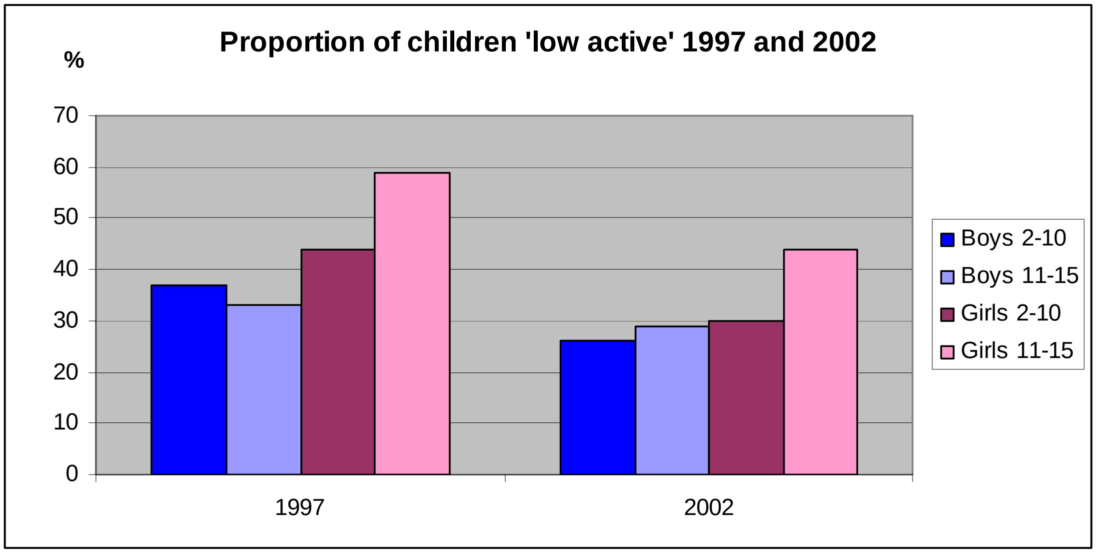
Figure 7.



Source: Health Survey for England 2002. Department of Health.

However, there do appear to be differences in the proportion of people in the lowest activity level, with levels declining between 1997 and 2002, particularly among girls, which is encouraging.

Figure 8.



Source: Health Survey for England 2002. Department of Health.

4.5.6. Types of physical activity

Active Play

Play is an extremely important source of physical activity for children, and especially for younger children. The Health Survey for England (Department of Health, 2002) found 'active play' to be the most common type of activity, reported by 69% of boys and 60% of girls on at least five days. Active play included things such as riding a bike, kicking a ball around, running about, playing active games and jumping around. This excludes activities carried out as part of housework or garden activity (which was the least common activity; with only 3% of boys and 5% of girls doing this type of activity regularly).

Much outdoor play is spontaneous and highly dependent on local circumstances and features of the environment (Millward & Wheway, 1997). It is a common perception that outdoor play among young people has declined (Hillman 1990) and a recent review highlighted the particular decline in natural play, and access to natural environments (Lester & Maudsley, 2006). However, nationally representative data on trends in play are rare and it appears likely that while the nature and type of play have changed, children's play levels have remained stable. Evidence from other countries may be relevant. For example, American trend data over the period 1981-1997 suggest that time spent in formal settings, such as schools and day care (including homework), has increased quite markedly for children. At the same time, increases have also been detected for sports/outdoor activities and shopping. Declines have been shown for general playing, TV viewing and other passive leisure (Sturm, 2005). Of course, more recent data may show increases in electronic sedentary behaviour, although the TV trends suggested by Sturm seem to be robust (Marshall, Gorely, & Biddle, 2006).

Physical education

Data on the physical activity that children do as part of the school curriculum is available from the School Sport Survey, conducted for DfES by an independent research company (TNS, 2006). This is an audit among all schools in the school sport partnership programme during the academic year 2005/06. In total, 16,882 schools within school sport partnerships took part in the survey between May and July 2006, representing 80% of all schools in England. This is a high coverage although it cannot be said to be representative of all schools in England as the sample is likely to be biased towards those schools more pre-disposed to sport and physical activity.

Time spent in PE

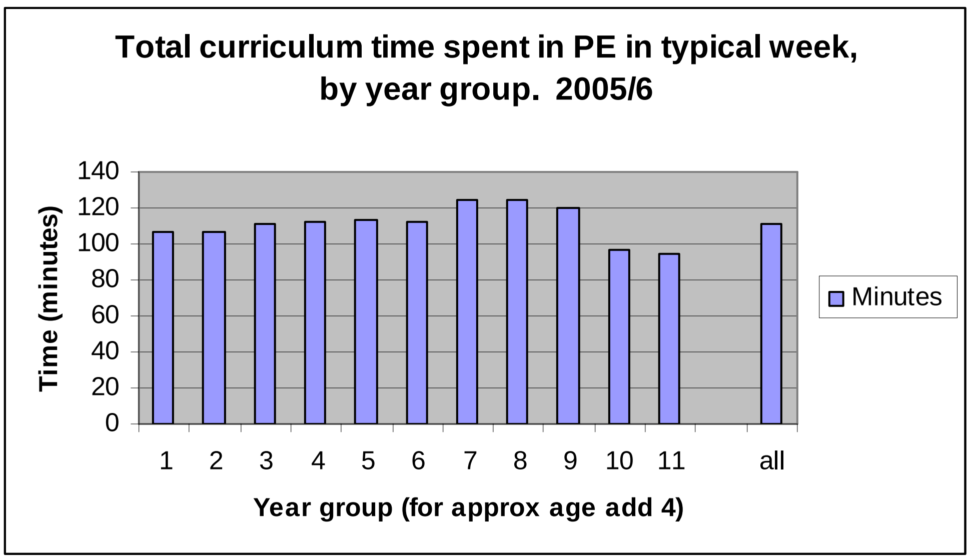
Results from the 2005/06 survey show that 80% of pupils in partnership schools participated in at least two hours of 'high quality'[4] PE and school sport in a typical week. This compares to 69% in the 2004/05 survey and 62% in the 2003/04 survey. These results may have been influenced by the manner in which the

4 High quality is defined as 'producing young people with the skills, understanding, desire and commitment to continue to improve and achieve in a range of PE, sport and health-enhancing physical activities, in line with their abilities.' *Learning through PE and Sport – A guide to the PE, School Sport and Club Links Strategy.*

questions were asked (making it difficult for teachers to admit to not hitting the Government target).

