

Metadato	Descrizione
TIPOLOGIA:	Pubblicazione
TITOLO:	Physical Activity Levels of Children Who Walk, Cycle, or Are Driven to School
DESCRIZIONE:	Active commuting to school by walking or bicycle is widely promoted to increase children's physical activity. However, there is little data to describe the impact that travel mode, and in particular cycling, may have on activity levels. In primary school-aged children, walking to school is associated with higher levels of overall physical activity compared with those who travel to school by motorized transport. Cycling is associated with higher overall physical activity only in boys.
AUTORE:	Ashley R. Cooper, Lars Bo Andersen, Niels Wedderkopp, Angie S. Page, Karsten Froberg,
COAUTORE:	
ARGOMENTO:	Attività fisica
COPERTURA GEOGRAFICA:	
RELAZIONE CON ALTRI DOC PRESENTI IN ARCHIVIO:	
DATA :	
LINGUA:	inglese
FORMATO:	pdf
LINK URL:	

Physical Activity Levels of Children Who Walk, Cycle, or Are Driven to School

Ashley R. Cooper, PhD, Lars Bo Andersen, PhD, Niels Wedderkopp, MD, Angie S. Page, PhD, Karsten Froberg, PhD

Background: Active commuting to school by walking or bicycle is widely promoted to increase children's physical activity. However, there is little data to describe the impact that travel mode, and in particular cycling, may have on activity levels.

Methods: Primary school children wore an accelerometer recording minute-by-minute physical activity, and completed questions describing travel habits. Total volume of physical activity and hourly physical activity patterns were estimated and groups of children compared by mode of travel to school. Data were collected as part of the European Youth Heart Study.

Results: A total of 332 children (average age 9.7 years, standard deviation [SD]=0.4 years) completed all measurements. Children who walked to school were significantly more physically active than those who traveled by car (accelerometer counts per minute [cpm]: 667.7, SD=233.7 vs 557.3, SD=191.4; $p=0.01$). Those who cycled to school recorded higher accelerometer counts than those who traveled by car, but differences were not significant. Boys who walked or cycled to school were significantly more physically active than those traveling by car (walk: 732.2 cpm, SD=253.1 vs 592.8 cpm, SD=193.9; $p=0.007$; cycle: 712.6 cpm, SD=249.1 vs 592.8 cpm, SD=193.9; $p=0.013$). In girls, walking but not cycling to school was significantly associated with higher daily physical activity levels (606.3 cpm, SD=197.7, vs 523.4 cpm, SD=185.0 cpm; $p=0.05$).

Conclusions: In primary school-aged children, walking to school is associated with higher levels of overall physical activity compared with those who travel to school by motorized transport. Cycling is associated with higher overall physical activity only in boys.
(Am J Prev Med 2005;29(3):179–184) © 2005 American Journal of Preventive Medicine

Introduction

The journey to school is an opportunity for children to achieve regular, daily physical activity, but increasingly children are being driven to school by car rather than walking or cycling. In the United States, approximately 50% of children aged 5 to 15 years travel to school by car, with only 10% walking.^{1,2} In the United Kingdom, the proportion of primary-school-aged children (5 to 10 years) driven to school increased from 29% in 1993 to 41% in 2002.³

In response to these trends, many programs to encourage active travel to school, both by foot and by bicycle, are being implemented.⁴ However, there is surprisingly little research on how active commuting to school may contribute to overall levels of physical

activity.⁵ Studies using objective measurement of physical activity have reported higher energy expenditure in Filipino adolescents who walk to school,⁶ and in English primary school children walking to school has been associated with higher overall levels of physical activity.⁷ In a nationally representative survey in the Russian Federation, omission of active commuting to school resulted in a decrease of 12% to 20% in the prevalence of 10-year-old children meeting health-related physical activity guidelines.⁸ Cycling to school is now unusual in many countries, with <2% of trips made by bicycle,^{2,3,8} and the contribution that cycling to school may make to overall physical activity is unknown.

