

Patterns of Sedentary Behaviour and Physical Activity Among Adolescents in the United Kingdom: Project STIL

Trish Gorely · Simon J. Marshall · Stuart J. H. Biddle · Noel Cameron

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Abstract The purpose of this study was to use ecological momentary assessment to investigate the patterning of physical activity and sedentary behaviours in UK adolescents and to examine if different lifestyle groups differ on key explanatory variables. A total of 1,371 (38% boys, mean age 14.7 years) adolescents completed diaries every 15 min for 3 weekdays outside of school hours and 1 weekend day. Cluster analysis yielded five-cluster solutions for both boys and girls to explain the grouping of sedentary behaviours and physical activity. The clusters demonstrated that adolescents engage in many leisure time behaviours but have one activity that predominates. Active adolescents spend more time outside and more time with their friends. Few demographic and environmental variables distinguished between clusters. The findings suggest a potential need for different behavioural targets in interventions to reduce sedentary behaviour in sub groups of the adolescent population. Further research is required to examine the modifiable determinants of different sedentary lifestyles among young people.

Keywords Ecological momentary assessment · Youth · Sedentary behaviour · Physical activity

Introduction

The magnitude of sedentary behaviours in youth populations and the consequent effect on health is a growing public health concern (UK Department of Health 2004). There is agreement that a sedentary lifestyle is related to negative health outcomes such as heart disease, diabetes, and obesity (UK Department of Health 2004). Even small reallocations of time spent in sedentary behaviours in favour of more physically active behaviours have been shown to have significant positive health implications (Epstein and Roemmich 2001). Increasing physical activity and decreasing sedentary behaviours are therefore key factors in promoting health (Nelson et al. 2005). Despite the importance of understanding sedentary behaviours, and the factors that influence them, few studies have addressed these issues (Henning Broderson et al. 2005; Marshall et al. 2002; Nelson et al. 2005). Understanding the relationship between sedentary behaviours and physical activity may lead to the development of more effective strategies for promoting healthy physical activity levels.

The most common approach to the study of inactive lifestyles has been to focus on highly visible and prevalent sedentary behaviours such as television viewing and use of other screen based media (see for example, Henning Broderson et al. 2005; Nelson et al. 2005, Schmitz et al. 2002). Although investigating individual behaviours is important, this focus is inadequate for understanding patterns of behaviour or how single behaviours impact the overall lifestyle of contemporary youth (Nelson et al. 2005). In particular, this single behaviour approach fails to capture the diversity and variability in young people's sedentary behaviour (Marshall et al. 2002). Measurement approaches are needed that can capture the multiple sedentary and active behaviours adolescents engage in.

T. Gorely (✉) · S. J. H. Biddle · N. Cameron
British Heart Foundation National Centre for Physical Activity and Health, School of Sport & Exercise Sciences, Loughborough University, Loughborough, Leics LE11 3TU, UK
e-mail: p.j.gorely@lboro.ac.uk

S. J. Marshall
San Diego State University, San Diego, USA

Objective methods of physical activity assessment, such as accelerometry and heart rate telemetry, are limited in this respect as they can not provide information about what people are actually doing or where they are being active.

One study has attempted to capture this behavioural diversity by investigating the relationship between seven common sedentary behaviours and physical activity in British and American 11–15 years olds (Marshall et al. 2002). Cluster analysis identified three groups of boys ('techno-active', 'non-socialising actives' and 'uninvolved inactives') and girls ('sociable actives', 'non-socialising actives' and 'uninvolved inactives'). Sociodemographic differences (nationality, age, ethnicity and body mass index) between the clusters were investigated. Differences were only observed for girls with the 'uninvolved inactive' group being older and more likely to come from North America. Although providing initial insight into the differing lifestyle patterns among adolescents, this research was limited by the investigation of only a small number of sociodemographic explanatory variables and the use of a 7-day recall self-report checklist which is likely to be biased by memory distortion (Smyth and Stone 2003) and limits the number of behaviours reported on.

In addition to describing clusters of behaviours it is necessary to try to explain why these different behaviours occur. The search for explanatory variables for a variety of health behaviours has increasingly been based on ecological models which suggest that behaviour is influenced by intrapersonal factors (e.g., demographic, psychological and biological factors), interpersonal factors (e.g., social support, normative beliefs) and the physical environment (e.g., weather, urban design, access) (Sallis and Owen 2002). In physical activity research with adolescents correlates at all of these levels have been identified (Sallis et al. 2000) and although there is limited research on sedentary behaviours there is some evidence that this model would be useful for understanding these behaviours (Henning Broderon et al. 2005; Gordon-Larsen et al. 2000; Gorely et al. 2004).