Looking in detail at time spent on physical education as part of the curriculum, pupils in the partnership schools surveyed spent an average of almost 2 hours (111 minutes) in a typical week in 2005/06. Of the year groups, year 7 spent the most time (125 minutes) and year 11 spent the least time (94 minutes) participating in curriculum PE in a typical week (Figure 9). Pupils in special schools spent the most time taking part in curriculum PE (126 minutes).

Figure 9.



Source: 2005/6 School Sports Survey. Dept for Education and Skills

There appears to be a distinct dip in time spent in PE at age 14-15 which corresponds with the rise in levels of inactivity among girls at that age shown in Figure 3. This appears to be a consistent finding as the Health Survey for England did not cover activities in the curriculum.

Sport in school

The Young People and Sport in England survey (Sport England, 2003) showed that nearly all young people participate in some kind of sport *at least once* in school lessons. Young people, on average, took part in nine sports *at least once* in the course of a year in 2002, compared to eight in 1994.

Over the last eight years there has been a small increase in the numbers of young people who are *not* taking part in at least one sport frequently (at least 10 times in the year) in lessons (from 15% in 1994 to 17% in 1999 to 18% in 2002). However, the average number of sports that are taken part in on a frequent basis in a year has remained at four.

One of the most significant growth areas has been participation by girls in football. Regular participation in school lessons increased from 7% in 1994 to 12% in 1999 to 13% in 2002 (almost a doubling of participation in 8 years). Overall, however, participation in football in school lessons did not increase between 1994 and 2002.

Sport out of school

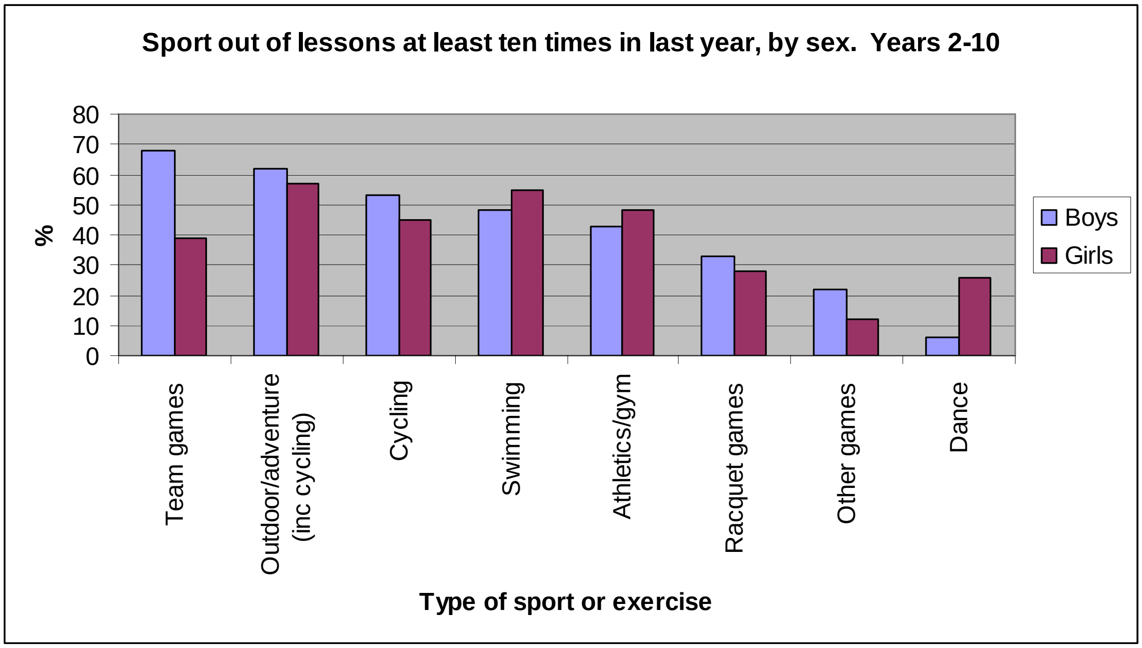
The Young People and Sport in England survey (Sport England, 2003) showed that almost all young people take part in some form of sporting activity *at least once* out of school lessons, with the figure remaining unchanged since 1994. However, year-on-year data have shown that a significant minority of young people (over one in ten) do not *frequently* take part in any sport out of lessons (at least 10 times in the previous 12 months).

The number of sports which young people try at least once out of lessons has increased from 10 in 1994 to 11 in 2002, and the number of sports participated in frequently has risen from four in 1994 to five in 2002.

Types of sports taken out of school

The Young People and Sport in England survey (Sport England 2003) goes into more detail than the Health Survey for England about the types of sport and exercise children take part in. Figure 10 shows the most popular categories of sport for boys and girls in years 2-10. The most popular activities to do regularly were team games, outdoor activities (mainly due to the inclusion of cycling in this category) and swimming. The largest differences between boys and girls are in team games (boys more than girls) and dance (girls more than boys).