In addition to the physical activity accrued in actually traveling to and from school, there is some evidence that walking to school may be associated with higher physical activity levels at other times during the day.⁷ In this study we used data collected in the Danish city of Odense as part of the European Youth Heart Study⁹ to investigate the association of active travel to school both by foot and by cycle with physical activity levels throughout the school day, compared with children traveling to

Department of Exercise and Health Sciences, University of Bristol (Cooper, Page), Bristol, United Kingdom; Institute of Sport Sciences, University of Copenhagen (Andersen), Copenhagen, Denmark; and Institute of Sports Science and Clinical Biomechanics, University of Southern Denmark (Wedderkopp, Froberg), Odense, Denmark

Address correspondence and reprint requests to: Ashley Cooper, PhD, University of Bristol, Department of Exercise and Health Sciences, Centre for Sport, Exercise and Health, Tyndall Avenue, Bristol, BS8 1TP, United Kingdom. E-mail: ashley.cooper@bris.ac.uk

school by car. Odense provides a model of a safe environment for cycling and walking, with a comprehensive program to protect children from road danger. Cycle lanes are protected from traffic by concrete barriers, there is a strong awareness of pedestrian traffic by motorists, and many cycle lanes lead directly to schools. Consequently, a significant proportion of children cycle to school. This study investigated the association between physical activity levels and mode of travel to school among primary-school-aged children.

Methods

This was a school-based study using data from the European Youth Heart Study, a multicenter international study addressing the prevalence and etiology of cardiovascular disease risk factors in children.⁹ This paper describes 9-year-old children from the Danish arm of this study. The study took place 1997/98. Schools were tested one at a time such that all children from an individual school were tested in the same period. The order of schools for testing was randomly assigned prior to commencement. All measurements except assessment of physical activity were carried out in the schools that the participants attended. Approval was given by the local scientific ethics committee (case 96/272). Written consent was obtained from the children's parent/guardian, and the children gave verbal consent to participate.

Participants

A sampling frame of schools in the city and region of Odense ($n=35$) was compiled using official lists. School catchment areas were stratified to low, middle, and high socioeconomic status, and the sampling of schools was performed within these strata. A total of 28 schools were randomly selected using probability proportional to the number of children on the register. Twenty-five schools agreed to participate. Children were sampled randomly within schools using the school registers.

Measurements

Height was measured to the nearest millimeter in bare or socked feet with a transportable Harpenden stadiometer (SECA, Birmingham, England), and weight was measured to the nearest 0.1 kg using a calibrated beam scale. Children completed a computerized questionnaire including items describing their travel to school. Relevant items were: "How do you usually travel to school?" (response options: by car or motorcycle, by bus or train, by bicycle, on foot) with a similar question for travel home, and "How long does it usually take you to travel to school from your home?" (response options: <5 minutes, 5 to 15 minutes, 15 to 30 minutes, 30 minutes to 1 hour, >1 hour). Physical activity was measured using an accelerometer (Manufacturing Technologies Inc. [MTI] model 7164) programmed to record physical activity each minute. The accelerometer was worn on an elastic belt around the waist, positioned above the right hip, for at least 4 days (including 2 weekend days) in the week prior to physical assessment, except when swimming, bathing, and sleeping.

Data Reduction

Accelerometer counts were summed for each hour of recording between 6 AM and 10 PM each day and converted to counts per minute for comparison with other studies. The mean of the total counts for each hour of the day was computed for the number of weekdays that the instrument was worn. Data from individuals recording <10 hours of measurement on any day were excluded from that day's computation. Participants with <2 weekdays of measurement were excluded from all analyses. To enable comparison of activity during the school journey, children failing to record readings between 7 AM and 8 AM on any weekday were also excluded. For comparison of weekday and weekend activity, children were required to record a minimum of 2 weekdays and 2 weekend days of measurements. Total daily moderate- to vigorous-intensity physical activity [MVPA]—that is, more than three metabolic equivalents—was calculated using age-specific cut-points.¹⁰

Analysis

Data are presented as mean and standard deviation unless otherwise stated. The independent associations between travel mode on physical activity (accelerometer counts per minute) were tested using general linear models. Models were tested with and without adjustment for gender, study location (school) and season. Hourly differences in physical activity between travel groups and differences between weekday and weekend activity levels were tested using one-way analysis of variance with Bonferroni adjustments for multiple comparisons where appropriate. Analyses were performed in 2004 and 2005 using SPSS, version 11.0 (SPSS Inc., Chicago IL, 2003) and Stata, version 8.1 (Stata Corp, College Station TX, 2003).

