

REVIEW

Evidence for secular trends in children's physical activity behaviour

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It is not clear whether the global increase in weight problems in children is the result of excessive energy intake or decreasing energy expenditure. Methodological limitations have made it difficult to analyse. There is evidence that at least part of the problem may lie with increasing energy consumption, but it is important to examine the other side of the energy equation also. However, it is not possible to conclusively describe physical activity trends because of the absence of suitable baseline data. One solution is to summate all available evidence in as many areas of daily activities as possible and then draw tentative conclusions. This review summarises available trend data on direct representations of physical activity in a range of contexts, together with indirect measures such as sedentariness, fitness, and attitudes. The conclusions drawn are: physical activity in clearly defined contexts such as active transport, school physical education, and organised sports is declining in many countries; young people would like to be active but are often constrained by external factors such as school policy or curricula, parental rules in relation to safety and convenience, and physical environmental factors.

attributable to measurement error and biological variation in the behaviour. This reduces the fidelity of the "signal" and attenuates statistical resolution, including comparisons between surveys separated by time. These issues are particularly relevant when children self report, as their physical activity exhibits relatively high intraindividual variability⁴ and their ability to meet the complex demands of recall is limited.⁵

So how can we tell if children are less physically active now than in previous generations? There is no one measure to give us the answer.⁶ We are left with the only option of summing all available evidence in as many areas of daily activities as possible and then drawing tentative conclusions. This review summarises available trend data on direct representations of physical activity in a range of contexts, together with indirect measures such as sedentariness, fitness, and attitudes.

The literature used for this summary is not exhaustive. Rather, it has been selected from major reports from governments and international organisations and peer reviewed scientific journals. Much of the information comes from Australian studies, but we have included relevant international data where it was available. In isolation, these studies are of limited value. However, when reviewed as a whole they provide us with some guidance for future action.

The current epidemic of overweight and obesity in many countries has raised questions about the aetiology of this serious public health problem. There is mounting evidence, based on repeat measures of food intake, that at least part of the problem may lie with increasing energy consumption.^{1,2} However, as this is only one side of the energy balance equation, it is equally critical to have serial measures of physical activity patterns so that trends can be established for the other side. Rowland,³ in discussing trends in youth physical activity, mused that if you "ask anybody on the street, ...the answer will probably be the same: Yes, today's youth... are becoming increasingly sedentary and their levels of fitness are in perilous decline". However, it is not possible to conclusively describe physical activity trends because of the absence of suitable baseline data.

Further, serious methodological limitations and inconsistencies are inherent in physical activity measurement. In particular, there is considerable random error associated with self reported physical activity, upon which representative surveys are largely based. Inaccuracies are

GLOBAL ESTIMATES OF PHYSICAL ACTIVITY AND ENERGY EXPENDITURE

Few studies have reported temporal trends in units of energy expenditure, most likely because of the lack of suitable baseline data from earlier surveys. This approach is also limited by the lack of data on energy costs of children's activities and consequent reliance on adult specific metabolic equivalent (MET) values when deriving estimates of daily energy expenditure. Indirect evidence was presented by Durnin,⁷ who pointed to a decline in energy intake among UK adolescents from the 1930s to the 1980s, with no concurrent change in body mass. It was therefore argued that energy expenditure must have declined over that time.⁸

A Swedish study of more than 33 000 male subjects quantified energy use among a range of ages from 15 to 50 year olds throughout the 20th century.⁹ It concluded that daily energy expenditure had significantly decreased across all ages studied. Although exercise related energy use was reduced, the greatest changes were found in occupational and active transport expenditures. Significant increases were also found in low intensity leisure activities, such as television and

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reading, among the younger groups since the 1950s.

Eisenmann *et al*¹⁰ recently examined national Canadian surveys conducted in 1981, 1988, 1994, 1996, and 1998, focusing on leisure time physical activity energy expenditure of 12–19 year olds. Interestingly, it increased between 1981 and 1988, and then remained relatively stable between 1988 and 1998. The prevalence of boys meeting the recommended 25.1 kJ/kg per day¹¹ increased between 1981 and 1988 and had not changed since. Among female subjects, this prevalence remained steady at about 10% since 1981, except for 12–14 year olds among whom there had been an increase between 1996 and 1998. Based on this analysis, there was no convincing evidence of declining leisure time physical activity among Canadian youth.