A consistent finding in the physical activity literature is that gender influences participation with boys having higher levels of participation (Sallis et al. 2000). There is also evidence that gender influences participation in sedentary behaviours (Marshall et al. 2002, 2006). For example, Marshall et al. (2006) demonstrated that boys are more likely to be high users of television and computer or video games. Given these gender differences in participation it can be argued that there is a need to understand physical activity and sedentary behaviour separately in boys and girls (Marshall et al. 2002, 2006; Sallis et al. 2000).

The present study aims to move forward from the work of Marshall et al. (2002) by using ecological momentary assessment to (1) investigate the patterning of physical

activity and sedentary behaviours in a representative sample of UK adolescents and (2) examine if different lifestyle groups differ on key explanatory variables. As participants only record what they are doing at that exact time, ecological momentary assessment helps to circumvent or reduce known sources of bias inherent in other retrospective self-report measures such as recall loss, estimation bias and telescoping (Baranowski 1985; Smyth and Stone 2003). It also has the potential to capture a wider range of behaviours as participants 'free-record' what they are doing. Ecological momentary assessment may be especially suitable for assessing sedentary behaviour in young people as they are less likely to provide reliable estimates of intermittent, unstructured, low intensity behaviour through recall (Welk et al. 2000). In addition, ecological momentary assessment generates data about the temporal patterns of behaviour and the context in which it occurs (Dunton et al. 2005). Following social ecological approaches, a range of potential explanatory variables were included: (a) intra personal (age, ethnicity, social class indicators, using father's occupation and mother's occupation as proxies, and physical maturity); (b) interpersonal (% time spent with friends) and, (c) physical environment (technology density in the home (total number of televisions, videos, video games players and computers in the home divided by the number of rooms in the home), physical activity equipment ownership, whether their home had a garden, home location on a busy road, and % time spent inside). Specific variables within each level were chosen on the basis of previous physical activity correlates research (e.g., Sallis et al. 2000), television and other screen based media research (Henning Broderon et al. 2005, Gordon Larson et al. 2000), and our initial qualitative pilot work with British teenagers which supported the role of physical and social settings as cues for sedentary behaviour.

Method

Sampling Design

Data were from a larger study of adolescent lifestyles (Project STIL—*Sedentary Teenagers and Inactive Lifestyles*) within the United Kingdom. Sampling took place between 2000 and 2002 across 15 regions stratified across England, Northern Ireland, Scotland, and Wales. Schools were randomly sampled from the largest Local Education Authority in each region, stratified by the ratio of government funded ("secondary") schools to fee-paying ("independent") schools in that Local Education Authority. To control for seasonal variation in behaviour, sampling occurred at all schools in two waves, 6 months apart (wave 1 predominantly March–May and wave 2

September–November). However, sampling procedures were designed to ensure that separate students were sampled in each wave. To further increase sample size, an additional sample was recruited 6 months after wave two and using the same procedures. At each school, a study coordinator randomly sampled one class from each of 3 year groups: year 9 (13–14 years old), year 10 (14–15 years old), and year 11 (15–16 years old). All students in the selected class were invited to participate in the study. All study procedures were approved by the Ethical Advisory Committee of the first author's institution and were in accordance with the ethical guidelines of the British Psychological Society. Informed consent was obtained from all parents/guardians and participants.

Participants

Of the 1,604 participants who returned diaries, 62% were girls, reflecting a gender bias ($\chi^2 = 84.92$, $df = 1$, $p < .01$). Of the returned diaries, girls were also more likely to provide complete data ($\chi^2 (4) = 21.61$, $p = .0001$). About 62 participants (4%) returned diaries with completed demographic data but no diary data (i.e., partial responders) and were therefore excluded from further analyses. Partial responders were more likely to be male ($\chi^2 (1) = 17.23$, $p = .0001$), but did not differ by age ($p = 0.80$) or ethnicity ($p = 0.34$), or whether they found the diary harder to understand ($p = 0.48$), compared to full responders.