Figure 10



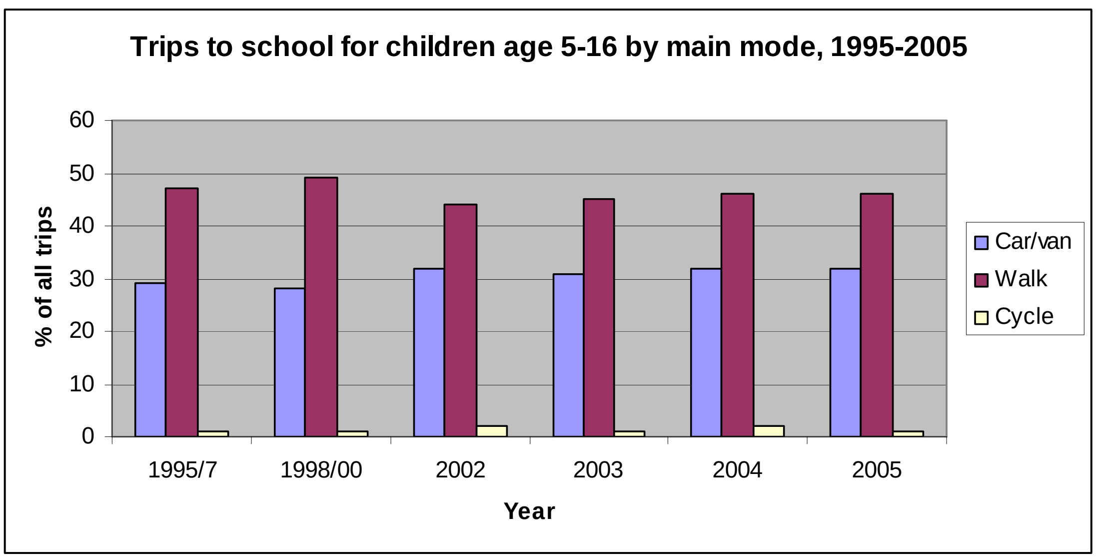
Out of lessons there have been significant increases in the number of young people trying tenpin bowling, gymnastics and basketball at least once. Whereas, participation in cycling, walking and angling/fishing at least once has declined over the last eight years.

Active travel

There is a growing body of research to underline the value of active travel – especially the trip to school - in contributing to overall levels of physical activity, with some research showing that it may offer greater opportunities for energy expenditure than school physical education (Mackett, 2004). Information on the mode of travel children take to school is collected by the Department for Transport as part of the National Travel Survey (NTS) (Department of Transport, 2006) and relevant results are presented here.

The NTS 2005 reports that the proportion of primary school children aged 5 to 10 walking to school declined from 53% in 1995/97 to 49% in 2005, with an increase from 38% to 43% in the numbers being driven to school during the same period. For secondary school pupils, the proportion travelling to school on foot has increased slightly from 42% in 1995/97 to 44% in 2005. Simultaneously, the proportion of secondary school children travelling to school by car has increased slightly from 20% to 22% during the same period. Levels of cycling to school have remained extremely low at 1 or 2% of trips. The average trip length to school for children aged 5 to 10 years increased from 1.3 to 1.5 miles between 1995/1997 and 2005, and for pupils aged 11 to 15, it remained about 3 miles, perhaps explaining the reason for many journeys to school by car. Figure 11 shows the trends in main mode of travel to school.

Figure 11



Source: National Travel Survey 2005

.

4.6. Discussion

Physical activity among children in England is generally at a high level: 70% of boys and 61% of girls achieve recommended levels, and trends appear to be generally stable over time. However, participation rates decline sharply with age, especially among girls after age 10. Many differences in participation may be masked by the use of composite physical activity indices that combine all types of activity into one measure. However, looking at sport and exercise in particular shows some differences, with lower participation among young people from lower socio-economic groups, and from some minority ethnic groups. Sport and PE in schools appears to be increasing while active travel to school is declining, possibly along with general types of play.

4.7. Conclusions: activity levels

- Surveys show that high proportions of children are active at recommended levels.
- There is, however, a significant minority of children who take little or no physical activity
- Inactivity is highest among young girls (from around age 10)
- Provision of PE and sport in schools has been increasing while active travel to school has declined.
- Levels of sport and exercise are lower among lower socio-economic groups and people from black and minority ethnic groups.

References (section 4)

Biddle, S., Sallis J.F., Cavill N. (1998). Young and active? Young people and health-enhancing physical activity- evidence and implications. London. Health Education Authority. Available at: www.nice.org.uk/page.aspx?o=502301

Department for Culture Media and Sport, (2005). 2005-2008 PUBLIC SERVICE AGREEMENT: TECHNICAL NOTE. From http://tinyurl.com/2ofyxz (accessed 9 May 2007).

Department of Health, (2003). Health Survey for England 2002. Available at: www.dh.gov.uk/PublicationsAndStatistics/Publications/PublicationsStatistics/PublicationsStatisticsArticle/fs/en?CONTENT_ID=4078027&chk=95TVt5

Department of Health (2004) At least five a week: Evidence on the impact of physical activity and its relationship to health. A report from the Chief Medical Officer, London, Author.

Department for Education and Skills (2006). 2005/06 School Sport Survey.. Available at: www.teachernet.gov.uk/docbank/index.cfm?id=10442

Department for Transport (2006). Transport Statistics Bulletin. National Travel Survey: 2005.. Available at: www.dft.gov.uk/stellent/groups/dft_transstats/documents/page/dft_transstats_612468.hcsp>

Hillman, M., Adams, J., Whitelegg J. (1990). One False Move: A study of children's independent mobility. London. Policy Studies Institute.

Janssen, I., Katzmarzyk, P. T., Boyce, W. F., Vereecken, C., Mulvihill, C., Roberts, C., Currie, C., Pickett, W. & THE Health Behaviour In School-Aged Children Obesity Working Group (2005) Comparison of overweight and obesity prevalence in school-aged youth from 34 countries and their relationships with physical activity and dietary patterns. Obesity Reviews, 6, 123-132

Lester, S., Maudsley, M. (2006). Play, Naturally. A review of children's natural play. London. National Play Council.

Mackett R et al. 2004. Making Children's Lives More Active. London: Centre for Transport Studies, University College London.

Marshall SJ, Gorely T, Biddle SJH. A descriptive epidemiology of screen-based media use in youth: A review and critique. Journal of Adolescence 2006; 29: 333-349.

Millward, A., Wheway, R. (1997). Child's play: Facilitating play on housing estates. London. Chartered Institute of Housing.

Nazroo, J., Becher, H., Kelly, Y., McMunn, A. (2001). Children's Health. In Joint Health Surveys Unit (2001). Health Survey for England – The Health of Minority Ethnic Groups 1999. London The Stationery Office.

NHS Information Centre (2006). Statistics on Obesity, Physical Activity and Diet: England.

Sport England (2003). Young people and sport in England. Trends in participation 1994-2002. London. Sport England.