A study of UK youth by the Schools Health Education Unit¹² used the health related behaviour questionnaire to cover the time span 1987–2003. This systematic series of surveys provides information on physical activity participation and attitudes among over 300 000 10–15 year olds. In 2003 there was a higher prevalence of boys reporting vigorous exercise at least three times in the previous week (49% of 14–15 year olds and 53% of 12–13 year olds), compared with 1995 (36% and 32%). Among girls, the prevalence rose from 20% to 31% for 14–15 year olds across the same time period, and from 24% to 37% for 12–13 year olds. Although there was no change in the level of enjoyment of physical activity among the same respondents, there was an increase of about 10% in the proportion of both boys and girls who perceived that they were “unfit”.

Data from the United States Youth Risk Behaviour Surveys show that engagement in vigorous physical activity among adolescents had been stable between 1993 and 1997.¹³ Based on a single question about whether the respondent performed vigorous physical activity for more than 20 minutes per episode, and on three or more occasions per week, 66% of grades 9–12 responded positively in 1993 and 64% in 1997. This finding is supported by another systematic surveillance of US youth, which reported stability of vigorous physical activity among 12th graders between 1976 and 1995, and among 8th and 10th graders between 1991 and 1995.¹⁴ The most recent Youth Risk Behaviour Survey has revealed an increase in the percentage of students engaging in exercise “to strengthen or tone their muscles on three or more of the past seven days”, from 48% in 1991 to 52% in 2003.¹⁵

In Canada, Irving and colleagues¹⁶ examined vigorous physical activity prevalence in Ontario youth between 1997 and 2001, also reporting no overall change in that time. However, considering age and sex categories, there was a significant decline in the reported participation of the girls between surveys, and also among both boys and girls in the 11th grade.

Overall, survey questions that do not specify particular contexts of physical activity fail to support the view that the current generation of young people is less active. Particular methodological issues need to be acknowledged when assessing these data: (a) questions about vigorous intensity activities or those that “make you huff and puff” may be biased by decreases in fitness¹⁷ and exposure to these types of activities, thereby increasing the level of perceived exertion during typical submaximal tasks; (b) small imbalances of excess energy of only a few kilojoules per day may result in significant body fat increases in a few years even in the face of constant physical activity patterns. Small changes in both energy intake and expenditure are outside of the resolution of current methods of measurements.

PARTICIPATION IN ORGANISED SPORT

Several large cross sectional surveys have measured the participation rates of Australian children in organised sport

either at school or for a community group, or both.^{18–21} The trends have been summarised by Norton and colleagues.²² The participation rates of children in organised sport have decreased substantially over the past two decades, particularly for those involved in more than one sport. Participation rates for the 9–15 year age range decreased by about 1.5%, 3%, and 4% per year for one, two, and three sports respectively. The losses in participation numbers have been across almost all sports. Those children that are left within organised sport are spreading out further across a greater variety of activities, particularly girls.

Changing sport preferences among Swedish youth between 1974 and 1995 were reported by Westerstahl and colleagues.²³ Between surveys, participation in traditional team sports fell and engagement in less structured leisure time sports increased. Engstrom²⁴ reported that Swedish children involved at least once a week in competitive or “keep fit” activities had declined from 82% to 62% for boys and from 68% to 43% for girls over the period 1968–1984.

The Sport England National Survey of Young People and Sport²⁵ paints a more optimistic picture of sport participation rates among UK youth over the last decade. This comprehensive surveillance system has reported unchanging rates of “frequent” participation (at least 10 times in the last 12 months) in curriculum based school sports between 1994 and 2002, staying at an average of 3.6 sports per child. Over that time, the frequent participation of girls in team games had increased by 5%. Frequent involvement in extracurricular sports organised by schools increased slightly from 4.2 to 4.6 sports per child, and the percentage of girls spending between one and five hours a week on extra-curricular sport rose from 44% in 1994 to 48% in 2002.²⁵ The same surveys revealed stable club sport participation (42% in 1994 and 43% in 2002), and involvement in community organisations such as youth clubs rose from 51% to 55% in that time. However, the positive trends in sport participation in girls noted by Sport England were not evident in another UK survey covering the same time span in which participation in active sports by UK girls had not changed from 1992 to 2000.²⁶ As this survey defined participation as “at least weekly”, methodological differences are likely to account for the discrepancy in trends.