It was not possible to compute an overall response rate for the study because of missing data in the logs completed by school staff that were used to track the number of diaries distributed at each school. However, 5,400 surveys were sent to 45 schools. If all surveys were distributed at all schools, this represents a response rate of 29.7%. However, this is likely to be a considerable underestimate of the true response rate because an excess of diaries were sent to each school to allow for differing class size, loss of diaries, etc., and many schools returned unused diaries or distributed them only to a single year group. As an indication of the potential scope of response rate underestimation, at the 13 schools who returned completed log books indicating the number of diaries actually handed out we calculated the response rate to be 50.2%. The terms of our ethical clearance did not allow us to collect any information about those who were eligible to participate but chose not to, hence it is unknown whether non-participants differed in anyway from participants.

The sample employed in this paper comprised the 1,371 (boys $n = 521$, girls $n = 850$) adolescents who returned completed diaries. The mean age of participants was 14.7 years ($SD = 0.92$, range 12.5–17.6 years) and 40.3% were in school year (grade) 9, 33.8% in year 10 and 25.9%

in year 11. The majority of the sample (90.7%) attended government funded rather than private schools which is consistent with national levels (UK Department for Education and Skills 2004). The sample was predominantly white-European (87.9%) broadly reflecting the racial/ethnic make-up of this school-aged population in the UK (UK Department for Education and Skills 2004). Analysis of socioeconomic status (using mothers' occupation) revealed that 39.1% of participants had mothers in senior or professional positions, 48% were in administrative or skilled positions, 6.8% were in less skilled positions and 5.6% were in other positions (e.g., unemployed, retired or homemaker) reflecting a higher than average socio-economic status.

Instrumentation

The principal data collection instrument was a pencil and paper self-report diary of "free-time" that school students completed outside of school hours. Because the focus of our study involved behaviours that could be regarded as 'volitional', behaviours in school were not assessed. The self-report diary is based on principles of ecological momentary assessment and has been described in Gorely et al. (in press). The first part of the diary involved background questions about the variables at child, family, and environmental levels that have been hypothesized to correlate with sedentary behaviour and physical activity. The second part was for recording the behaviours, locations, and social contexts that the young people engaged in each day.

Participants were instructed to complete the diary for four randomly assigned days (3 weekdays and 1 weekend day). The diary was introduced to participants by their teachers who were given written standardised background information and instructions to use during this introduction. Detailed written instructions of how and when to complete the diary were also provided to both participants and parents at the front of the diary. To reduce behavioural reactivity, the terms 'physical activity', 'exercise', 'fitness', 'inactivity, and 'sedentary' were deliberately avoided when the diary was being introduced to students. At 15-min intervals, participants self-reported (free-response) their main behaviour and also responded to two closed-response items, "Where are you?" (LOCATION) and "Who's with you?" (WHO). For LOCATION, participants selected one location from a list of 12. For the WHO item, participants selected one context from a list of five. At each time sample participants were instructed to report only the main behaviour they were engaged in as pilot work that allowed both a main and a secondary behaviour to be reported proved too burdensome for participants.

For each weekday, 44 time-samples were obtained (one every 15 min from 07.00 h to 08.45 h and from 15.00 h to 23.45 h). For the weekend day, 68 time-samples were obtained (one every 15 min from 07.00 h to 23.45 h). In ecological momentary assessment studies this recording schedule is referred to as “interval-contingent” because reports are made only at pre-specified times. The dense sampling strategy is also appropriate when the phenomena of interest can be brief, infrequent, and prone to natural variation (Stone and Shiffman 2002). In our study, we were interested in capturing sporadic behaviours (e.g., talking on the telephone) in addition to more enduring episodes of behaviour that follow predictable patterns (e.g., doing homework).

To assess the reliability of the ecological momentary assessment method, participants responded to a five-point categorical item estimating the average time lag between each interval prompt and actual diary entry (5, 15, 30, 60 or >60 min). Only 11% of respondents reported completing each diary entry within 5 min of the specified interval. Almost 15% (14.9%) reported completing the diary usually within 15 min, 17% within 30 min, 17.4% within 1 h and 39.7% usually greater than 1 h. This suggests that most participants relied on some degree of retrospective recall for recording their behaviour and the context in which it occurred but the duration of recall and subsequent effects of memory distortion are likely to be minimized using this method relative to other forms of recall self-reports (Smyth and Stone 2003).