Results

A total of 590 children (280 boys and 310 girls) were recruited, of whom 417 wore the accelerometer. Data were lost from 27 participants through faulty instruments, 25 did not record sufficient weekday data for inclusion, 25 did not record MTI measurements between 7 AM and 8 AM, and 8 did not complete the travel questions. A final sample of 323 children (152 boys, 180 girls) fulfilled the inclusion criteria. No significant differences existed in gender, age, or body mass index (BMI) between excluded children and those included in the analysis. Mean age of the children was 9.7 years (standard deviation [SD]=0.4 years), and this did not differ between travel or gender groups. There were no significant differences in height or BMI between any groups (boys: average height 139.4 cm, SD=6.1 cm, average BMI 17.2, SD=2.3; girls: average height 138.2 cm, SD=6.7 cm, average BMI 17.1, SD=2.5). Children wore the accelerometer for 2 (39.2%), 3 (40.4%), 4 (14.2%), or 5 (6.3%) weekdays. Average wearing time for the accelerometer was 14.4 hours (90% of available time) during the week, and 13.1 hours (82% of time) at the weekend, and was similar in all subgroups.

Table 1. Weekday physical activity levels (mean \pm SD) of Danish primary school children

	Mode of travel to school			
	Walk (9 boys, 41 girls)	Bicycle (56 boys, 73 girls)	Car (40 boys, 42 girls)	Bus (17 boys, 24 girls)
Accelerometer counts per minute				
Total	667.7 \pm 233.7	604.1 \pm 249.0	557.3 \pm 191.4	555.0 \pm 185.7
Boys	732.3 \pm 253.1	712.6 \pm 249.1	592.8 \pm 193.9	607.5 \pm 228.5
Girls	606.3 \pm 197.7	520.8 \pm 216.0	523.4 \pm 185.0	517.8 \pm 141.9
Total daily MVPA (minutes)				
Total	192.7 \pm 59.3	165.8 \pm 66.9	155.8 \pm 61.5	154.8 \pm 64.0
Boys	204.0 \pm 55.1	197.5 \pm 70.4	170.0 \pm 60.3	172.0 \pm 83.8
Girls	182.1 \pm 61.8	141.5 \pm 52.8	142.3 \pm 60.2	142.6 \pm 52.8

MVPA, moderate to vigorous physical activity; SD, standard deviation.

Children traveled to school on foot (24.1%) or via cycle (38.9%), car (24.7%), and bus (12.3%). Most (>85%) of the children traveling on foot, or via bicycle or car had a journey time of \leq 15 minutes. The bus journeys to school were made by public transport, not dedicated school buses. The amount of walking in the journey was thus unknown, and data from children traveling to school by bus were excluded from further analyses.

Physical Activity Volume

Physical activity data for the travel groups is shown in Table 1. There was a significant main effect of travel mode on physical activity counts per minute ($F[2,288]=4.72$, $p<0.01$). Children who walked to school were significantly more active than those who traveled by car ($F[1,160]=10.86$, $p<0.01$). There was a significant main effect for gender ($F[1,158]=8.87$, $p<0.01$), but no significant interaction between gender and travel mode. Children who cycled to school recorded counts between those who walked and those who traveled by car, but these differences were not significant. However, the magnitude of the difference between the cycle and car groups may be diminished by the proportion of girls cycling to school being higher than in the other groups (Table

1), girls being generally less physically active than boys. Results were unaltered when analyses were repeated while controlling for school to account for potential differences due to the school environment.

Analyzed by gender, boys who walked to school were significantly more active than those who traveled by car ($F[1,77]=7.59$, $p<0.01$), as were those who traveled by bicycle ($F[1,94]=6.45$, $p<0.05$). Girls who walked to school were also significantly more active ($F[1,81]=3.89$, $p=0.05$) than those traveling by car, but no difference existed between cyclists and car users.

Physical activity levels at the weekend were investigated in children recording both weekday and weekend data ($n=214$) (Table 2). Weekday values were only marginally adjusted in this subgroup, and all relationships between travel groups during the week were unaltered. At the weekend, boys who had walked or cycled to school, but not those driven, were significantly less active than during weekdays (mean differences—walk: 120.9 cpm, SD=228.3 cpm, 95% CI=32.4–209.4, $p=0.009$; cycle: 103.8 cpm, SD=258.6 cpm, 95% CI=27.9–179.7, $p=0.008$). There were no significant differences in activity level between weekdays and the weekend for girls. No significant differences were seen between travel groups at the weekend.