Sturm R. Childhood obesity: What we can learn from existing data on societal trends, Part 1. Preventing Chronic Disease [serial online] 2005; 2, January: http://www.cdc.gov/pcd/issues/2005/jan/04_0038.htm

TNS (2006). 2005/06 School Sport Survey. Department for Education and Skills. Available at: http://www.teachernet.gov.uk/docbank/index.cfm?id=10442

5. Does physical activity 'track' from childhood to adulthood?

5.1. Summary

- Physical activity tracks within childhood at moderate levels.
- Tracking from childhood/adolescence into adulthood is small. It is difficult to determine whether this is due to a true effect or is attributable to measurement problems.
- Tracking is likely to be strengthened by increasing the quality of the physical activity experience
- Sedentary behaviours appear to track better than physically active behaviours, but this would be clarified by further research.

5.2. Introduction

The saying "give me the child until he is seven and I will give you the man" is based on the commonly held belief that many habits, beliefs and patterns of behaviour are set in childhood. Many public health interventions aimed at children and young people are based on the principle that healthy behaviours established in childhood will persist into adulthood, where they will go on to have a positive influence on health. This stability of behaviour over time is 'tracking', defined as the tendency of individuals to maintain their rank or position within a group over time (Malina, 1996). Applied to physical activity, this is the notion that active children will become active adults. This is clearly an important concept: if tracking is indeed strong for physical activity across the lifespan, then this would have important implications for the planning and implementation of physical activity interventions aimed at young people. As the previous chapter demonstrated, there are few direct, or at least easily measurable, health benefits of physical activity for young people's health. However, strong tracking of physical activity would justify a focus on encouraging healthy activity patterns in childhood not for their immediate benefits, but for the establishment of healthy activity patterns in adulthood when we see more obvious health benefits of an active lifestyle.

5.3. Methodology

Studies of tracking need to draw on data that include an indicator of physical activity measured in both childhood and adulthood, ideally within the same population. Fortunately, measures of physical activity have been included in many longitudinal studies that follow up a cohort of people over time. This review focuses on studies that have investigated the relationship between a measure of physical activity from at least one time point in childhood, with one from at least one time point in adulthood.

This review synthesises evidence from key reports and studies in the literature. While the review did not set out to be a formal systematic review, we have aimed to be as comprehensive and transparent in our review methods as possible within the time and resources available.

5.3.1. Search strategy

The topic of tracking of physical activity has been the subject of a number of good quality reviews. We have therefore based our analysis on the findings of these reviews, and updated them where necessary. Searches were conducted using the following databases: PubMed, Metalib (including Web of Science, Sportdiscus, Psychinfo, Zetoc, Physical Education Index, Articlefirst). Searches were from 2001 and included the terms children, adolescents, young people, childhood, adulthood, pre-school; physical activity, sport, exercise; prevalence, pattern, tracking, maintenance, longitudinal, trends, survey. This was conducted with a search of our own files, and limited searches on Google / Google scholar.

5.3.2. Inclusion criteria

Studies were included if they satisfied the following criteria:

- Used a longitudinal (or 'cohort' study design)
- Measured physical activity at least once in childhood and at least once in adulthood
- Analysed the relationship between childhood and adult physical activity
- Published papers in English.

5.4. Findings

5.4.1. Reviews of tracking

The most comprehensive review of physical activity in the UK in recent years was undertaken by the Chief Medical Officer in his report of 2004 (Department of Health, 2004). This was based on a systematic review of the literature published up to 2002. The review included a section on tracking and concluded that "tracking of physical activity through childhood, or through adulthood, appears relatively good (Janz et al, 2000; Fortier et al, 2001), but tracking from childhood to adulthood is, at best, weak to moderate (Twisk et al, 2000; Malina 1996). Stronger associations between physical activity in childhood and physical activity in adulthood are found when the quality of the physical activity experience in childhood, rather than simply the quantity, is taken into account (Engstrom, 1991, Taylor, et al., 1999, Telama, et al., 1994)".

This finding was consistent with those from other reviews carried out prior to 2002. The most comprehensive review on physical activity tracking was conducted by Malina (1996). He concluded that the magnitude of tracking during adolescence and into adulthood is 'low to moderate'. In other words, there is not a strong likelihood that active young people will become active adults. Riddoch (1998), drawing on similar studies to Malina (1996), arrived at the same conclusion and highlighted that the correlations for tracking are particularly weak when self-report measures are used. Similarly Cavill and Biddle (2003) concluded that the strength of the relationship between physical activity in adulthood and activity in childhood or adolescence show a low-to-moderate level of association, meaning that it is not highly probable that active children will become active adolescents or active adults.

More recently, tracking was included as one topic in a systematic review of adolescent physical activity and health (Hallal et al, 2006). This review investigated evidence for a conceptual model for how physical activity may be beneficial for health, which included investigating the potential pathway that adolescent physical activity may influence adult morbidity and mortality through a direct influence on adult physical activity patterns. The review included studies from 2000 to 2004 that investigated tracking from adolescence to adulthood. The reviewers found thirteen studies, of which ten were cohort studies, and three were studies in which data on adolescent physical activity were collected retrospectively. The latter study design has more potential for bias due to poor recall of adolescent physical activity levels by adults. Results from Hallal et al are shown in Table 2. The review concluded that “The literature shows a consistent effect of PA during adolescence on adult PA. However, the magnitude of this association is moderate.”

5.4.2. Primary studies of tracking from childhood into adulthood published since 2004

In order to update the findings of Hallal et al (2006), we reviewed primary studies of tracking that had been published since 2004 (the inclusion date for the Hallal et al review). We found six studies that had used a cohort design and had measured physical activity in children and again as adults. Data were extracted for the key study characteristics (Table 3). The studies were consistent with the findings of the previous review, with ‘small-to-moderate’ correlations between activity in childhood and activity in adulthood (typically correlation coefficients of approximately 0.2 to 0.4). The one exception was the analysis of data from the Cardiovascular Risk in Young Finns study (Telama et al., 2006) which found high correlations between youth sport participation and levels of adult physical activity.

However, it is important to note that the levels of sport in this study were extremely high: participation in sports training sessions ‘many times’ per week. This study may therefore indicate that tracking of activity is greater among more active people. One study is worth additional consideration as it was conducted in the UK on a large sample (Parsons et al, 2006). This measured activity using a single question, among around 11,000 participants at baseline aged 11 followed up at ages 33 and 42. This also found a ‘low to moderate’ level of tracking.