There are no consistent patterns of organised sport trends across different countries. Access to opportunities is likely to be an important factor in the observed declines in Australia. The costs associated with participation, such as uniforms and registration, appear to be an emerging barrier among Australian children.²⁷

PHYSICAL EDUCATION (PE) CLASSES IN SCHOOLS

Recently there has been increasing competition for space in the Australian school curriculum with less time and expertise in many schools for implementing structured physical activity programmes.²⁸ There is a recommendation that South Australian children should receive 100 minutes of PE each week in the compulsory years of schooling. An audit of the South Australian schools' PE programmes was carried out in 1999.²⁸ In summary, 87% of primary schools and 91% of secondary schools surveyed were aware of the “100 minutes” recommendation. However, only 45% of primary schools and 32% of secondary schools were satisfying the recommendation. Furthermore, 29% of year 8, 42% of year 9, and 57% of year 10 classes conducted PE as half year courses.

Systematic PE participation data are available in the United States, showing that rates in high school PE fell from 65% in 1984 to 52% in 1990.²⁹ Similar US trends were noted in the Youth Risk Behaviour Surveys,¹³ with a reduction in daily PE from 42% of children in 1991 to 28% in 2003. Compounding this problem is the declining amount of time reported being

active within PE classes³⁰ affecting some groups more than others.¹³

Harris³¹ also reported that the time allocated to PE in England had declined by 21% between 1974 and 1994. More recently, the National Sport England study surveyed teachers on time committed to PE in UK primary and secondary schools, and found that the percentage of schools offering two or more hours of PE a week fell from 46% in 1994 to 33% in 1999, but recovered to 49% in 2002.²⁵ The surveyed teachers suggested that the dip in 1999 coincided with the introduction of new literacy and numeracy components into the curriculum around that time.

Evidence from these reports suggests that pressure to provide time in the curriculum “budget” to more vocationally orientated learning areas is seriously affecting the status of PE in schools. This is worrying as PE programmes typically contribute to total energy expenditure while also aiming to increase motor skills among children.²⁸

TRANSPORT PATTERNS

It is clear from the public health literature that active transport (walking and cycling) has become a focus of strategies to increase overall physical activity. A recent review found that the frequency of all trips by foot and cycle made by US children fell by 37% between 1977 and 1995.³² There has also been a decline in the “independent mobility” of English children, with fewer allowed to visit leisure places alone and to cycle on roads.³³ For many parents the perceived increase in danger led to declines in the proportion of UK children aged 7–8 years who travelled to school on their own, across the period 1971–1990.³³ Between 1975–1976 and 1989–1994, the percentage of 5–10 year old British children walking to school fell from 71% to 62%, whereas the percentage travelling by car rose from 15% to 28%.³⁴ Between 1985 and 1993, the average yearly distance walked by British children aged under 15 years fell from 395 to 317 km, and the average distance ridden on bicycles fell from 61 to 45 km.³⁵

The few studies to report trends in walking and cycling among children are portraying consistent declines in the United Kingdom and United States.

ELECTRONIC AND SCREEN BASED ENTERTAINMENT

Electronic and screen based entertainment is available in the homes of virtually every child in developed countries, regardless of location, ethnic background, or socioeconomic strata.^{36–37} It follows therefore that a significant proportion of children’s total leisure time is currently spent on “electronic entertainment”, varying from an average of 55% for Australian children³⁸ to over eight hours a day for US children.³⁹ In developing countries such as China and the Philippines, television ownership has “skyrocketed”, leading to greater inactivity during leisure time.⁴⁰