Table 2. Comparison of weekday vs weekend physical activity levels (mean \pm SD) of Danish primary school children

Accelerometer counts per minute	Mode of travel to school			
	All (103 boys, 111 girls)	Walk (28 boys, 31 girls)	Bicycle (47 boys, 48 girls)	Car (28 boys, 32 girls)
Weekday				
Total	618.8 \pm 241.3	685.3 \pm 247.7	614.3 \pm 252.3	560.6 \pm 201.2
Boys	682.1 \pm 260.1	741.6 \pm 280.8	702.6 \pm 260.9	588.0 \pm 217.0
Girls	560.1 \pm 206.8	634.4 \pm 205.0	527.9 \pm 212.8	536.6 \pm 186.3
Weekend				
Total	582.1 \pm 267.4	655.5 \pm 293.4	560.3 \pm 243.6	544.6 \pm 267.1
Boys	593.6 \pm 254.3	620.7 \pm 259.3	598.8 \pm 263.9	557.8 \pm 237.1
Girls	571.5 \pm 279.7	686.9 \pm 322.1	522.7 \pm 218.1	533.0 \pm 294.2

SD, standard deviation.

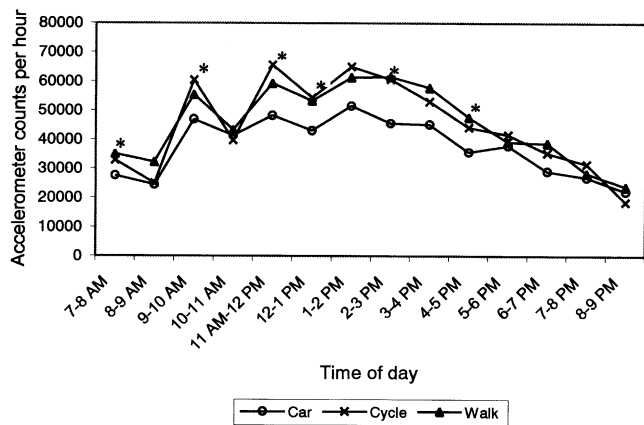


Figure 1. Weekday activity pattern of boys by method of travel to school. $p < 0.05$ for active travel (walk and cycle) versus car.

Physical Activity Patterns

Danish primary-school-aged children attend short classes in the morning with frequent breaks, and after 1 PM attended a day center on school property where they are free to play. To investigate when differences in activity between travel groups occurred, accelerometer data were plotted for each hour of the day between 7 AM and 9 PM for boys and girls (Figures 1 and 2). The pattern and level of activity of boys traveling on foot and by bicycle were similar throughout the day, and were higher at most time points than those who traveled by car. Combining walking and cycling as “active commuting” identified consistent significant differences compared with boys who were driven to school by car (not shown). In girls there were no differences between any travel mode during the day, or between active commuting and car travel with the exception of when traveling to school. During the late afternoon and evening, there was a trend for girls who had walked to school to be more active, but hourly differences did not reach statistical significance.

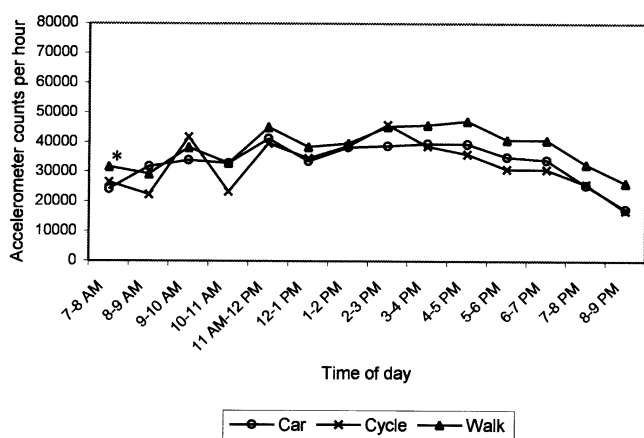


Figure 2. Weekday activity pattern of girls by method of travel to school. $p < 0.05$ for active travel (walk and cycle) versus car.

To summarize differences during the day, mean accelerometer counts per minute were computed for the periods when the children were traveling to school (7 to 8 AM), in classes (8 AM to 1 PM) or day center (1 PM to 4 PM) and after school/evening (4 PM to 9 PM). Boys using active commuting were significantly more physically active when traveling to school (561.4 cpm, SD=298.2 cpm, vs 449.9 cpm, SD=238.2 cpm, 95% CI of difference 6.4–216.6, $p = 0.038$), during school (814.0 cpm, SD=287.7 cpm vs 677.8 cpm, SD=235.0 cpm, 95% CI of difference 34.3–238.1, $p = 0.009$), and at the day center (996.7 cpm, SD=507.7 cpm vs 787.4 cpm, SD=439.0 cpm; 95% CI of difference 27.1–391.4, $p = 0.025$) than those traveling by car, but there were no significant differences between groups in the evening. Girls using active travel to school were significantly more active than car users only when traveling to school (479.6 cpm, SD=214.1 cpm vs 404.0 cpm, SD=164.1 cpm, 95% CI of difference 3.5–147.6, $p = 0.04$).