5.4.3. Tracking of activity versus inactivity

The relatively weak degree of tracking of physical activity found in most studies may be in part due to poor measurement methods. Even well validated measurement tools may lack the precision needed to detect small changes in activity. However, most studies of measurement of physical activity have found that measures at the extreme of the behaviour may be more reliable. In other words, physical activity tools are better able to detect very active or very inactive people. It may therefore be worth looking into whether there is better tracking for sedentary behaviour, such as TV viewing, use of computers, reading etc

One issue in this field is to recognise that often ‘physical inactivity’ is assessed simply as the absence of physical activity. In other words, if a child does not meet a criterion level of physical activity set for the study, they are categorised as ‘inactive’. This may or may not reflect true sedentary behaviour (depending on the criterion level), and it does not provide information of what sedentary pursuits might be highly prevalent. When specific sedentary behaviours are assessed, this is overwhelmingly limited to TV or related technologically-based behaviours (e.g., computer use), and rarely assesses other highly prevalent sedentary behaviours such as homework or motorised transport. Assessments are usually performed via self-report or via parental proxy reporting.

To help arrive at clear conclusions on the tracking of sedentary behaviours, 7 additional papers were reviewed (Gordon-Larsen et al., 2004; Janz et al., 2005;

Janz et al., 2000; Kelly et al., 2007; Nelson et al., 2006; Pate et al., 1999; Raitakari et al., 1994). These were not derived from a comprehensive search, although search procedures were adopted. We cannot assume all papers on the topic are included, but we believe that we have most of the key papers.

Background to papers:

- Number of studies (K=7); 1994-2007
- Nationality of samples: USA (5), UK (1), Finland (1)
- Age groups studied: 0-7y = 2; 8-12y = 1; 12+ = 3; other (overlapping 8-12 & 12+ = 1)
- Measures of PA: accelerometers = 2; self-report = 5
- Measures of inactivity/sedentary behaviour: accelerometers = 1; self-report = 5; parental report = 1.
- Sedentary behaviour assessed as ‘activity absence’: 2
- Sedentary behaviour assessed as specific sedentary behaviours: 6 (1 did both)
- Sedentary behaviours assessed: TV/video: 5; computer: 3; other: 1.
- 5 studies clearly addressed tracking; 2 addressed longitudinal trends that could be interpreted as a marker of behavioural stability.

Tracking of inactivity: results

All 7 studies showed evidence for either greater tracking of sedentary behaviour compared with physical activity (k=5) or trends suggestive of behaviour stability in sedentary behaviour (k=2). Where strength of effect could be estimated, or was stated, effects are best described as ‘fair’ or ‘moderate’.

One area of enquiry being considered by NICE is the under-7 age group. The two papers specifically addressing the issue of tracking of sedentary behaviour in this age group were those by Janz et al. (2005) in the US and Kelly et al. (2007) on Scottish children. Janz et al. assessed sedentary behaviours at baseline (mean age = 5.6y) and had a 3-yr follow-up (n=379). Behaviours were assessed by parental report (TV viewing and video/computer game use). In a systematic review of the measurement of TV viewing in children, Bryant et al. (2007) report that the relationship between child and parental reports of TV are generally quite well correlated, but that parents tend to underestimate the child's own reporting of TV viewing.

Janz et al. (2005) reported Spearman rank-order correlation coefficients between baseline and follow-up as follows: TV viewing: boys r=.46 and girls r=.52; video/computer playing: boys r=.18 (NS) and girls r=.37. The values for TV viewing are generally higher than for overall physical activity (boys/girls: .32/.38), vigorous physical activity (.39/.39) and moderate physical activity (.40/.32). The odds of being in the highest TV viewing group at follow-up compared to baseline is high for TV viewing (odd ratio boys = 4.3; girls = 4.0) but mixed, though still elevated, for video/computer games (boys = 1.8; girls = 3.6). The figures for TV viewing are higher than for overall physical activity. The two highest sets of odds ratios were for TV viewing and accelerometer time in inactivity, suggestive of stronger tracking for inactivity than activity.

The other study investigating young children was conducted in Scotland (Kelly et al., 2007). Children were aged 3.8y at baseline and were followed up over 2 years (n=42). Accelerometry was used to assess total physical activity and sedentary behaviour. Spearman rank-order correlation, testing the relationship between baseline and follow-up for total PA, was 0.35, similar to that reported by Janz et al. (2005). The figure for sedentary behaviour was also .35. Kappa statistic was calculated to determine the likelihood that a child would remain in the same group from baseline to follow-up. For total PA, kappa = 0.17 ('poor strength of agreement') whereas for sedentary behaviour it was 0.21 ('fair strength of agreement'). This small study, using 'activity absence' as the measure of 'sedentary behaviour', is suggestive that sedentary behaviour may track slightly better than physical activity.

5.4.4. Other predictors of adult physical activity

If the direct relationship between childhood and adult levels of physical activity is weak, it is worth considering whether there are other aspects of childhood physical activity that may predict greater activity as an adult. Engstrom (1991) investigated aspects of the quality of childhood physical activity and supported the view that "early experience with physical activity during childhood and adolescence ... is of importance for the practice of keep-fit activities in adulthood" (pp. 480-481). This emphasises the importance of the nature of the physical activity experience, rather than simply the level or frequency of physical activity. This issue was also addressed by Taylor and colleagues (1999), who investigated whether childhood experiences in physical activity predicted adult participation. Correlations between recalled childhood experiences in physical activity (e.g., enjoyment of activity, being encouraged to exercise) and current weekly energy expenditure in exercise were all very low (range -0.20 to 0.17). They found adult energy expenditure in exercise to be negatively related to the frequency of being forced to exercise in the preteen years (when controlling for potential confounders such as current fitness and body weight/adiposity). This supports Engstrom's findings that if tracking does exist it is likely due to the quality of physical activity experiences in youth rather than involvement per se (Cavill and Biddle, 2003).