Australian Bureau of Statistics surveys^{41–42} indicate that, between 1981 and 2000, television and VCR ownership increased from 92% to 100% (61% in Australia and 75% in the United States have two or more televisions) and from 3% to 86% respectively. Many surveys now report the number of homes with three or more televisions (currently around 40% in Australia and the United States) or the number of children with televisions in their bedroom.^{37–43} Children with a television in their bedroom spend an average of 38 more minutes a day watching it compared with those without a bedroom television.⁴⁴ There has also been a threefold increase in PAY television in the past four years in Australia and increases from 7% to 76% of homes in the United States over the last 35 years.³⁷ About 76% of Australian homes with children aged between 5 and 14 years have a computer. Internet access has grown from 4% in 1996 to over 24% of

residences in 1998 (56% of homes with children). Time spent watching television by Australian children has increased from 113 minutes a day in 1992 to 130 minutes in 1997.⁴² Children aged 5–14 years are watching television or videos an average of 21.7 hours a fortnight.³⁶ In addition, 9% of Australian children spent more than 20 hours a fortnight playing electronic or computer games, with the highest rates among older boys.³⁶

Contrasting the Australian patterns of screen use, a systematic review of UK data on sedentary behaviours in young people reveals that daily television viewing has remained steady at about 3.1 hours a day since the late 1950s.⁴⁵ However, this analysis did not take into account the range of screen based entertainments such as videos and DVDs available to the current generation of youth. Recent estimates among western adolescents point to total use of electronic media of about five hours a day.⁴⁵

Systematic surveillance of television viewing among US youth reveals that the percentage of 9, 13, and 17 year olds watching six hours or more of television a day increased between 1982 and 1986, and had more or less returned to 1982 levels by 1994.¹⁴ This may reflect increased access to and engagement in alternative screen entertainments. Similarly, Sturm³⁹ concluded a decrease in television time for US children of all ages in repeat surveys from 1981 to 1997 by about 23% or four hours a week. Like many other studies, alternative forms of electronic media that could compete with television time were not included in these analyses.

It is hard to predict the impact on youth obesity of any shift in preference for screen based entertainment. For instance, if television influences food choices through advertising,⁴⁶ a reduction in television is likely to be a positive change, even if other activities such as DVDs and video games become more popular.

SOCIOCULTURAL CHANGES

Social trends such as changes in the home and school environments, family structure, or demographics of where and how people live can all impact on physical activity habits.

The home environment

The physical characteristics of the home and immediate surroundings have continued to evolve in recent decades. The trend is towards larger homes being built on smaller land blocks or multiple town houses replacing traditional family homes, the so-called “in-fill” phenomenon.⁴² Coupled with increasing concerns for safety, this effectively reduces the available play space for children, particularly outdoors. The time spent outdoors by children is strongly related to the energy expended in physical activity.⁴⁷

Changing role of significant others

Martin *et al*⁴⁸ compared results from two Australian surveys in 1985²¹ and 1997²⁰ and provided evidence of a decay of parental role modelling for organised sport. There was a significant association of boys’ sport participation with fathers’ activity frequency in 1985, but not in 1997. Similarly, mother’s activity was associated with girls’ sport, but only in the earlier survey. In other words the strong link between parents as role models for their children’s physical activity patterns had eroded over the 15 year period.

The school environment

The importance of the school environment as a setting for physical activity has broad acceptance.⁴⁹ However, very few data on activity related resources in schools have been systematically collected. Rowe and Champion²⁵ surveyed UK schools on the availability of 13 specific facilities—for example, pools, gymnasias, sports fields. Schools in 2002 reported greater availability of eight of the 13 facilities

compared with schools in 1994, but resources were still concentrated in a relatively few privileged schools. In fact, the level of dissatisfaction with PE and sport facilities among secondary teachers rose from 24% in 1994 to 39% in 2002. The corresponding levels of dissatisfaction among primary school teachers were 23% in 1994 and 40% in 2002.

Demographic influences

Low energy expenditure and the associated overweight epidemic have affected groups in disproportionate ways throughout the population.^{20 30-32} In many developed countries, those in lower socioeconomic groups have been shown to have the highest levels of overweight and the lowest levels of physical fitness.^{20 33} Adolescent girls are at particular risk.³⁴ Urban Australian children have also been found to have lower fitness and greater levels of fatness than their rural counterparts,³⁵ whereas McMurray and colleagues³⁶ reported greater fatness among rural elementary schoolchildren in North Carolina.