Physical Activity Intensity

Physical activity data collected by the MTI accelerometer may be used to estimate physical activity intensity using age-specific count values equating to the threshold between moderate- and light-intensity activity. Any minute of recording in which counts exceed a given value is rated as a minute of moderate to vigorous physical activity (MVPA). Such estimates allow data to be interpreted in practical terms, and enables comparison between studies. Values for mean daily MVPA are given in Table 1. Boys who walked to school recorded almost 34 minutes (95% CI=8.0–59.8, $p = 0.011$) more MVPA per day than those traveling by car, while cyclists recorded 27.5 minutes more (95% CI=0.2–54.8, $p = 0.048$). Girls who walked to school recorded 40 minutes (95% CI=13.1–66.4, $p = 0.004$) more MVPA than car users, with no difference between cyclists and car users. The journey to school itself contributed relatively little to these totals, with children who walked to school recording 3.5 minutes (12.8 vs 9.3 minutes) more than those who traveled by car between 7 AM and 8 AM. Cycling is not reported for this period since the accelerometer relies on whole-body accelerations when worn at the waist, and thus under-estimates physical activity when cycling.¹¹

Discussion

This study investigated the relationship between active commuting to school and the daily physical activity levels and patterns of a representative sample of Danish primary school-aged children. Walking to school was associated with higher overall levels of physical activity compared with traveling by car, although the journey to school itself contributed relatively little. This study is

What This Study Adds . . .

Walking or bicycling to and from school can contribute to attaining public health goals for total physical activity.

Using accelerometers to assess primary school-aged children in Denmark, it was found that walking (for girls) and cycling (for girls and boys) to school was associated with higher levels of physical activity, but only some of this increase was attributable to the journey itself.

the first to investigate the association between cycling to school and daily physical activity, and found that cycling was also associated with significantly higher activity levels in boys but not in girls when compared with motorized travel.

Although accelerometry is one of the best methods for measuring free-living physical activity, there are limitations to its use that should be considered when interpreting our findings. The MTI accelerometer is a uniaxial device that detects whole-body vertical accelerations. These movements are limited when cycling, and thus an accelerometer worn around the waist will under-report physical activity during cycling. The extent of this under-reporting is hard to assess, as the children did not report periods when cycling. However, since they will not be using their bicycles during school time or during play school, the relationships seen in this study remain unchanged. Furthermore, 4 to 5 days of activity monitoring have been proposed as suitable duration for accurately and reliably assessing the usual activity behavior in children,¹⁵ whereas only 2 to 3 days of weekday data were available for most of our participants. It is possible that this slightly shorter monitoring period may either enhance or attenuate the true association between travel mode and physical activity level.

It is possible that naturally active children choose to travel to school by active means, explaining the differences seen. To explore this issue, we investigated physical activity levels at the weekend. Boys who traveled to school by active means in the week were markedly less active at the weekend, but were still more active than the car users, providing some evidence that the car users may be generally less active children. However, these differences were not statistically significant. In girls, activity levels at the weekend approximated those during the week, although girls who walked to school in the week were more active at the weekend. Again, no significant differences were seen between travel groups. These results suggest that differences during the week cannot be explained by natural differences in activity level between groups of children.

Few other studies have investigated the relationship between active commuting to school and overall

physical activity using objective measurement. The Caltrac accelerometer was used in a large population of Filipino adolescents to show higher energy expenditure by those who reported walking to school, with males recording higher values than females.⁶ However, the Caltrac provides an estimate of energy expenditure in physical activity that is not time resolved, and thus the time of day when differences among travel groups arose could not be determined. Only two studies have investigated associations between travel to school and physical activity using minute-by-minute accelerometry. In a study of children aged 5 years, no differences in physical activity levels were seen in association with travel mode.¹² In contrast, in English primary school children, boys who walked to school were significantly more active than those commuting by car, and this difference could not be accounted for by the journey alone.⁷ Major differences in activity occurred after school in outdoor play/games, suggesting that active commuting may have acted as a catalyst for increasing informal and spontaneous aspects of physical activity.¹⁶