5.5. Discussion

5.5.1 Tracking of activity

Overall, the literature on tracking shows that physical activity does 'track' from childhood to adulthood, but at relatively low levels. However, it is very important to consider the significant methodological limitations of the tracking literature. Firstly, there is the problem common to much of the physical activity literature – that of the measurement of the behaviour itself. Studies use varied methods of physical activity assessment, and produce a wide variety of composite measures, often based on a small number of questions for lack of space or time within a complex cohort study measuring many aspects of health and development. Some studies with longer follow up periods have found a smaller influence of childhood activity on levels in adulthood (Telama et al 2005). However, the review by Hallal et al (2006) did not detect the expected trend that studies with longer follow-up periods reported a smaller influence of adolescent physical activity. Finally, the measure used in most studies (a simple correlation between activity at two time points) may be over-simplistic, masking a large number of confounding influences on adult activity levels. Hallal et al (2006) pointed out that reviews of correlates (e.g., Trost et al., 2002) have shown adult physical activity to be a complex behaviour, influenced not only by adolescent activity levels, but also by socio-demographic, environmental, personal and behavioural variables. Indeed, a correlation between two time points will merely show the relative position of individuals from Time 1 to Time 2, regardless of actual changes in activity levels over time. It is therefore hardly surprising that there is not a simple 'tracking' of activity from childhood to adulthood. When adult participation in physical activity varies so much throughout the lifespan, how can we expect a behaviour such as physical activity to be stable throughout one of the most turbulent of life stages?

5.5.2. Tracking of inactivity

Studies concerning the tracking of sedentary behaviours are still relatively sparse and use diverse methods. Only two address the age group of specific interest here (i.e., under 7s). Overall, it is concluded that sedentary behaviour does track slightly better than physical activity, and this holds for younger children. This is likely to be explained by various factors:

1. children have plenty of opportunities to be sedentary and many of these are available as adolescents and adults
2. advances in technology is making sedentary pursuits very attractive and reinforcing

3. sedentary behaviours are largely behaviours characterised by high frequency and duration, and low effort. This contrasts with some forms of physical activity (e.g., some sports and vigorous PA) that are less frequent and may require more effort. This is likely to lead to greater challenges for behaviour change in respect of physical activity, and ease for tracking of sedentary behaviors.

5.6. Conclusions: tracking

- Physical activity tracks within childhood at moderate levels.
- Tracking from childhood/adolescence into adulthood is small. It is difficult to determine whether this is due to a true effect or is attributable to measurement problems.
- Tracking is likely to be strengthened by increasing the quality of the physical activity experience
- Sedentary behaviours appear to track better than physically active behaviours, but this would be clarified by further research.

Table 2. Data from Hallal et al (2006)

Study (Country)	Sample	Design	Definition of PA in adolescence	Definition of PA in adulthood	Main results
Hirvensalo et al.[15] (Finland)	1324 men and women aged 65–84y at baseline followed up for 8y	Cohort, but participation in PA in adolescence was collected retrospectively	Competitive and recreational sports practice between 10–19y	PA score ranging from 1 (to move only for minimal necessary tasks) to 6 (exercise to keep fitness level or doing sports several days per week)	Competitive sports practice at 10–19y was associated with PA in adulthood (OR: 1.86 in men and 2.31 in women) Recreational sports practice at 10–19y was not associated with adult PA
Beunen et al.[10] (Belgium)	109 men followed up from 13 to 40y	Cohort	Physical fitness at 13, 15 and 18y	Score of sports, occupational and leisure-time activities, ranging from 3 to 15 and accelerometry	Work and leisure-time indexes and accelerometer counts in adulthood were weakly associated with fitness in adolescence. The sports index in adulthood showed a stronger association with fitness in adolescence
Kemper et al.[16] (The Netherlands)	400 boys and girls (baseline mean age: 13y) followed up for 20y	Cohort	School, work, home, free time, (un)organised, sport stair climbing and transport activities over the preceding 3mo	School, work, home, free time, (un)organised, sport stair climbing and transport activities over the preceding 3mo	PA in adolescent presented stability coefficients of 0.29–0.35 with PA in adulthood. Higher tracking values were observed for physical fitness
Campbell et al.[12] (Canada)	153 boys and girls followed up for 12y	Cohort	Physical work capacity at a heart rate of 150 bpm, daily energy expenditure, inactive time and time spent in moderate to vigorous PA	Physical work capacity at a heart rate of 150 bpm, daily energy expenditure, inactive time and time spent in moderate to vigorous PA	Physical work capacity showed higher tracking values (r = 0.24 in boys and 0.46 in girls) than PA (r = 0.07–0.25 in boys and 0.06–0.22 in girls)
Kemper et al.[17] (The Netherlands)	181 boys and girls followed up from 13 to 27y	Cohort	Daily PA	Maximum oxygen uptake and maximum slope of the track	An increase of 30% in daily PA at 13y results in a 2–5% increase in aerobic fitness at 27y
Alfano et al.[8] (USA)	486 women (18–39y)	Cross-sectional	PA score ranging from 0 (no past sport participation) to 3 (high sports participation)	Score of sports, occupational and leisure-time activities, ranging from 3 to 15	A 1-unit increase in the adolescent PA score was associated with an increase of 0.22 in the adult PA score

Table 2 (contd) from Hallal et al (2006)