In contrast with developed countries, children from higher socioeconomic groups in developing countries have the greatest levels of overweight and obesity, and are more likely to lead sedentary lives.⁴⁰ In these countries, as economic growth occurs, there is a transition throughout the economic strata involving greater disposable income and the adoption of many features of Western lifestyles. This results in more sedentary leisure time pursuits and greater overweight prevalence, which dramatically and selectively affects the higher socioeconomic groups.⁴⁰

Trends in allocation of time "budgets"

Sturm³⁹ has recently reported on trends in time use among US children aged 3–12 years, based on the University of Michigan surveys of 1981 and 1997. Free or discretionary time had declined by about 12% between surveys, largely because of increases in time spent in school and child care. Time spent in school increased by about two hours a week, and time in day care rose from about 14 minutes to three hours a week.³⁹ This observation underscores the importance of ensuring that both the school and day care environments provide ample opportunities for children to engage in active play.

TRENDS IN FITNESS LEVELS AMONG CHILDREN

If children are involved in decreasing levels of physical activity, then one might reasonably expect parallel declines in physical fitness components. A review of US studies that examined oxygen consumption indicates that there has been little change in absolute (litres/min) and relative (ml/min/kg) peak $\dot{V}O_2$ in boys and young girls from the 1930s through the 1990s.³⁷ However, in girls 15 years and older, there has been a decline of about 20% over the past few decades. The authors point to the relatively small samples of girls involved in the reviewed studies, making the downward trends among older girls less certain. Temporal comparisons will also be affected by concurrent trends in biological maturation,³² which would tend to favour those of the same chronological age in later surveys and therefore mask decreases in fitness.³⁸

A recent worldwide meta-analysis of children's aerobic performance trends (using the 20 m shuttle run scores) reported a decline of about 1% a year over the past 20 years.¹⁷ Australian children were among those with the largest rates of decline. In other Australian studies, 7–10 year old children showed marked declines in aerobic performance using the 1.6 km run/walk and smaller falls in sprint speed (50 m) compared with data collected a decade earlier.⁵⁹ Others have also found significant declines in aerobic performance (1.6 km run/walk), and these were most obvious in urban (versus rural) children,⁵⁵ and those in public (versus private) schools.⁵³

Using 1.6 km run/walk data from Australian surveys in 1985 and 1997, Olds and Dollman⁶⁰ found that matching for fatness across studies reduced aerobic performance differences by about 61% in boys and 37% in girls. This suggests that declines in performance cannot be entirely attributed to increased adiposity among children in later surveys.⁶⁰ Although differences in motivation levels between surveys will remain an elusive possibility, unexplained differences in performance are likely to reflect true changes in cardiorespiratory fitness, in turn suggesting reduced exposure of current children to fitness enhancing physical activity.

ATTRACTION TO SPORT AND PHYSICAL ACTIVITY

The most favourite activities of children

Repeat surveys on the favourite activities of Australian children show many interesting patterns over the past half century. Norton and colleagues⁶¹ summarised five surveys since 1957 that asked children aged 12–15 years to list their favourite activities. Playing sport was the most preferred activity for both boys and girls, and this pattern is essentially unchanged today. Some of the activities that have changed include the rise and rise of television watching from 13th for boys in 1974 to 4th in 2000, and 10th in 1974 to 2nd in 1994 and 2000 for girls. Making its mark very rapidly is high tech entertainment for both boys (2nd) and girls (3rd) in 2000. Alarming, eating and sleeping are now ranked in the top 10 most preferred activities. The trend towards a preference for less active and indoor leisure pursuits is apparent. These activities have taken over from more active pastimes such as swimming/water sports, cycling, hiking and walking, tennis, and "playing" in previous generations.