The results from this study of Danish children are similar to those reported for English children of the same age, with walking to school associated overall with higher daily physical activity levels. In contrast to the English study, walking to school was associated with higher physical activity in both boys and girls. Boys recorded higher activity during school and free play, while girls were more active later in the day. A strong gender difference was seen in activity associated with cycling to school. Although more girls cycled to school than boys, only in boys was a higher level of overall daily physical activity seen. The reason for these gender differences is unknown, but may reflect the activities that boys participate in during free time such as football and chasing games.¹³ That differences in physical activity associated with travel mode occurred both within school and during supervised free play raises the possibility that, at least in boys, physical activity early in the day may prompt increased activity throughout the day. Limited experimental evidence supports this possibility,¹⁴ although more extensive investigation is required.

This study demonstrates that walking and cycling to school may be associated with overall higher levels of daily physical activity in primary school children when compared with children who travel to school by car. The mechanisms by which these differences occur are not known, and more research is required into the social and environmental determinants of physical activity associated with active commuting. Nonetheless, that similar results have been described in different cultures and school systems provides good evidence in support of policy initiatives to promote active commuting to school as a means of increasing children's daily physical activity.

No financial conflict of interest was reported by the authors of this paper.

References

1. Federal Highway Administration. Our nation's travel: 1995 NPTS early results report. Washington DC: U.S. Department of Transportation, 1997.
2. Centers for Disease Control and Prevention. Barriers to children walking and biking to school—United States, 1999. *JAMA* 2000;288:1343–4.
3. Department for Transport. Transport statistics bulletin. National travel survey: 2002. London: Stationery Office, 2004.
4. Department of the Environment, Transport and the Regions. School travel strategies and plans; a best practice guide for local authorities. London: Stationery Office, 1999. Available at: www.saferoutestoschools.org.uk. Accessed June 2004.
5. Tudor-Locke C, Ainsworth BE, Popkin BM. Active commuting to school. An overlooked source of children's physical activity? *Sports Med* 2001;31:309–13.
6. Tudor-Locke C, Ainsworth BE, Adair LS, Popkin BM. Objective physical activity of Filipino youth stratified for commuting mode to school. *Med Sci Sports Exerc* 2003;35:465–71.
7. Cooper AR, Page AS, Foster LJ, Qahwaji D. Commuting to school. Are children who walk more physically active? *Am J Prev Med* 2003;25:273–6.
8. Tudor-Locke C, Neff LJ, Ainsworth BE, Addy CL, Popkin BM. Omission of active commuting to school and the prevalence of children's health-related physical activity levels: the Russian Longitudinal Monitoring Study. *Child Care Health Dev* 2002;28:507–12.
9. Riddoch CJ, Edwards D, Page AS, et al. The European Youth Heart Study—cardiovascular disease risk factors in children: rationale, aims, study design and validation of methods. *J Phys Activity Health* 2005;2:115–9.
10. Trost SG, Kerr LM, Ward DS, Pate RR. Physical activity and determinants of physical activity in obese and non-obese children. *Int J Obes* 2001;25:822–9.
11. Welk GJ. Use of accelerometry-based activity monitors to assess physical activity. In: Welk GJ, ed. *Physical activity assessments for health-related research*. Champaign IL: Human Kinetics, 2002;125–41.
12. Metcalf B, Voss L, Jeffery A, Perkins J, Wilkin T. Physical activity cost of the school run: impact on schoolchildren of being driven to school (*EarlyBird* 22). *BMJ* 2004;329:832–3.
13. Sleaf M, Warburton P. Physical activity levels of 5–11-year-old children in England: cumulative evidence from three direct observation studies. *Int J Sports Med* 1996;17:248–53.
14. Dale D, Corbin CB, Dale KS. Restricting opportunities to be active during school time: do children compensate by increasing physical activity levels after school? *Res Q Exerc Sport* 2000;71:240–8.
15. Trost SG, Pate RR, Freedson PS, Sallis JF, Taylor WC. Using objective physical activity measures with youth: how many days of monitoring are needed? *Med Sci Sports Exerc* 2000;32:426–31.
16. Cooper AR, Page AS. Physical activity and the environment. In: Cameron N, Norgan NG, Ellison TH, eds. *Childhood obesity: strategies for prevention*. New York: Taylor & Francis. In press.