Table I. Contd

Study (Country)	Sample	Design	Definition of PA in adolescence	Definition of PA in adulthood	Main results
De Bourdeaudhuij et al.[13] (Belgium)	172 young adults (mean age: 21y) followed up for 7y	Cohort	Total and moderate-intensity energy expenditure	Total and moderate-intensity energy expenditure	No significant correlations were found among men. Among women, correlations were 0.34 and 0.41 for total and moderate-intensity energy expenditure, respectively
Tammelin et al.[19] (Finland)	7794 men and women aged 14 and 31y	Cohort (data collected by postal inquiry)	Sports practice after school hours	Individuals were classified as very active, active, moderately active or inactive based on light and brisk physical activities	Participation in sports in adolescence once a week was associated with a greater likelihood of being active in adulthood among women. Among men, 2–3 times per week were necessary to have the same benefit
Kraut et al.[18] (Israel)	3687 male industrial workers	Cohort, but participation in PA in adolescence was collected retrospectively	Extracurricular organised sports activities	Leisure-time PA. Subjects were classified as active if performing at least 1 day per week of PA during at least 30 min each	Participation in sports in adolescence increased the likelihood of being active in adulthood (OR: 3.6)
Trudeau et al.[20] (Canada)	166 subjects aged 10–12y at baseline and followed up for ~24y	Cohort	Total weekly time spent on PA	Total weekly time spent on PA	Childhood PA was positively associated with total adult PA (r = 0.20)
Beunen et al.[9] (Belgium)	166 men followed from 1969 to 1996	Cohort	Weekly time spent in sports activities	Activity counts using accelerometer	A regression model including weekly time spent in sports activities, flexibility, pulse recovery, and degree or urbanisation at 16y explained 12.9% of activity counts at 40y
Gordon-Larsen et al.[14] (USA)	13 030 men and women followed from 1994 to 2002	Cohort	Individuals were classified as achieving or not achieving ≥5 weekly sessions of moderate to vigorous PA	Individuals were classified as achieving or not achieving ≥5 weekly sessions of moderate or vigorous PA	Two-thirds of the adolescents who achieved ≥5 sessions of moderate to vigorous PA remained achieving this threshold in adulthood
Boreham et al.[11] (Northern Ireland)	476 men and women visited in adolescence (mean age: 15y) and early adulthood (mean age: 22y)	Cohort	Daily participation in activities that were based around a typical school day	Score of sports, occupational and leisure-time activities, ranging from 3 to 15	PA in adolescence was positively associated with PA in adulthood in males (weighted κ: 0.20). In females, no such trend was observed (weighted κ: 0.02)

bpm = beats/min; **OR** = odds ratio.

Table 3. Studies investigating relationship between childhood and adult physical activity published post 2004

Study (date); country	Sample	Design	Definition of pa in childhood	Definition of pa in adulthood	Main results
Anderssen et al (2004); Norway	557 adolescents aged 13 at baseline followed up until aged 21	Cohort	Hours per week in activity causing sweat or loss of breath	Hours per week in activity causing sweat or loss of breath	Weak degree of tracking. Pearson r 0.22 for boys and 0.18 for girls across eight year period
Telama et al (2005); Finland	2,309 boys and girls aged between 3 and 12 at baseline; followed up 5 times over 21 years	Cohort	Physical activity and participation in sports, combined into a physical activity index	Physical activity and participation in sports, combined into a physical activity index	High level of pa at ages 9 to 18, especially when continuous, significantly predicted a high level of adult pa. Correlations 'low or moderate' (Spearman's rank order 0.33 to 0.44 in males; 0.14 to 0.26 females.) over 21 years.
Matton et al (2006); Belgium	138 females mean age 16.6 at baseline followed up when mean age 40.5.	Cohort	Sports participation inventory	Sports participation inventory	Sports participation was not a stable characteristic (r=0.13). Anthropometric and fitness characteristics demonstrated higher levels of stability from adolescence to adulthood.
Parsons et al (2006); Britain	11,407 subjects aged 11 at baseline followed up aged 33; 11,419 subjects aged 11 at baseline followed up aged 42	Cohort	Leisure time physical activity and sport from activity frequency variable	Single sports/activity participation question	Tracking 'low to moderate'. Spearman correlation coefficient for ages 11-42 = 0.09 males and 0.07 females.
Telama et al (2006); Finland	1,606 boys and girls aged 9-18 years at baseline followed up 21 years later.	Cohort	Participation in sports-club training	Total physical activity combined into a physical activity index	Participation in youth sport significantly predicted adult physical activity. eg youth who participated 'many times' per week were 5-6 times more likely to be highly active as adults.
Yang et al (2006); Finland	626 boys and 693 girls between 9 and 18 years at baseline followed up for 21 years.	Cohort	Physical activity and participation in sports, combined into a physical	Physical activity and participation in sports, combined into a physical activity index	Significant relation between youth pa and adult pa in both sexes. Pearson r = 0.18 to 0.32

			activity index		

References (section 5)

Alfano CM, Klesges RC, Murray DM, et al. History of sport participation in relation to obesity and related health behaviors in women. Prev Med 2002; 34: 82-89

Beunen GP, Lefevre J, Philippaerts RM, et al. Adolescent correlates of adult physical activity: a 26-year follow-up. Med Sci Sports Exerc 2004; 36: 1930-1936

Beunen GP, Philippaerts RM, Delvaux K, et al. Adolescent physical performance and adult physical activity in Flemish males. Am J Hum Biol 2001; 13: 173-179

Biddle, S. J. H. & Gorely, T. (2005) Couch kids: Myth or reality? The Psychologist, 18, 276-279

Biddle, S. J. H., Gorely, T., Marshall, S. J., Murdey, I. & Cameron, N. (2004) Physical activity and sedentary behaviours in youth: Issues and controversies. Journal of the Royal Society for the Promotion of Health, 124, 29-33

Boreham C, Robson PJ, Gallagher AM, et al. Tracking of physical activity, fitness, body composition and diet from adolescence to young adulthood: the Young Hearts Project, Northern Ireland. Int J Behav Nutr Phys Act 2004; 1:14

Bryant MJ, Lucove JC, Evenson KR, Marshall S. Measurement of television viewing in children and adolescents: A systematic review. Obesity Reviews 2007; 8: 197-209.

Campbell PT, Katzmarzyk PT, Malina RM, et al. Prediction of physical activity and physical work capacity (PWC150) in young adulthood from childhood and adolescence with consideration of parental measures. Am J Hum Biol 2001; 13: 190-6

Cavill, N., & Biddle, S. (2003). The determinants of young people's participation in physical activity, and investigation of tracking of physical activity from youth to adulthood. In A. Giles (Ed.), A lifecourse approach to coronary heart disease prevention: Scientific and policy review (pp. 179-197). London: TSO (The Stationery Office).

Davison, K. K., Marshall, S. J. & Birch, I. L. (2006) Cross-sectional and longitudinal associations between TV viewing and girls' body mass index, overweight status, and percentage of body fat. Journal of Pediatrics, 149, 32-37

De Bourdeaudhuij I, Sallis J, Vandelanotte C. Tracking and explanation of physical activity in young adults over a 7-year cardiovascular risk factors at adult age, and physical activity period. Res Q Exerc Sport 2002; 73: 376-85

Department of Health (2004c) At least five a week: evidence on the impact of physical activity and its relationship to health. London: Department of Health.