Although there is growing evidence of intra-personal and inter-personal influences on physical activity in young people, there is a paucity of data on trends in these attributes over time. Rowe and Champion²⁵ have systematically surveyed UK youth since 1994. Their results indicate that feelings of attraction to sport and physical activity, perceptions of competence in physical activity, and expectations of outcomes from engaging in sport have remained at high levels. About 90% of respondents indicated that they enjoyed PE, sport and exercise in 1994, 1999, and 2002, and over 90% in all three surveys believed that "being fit" was important. Notably, there was a slight reduction in some of the hypothesised barriers to physical activity across the surveys, with 43% in 1994 and 36% in 2002 indicating that being "cold and wet" was a deterrent to their involvement in PE. Similarly, being "hot and sweaty" was less of a concern in 2002 (36%) compared with 1994 (39%).

Overall, children still enjoy being physically active. In repeat surveys of Australian children since 1985, over 80% consistently report enjoying activities such as games and general playing.⁶² Also, there were no sociodemographic gradients in the widely reported psychosocial predictors of youth physical activity: self efficacy, perceived competency, perceived outcomes and benefits, role modelling, and social support. Taken together, these observations suggest that children are relatively homogeneous in their predisposition to physical activity, and their general acceptance of physical activity is high. The translation of this psychological "readiness" into active lifestyles therefore may hinge on improved access to opportunities and more strategic "marketing" of physical activity as an alternative to sedentary leisure.

DISCUSSION

There is no evidence that the rapid rise in overweight among children will reverse, stop, or even slow down in the near future. At current rates of increase, "adult" percentages of overweight children will be reached within about 30 years.

What is already known on this topic

- It is unclear whether the growing problem of overweight children is due to excessive energy intake or decreasing energy expenditure
- Methodological limitations have made it difficult to accurately measure either side of the energy equation, and trend analysis is best gauged by summing all available evidence of daily activity

Therefore, without environmental changes and interventions, including perhaps legislated changes, we should expect this pattern of increasing prevalence of overweight among children to continue.

Displacement/replacement of one form of physical activity by another is an unexplored possibility. For instance, would declining participation in organised club sport pave the way for greater engagement in unstructured play on weekends? Would a reduced emphasis on school sport, which is available for only the selected few, provide more physical activity opportunities for the wider school population? Do children who are driven to school arrive earlier and expend more energy in vigorous play in the schoolyard each morning? Although a recent US survey of 3rd and 4th graders found that children did not compensate for low levels of physical activity at school by increasing participation after school,⁶³ detailed, purposive use of time surveys are required to identify the interactions among all contexts of physical activity.

There is mounting evidence that physical activity in particular, clearly defined contexts, such as active transport (in many countries), school physical education (particularly in Australia and the United States), and organised sport (particularly in Australia) is waning. Arguably these forms of activity are more constrained by institutional (such as school curriculum), social (such as parental support), and physical (such as neighbourhood safety) environmental factors, and their decline is unsurprising in the light of recent macro-environmental and demographic changes typical of developed countries.

The trend and cross sectional data on attitudes towards physical activity suggest that young people continue to almost universally endorse physical activity as enjoyable and worth while.²⁵ The media driven characterisation of today's youth as slothful and lazy by choice is not supported by the data at our disposal. Instead we see the emergence of "activity toxic" environments, which are restricting free movement among children, particularly beyond the school gate, and most dramatically among the sociodemographically disadvantaged in developed countries and higher socio-economic groups in developing countries.

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What this study adds

- Physical activity in particular, clearly defined contexts such as active transport, school physical education, and organised sports is waning in many countries
- Young people report a strong and consistent desire to be active but are often constrained by external factors such as school policy or curricula, parental rules in relation to safety and convenience, and physical environmental factors

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COMMENTARY

The focus on the worldwide childhood obesity epidemic has led many to conclude that physical activity has declined. However, little empirical evidence exists to support this notion. This paper describes the physical activity levels of children and adolescents globally over the past few decades by summarising the available evidence across a range of domains of physical activity. Although firm conclusions about declines in children's total physical activity cannot be made, tentative conclusions suggest a decline in activity in clearly defined contexts, such as active transport and school physical education. It is of significant public health importance to understand trends in children's physical activity. This may assist in the implementation of appropriate strategies and interventions to prevent further increases in the rates of overweight and obesity.

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