Engstrom L-M. Exercise adherence in sport for all from youth to adulthood. In: Oja P, Telama R, editors. Sport for all. Amsterdam: Elsevier, 1991: 473-483.
Fortier MD, Katzmarzyk PT, Malina RM, Bouchard C. Seven year stability of physical activity and musculoskeletal fitness in the Canadian population. Medicine and Science in Sports and Exercise 2001; 33: 1905-1911.

Gordon-Larsen P, Nelson MC, Popkin BM. Longitudinal physical activity and sedentary behavior trends: adolescence to adulthood. Am J Prev Med 2004; 27: 277-83
Hallal PC, Victora CG, Azevedo MR, Wells JC. Adolescent physical activity and health: a systematic review. Sports Med. 2006;36(12):1019-30.

Hirvensalo M, Lintunen T, Rantanen T. The continuity of physical activity: a retrospective and prospective study among older people. Scand J Med Sci Sports 2000; 10: 37-41

Janz KF, Burns TL, Levy SM. Tracking of activity and sedentary behaviors in childhood: The Iowa Bone Development Study. American Journal of Preventive Medicine 2005; 29: 171-178.

Janz KF, Dawson JD, Mahoney LT. Tracking physical fitness and physical activity from childhood to adolescence: the Muscatine study. Medicine and Science in Sports and Exercise 2000; 32: 1250-1257.

Kelly LA, Reilly JJ, Jackson DM, Montgomery C, Grant S, Paton JY. Tracking of physical activity and sedentary behavior in young children. Pediatric Exercise Science 2007; 19: 51-60.

Kemper HC, de Vente W, van Mechelen W, et al. Adolescent motor skill and performance: is physical activity in adolescence related to adult physical fitness? Am J Hum Biol 2001; 33.13: 180-9

Kemper HC, Twisk JW, Koppes LL, et al. A 15-year physical activity pattern is positively related to aerobic fitness in young males and females (13-27 years). Eur J Appl Physiol 2001; 84: 395-402

Kraut A, Melamed S, Gofer D, et al. Effect of school age sports on leisure time physical activity in adults: the CORDIS Study. 2003: CD001872 Med Sci Sports Exerc 2003; 35: 2038-42

Malina RM. Tracking of physical activity and physical fitness across the life span. Research Quarterly for Exercise and Sport 1996; 67: S1- S10.

Marshall, S. J., Biddle, S. J. H., Gorely, T., Cameron, N. & Murdey, I. (2004) Relationships between media use, body fatness and physical activity in children and youth: A meta-analysis. International Journal of Obesity, 28, 1238-1246.

Nelson MC, Neumark-Stzainer D, Hannan PJ, Sirard JR, Story M. Longitudinal and secular trends in physical activity and sedentary behavior during adolescence. Pediatrics 2006; 118: e1627-1634.

Pate RR, Trost SG, Dowda M, Ott AE, Ward DS, Saunders R, et al. Tracking of physical activity, physical inactivity, and health-related physical fitness in rural youth. Pediatric Exercise Science 1999; 11: 364-376.

Raitakari, O.T., Porkka, K.V.K., Taimela, S., Rasanen, L., & Viikari, S.A. (1994). Effects of persistent physical activity and inactivity on coronary risk factors in children and young adults. The Cardiovascular Risk in Young Finns Study. American Journal of Epidemiology, 140, 195-205.

Riddoch, C. (1998). Relationships between physical activity and physical health in young people. In S. Biddle, J. Sallis & N. Cavill (Eds.), Young and active? Young people and health-enhancing physical activity: Evidence and implications (pp. 17-48). London: Health Education Authority.

Tammelin T, Nayha S, Hills AP, et al. Adolescent participation in sports and adult physical activity. Am J Prev Med 2003; 24: 22-8

Taylor WC, Blair SN, Cummings SS, Wun CC, Malina RM. Childhood and adolescent physical activity patterns and adult physical activity. Medicine and Science in Sports and Exercise 1999; 31: 118-123.

Telama R, Laasko L, Yang X. Physical activity and participation in sports of young people in Finland. Scandinavian Journal of Medicine and Science in Sports 1994; 4: 65-74.

Telama R, Yang X. Decline of physical activity from youth to young adulthood in Finland. Med Sci Sports Exerc. 2000 Sep;32(9):1617-22.

Trost SG, Owen N, Bauman AE, et al. Correlates of adults' participation in physical activity: review and update. Med Sci Sports Exerc 2002; 34: 1996-2001

Trudeau F, Laurencelle L, Shephard RJ. Tracking of physical exercise, from childhood to adulthood. Med Sci Sports Exerc 2004; 36: 1937-43 38.

Twisk JW, Kemper HC, Van Mechelen W. Tracking of activity and fitness and the relationship with cardiovascular disease risk factors. Medicine and Science in Sports and Exercise 2000; 32: 1455-1461.

Yang X, Telama R, Leskinen E, Mansikkaniemi K, Viikari J, Raitakari OT.

Testing a model of physical activity and obesity tracking from youth to adulthood: the cardiovascular risk in young Finns study. Int J Obes (Lond). 2007 Mar;31(3):521-7. Epub 2006 Sep 5.

Overall Conclusions

This review set out to define patterns of physical activity in children, and to determine the impact of physical activity on short and long term health, and other outcomes. The overall purpose was to help NICE identify populations or developmental stages in which physical activity is low and therefore of concern.

The review has shown that there is a clear rationale for promoting physical activity among children. Physical activity improves current health of children, notably helping to prevent overweight, obesity and type II diabetes, as well as improving skeletal health and mental well-being. Childhood physical activity is also likely to have a positive influence on adult health either through influencing the tracking of risk factors from childhood to adulthood, or through developing patterns of activity that may track into adulthood, although these trends are usually small.

The review of patterns of participation in physical activity showed that there are some specific population sub-groups in which levels of activity are low. These include young girls (aged 10+), children from lower socio-economic groups, children from black and minority ethnic groups, and overweight and obese children.

Data on the provision of PE and sport in school has shown that this mode of activity is generally increasing, and this trend should be encouraged. However, a higher priority might be given to active travel to school, which has been declining for many years.

There is very little evidence available to quantify trends in levels of active play. However, review level evidence for the decline in natural play, and access to natural environments, suggest that this might also be a mode of activity that would benefit from being prioritised.