Data Analysis

The behaviours were first coded into 23 categories (sleep, personal care, eating, at school, motorised travel, active travel, television/video watching, computer/internet use, computer games, sitting and talking, hanging out/shopping, listening to music, telephone, homework, reading (non-school), behavioural hobbies, cognitive hobbies, unstructured play, chores, paid work, sitting, sports or exercise, and other) derived inductively from our own focus group research about how English youth spend their free time. The categories are described more fully in Gorely et al. (in press). To estimate the time spent in each behaviour category the interval-level data were aggregated for each individual (separately by weekday and weekend day) by multiplying the daily frequency of the event by 15 (1 interval = 15 min). This makes an assumption that each episode of behaviour occurred for the entire 15 min of the sampling period. Although this may not always be true, underestimation and overestimation errors are assumed to cancel out in interval-contingent sampling schedules and, when aggregated across the day or class, yield valid

estimates of duration (Heath et al. 2006; Saudargas and Zanolli 1990). The weekday data and weekend data were then aggregated to produce a weighted mean for each behaviour, in min day^{-1} .

A cluster analysis was employed to identify groups of adolescents with similar patterns of leisure-time behaviour. Because cluster analysis is very sensitive to the cluster variates employed (Hair et al. 2006), a decision on whether a behaviour was included in the analysis was made based on (i) at least 10% of the sample reporting a behaviour, and (ii) the mean duration of a behaviour/group of behaviours being at least 15 min. Behaviours of very short mean duration or low prevalence were excluded as they were considered unlikely to be meaningful targets in the promotion of active lifestyles. Some conceptually similar behaviours were grouped together. The behaviours included in the analysis were: television/video viewing, computer use (computer games + computer or internet use), sports/exercise, socialising behaviours (hanging out + sitting and talking + phone), homework, and working (paid work + chores).

To reduce the influence of outliers, observations that exceeded 3.29 standard deviations from the mean were omitted as univariate outliers (Field 2005). Multivariate outliers were identified using Mahalanobis distance. All potential multivariate outliers were also univariate outliers. The proportion of total cases excluded was 6.6% ($n = 37$) for boys and 7.4% ($n = 65$) for girls. Analyses of excluded data revealed no differences for grade or ethnicity. The final sample was 484 boys and 785 girls.

A two stage cluster analysis was conducted following the recommendations of Hair et al. (2006). In the first stage, an agglomerative hierarchical cluster analysis (using Ward's method with squared Euclidean distance) was performed to determine the potential number of clusters within the data set and to identify the seeds (i.e., starting points) for each cluster centre at the second stage, a non-hierarchical k-means cluster analysis. All analyses were run on standardised scores (i.e., z scores) to further reduce the effect of outliers. The number of clusters were chosen based on the percentage change in the agglomeration coefficient at each step, visual inspection of the dendrogram, and conceptual considerations. Similarities between the final cluster centroid values and cluster sizes and initial cluster centroid values and cluster size were compared as a measure of confidence for the number of clusters chosen. The stability of the solution was tested by comparing the final k-means solution with one generated using random seed points (Hair et al. 2006). Once a consistent cluster solution was identified discriminant function analysis was used to examine cluster profiles on key explanatory variables.

Results

Table 1 presents the correlation matrix for the five sedentary behaviours and sports/exercise for boys and girls. All correlations were generally low with no correlations greater than ± 0.3. Variance inflation factors, which provide evidence of multicollinearity, were all less than 10 (range: boys 1.08–1.41; girls 1.04–1.35), suggesting that associations were unlikely to influence the clustering procedure.

Cluster Analyses

The initial cluster analyses for boys and girls suggested that ‘working’ in boys, and ‘computer use’ in girls, were not distinctive variables across the derived clusters and the decision was made to remove these variables (Hair et al. 2006) and respecify the analysis. From the subsequent two-stage analyses, five-cluster solutions emerged as tenable for both boys and girls to explain the grouping of sedentary behaviours and physical activity. Figures 1 and 2 show the cluster profile for boys and girls expressed in standardised scores. A z-score of ±0.5 was the criterion chosen to represent distinguishing characteristics within each cluster (Marshall et al. 2002). Table 2 shows the raw scores for each behaviour in mean minutes per day for each cluster. This table also shows the frequency counts of those reaching criterion levels for the two behaviours, physical activity (sports + active travel) and television viewing, where there are published guidelines/recommendations.

Boys. Boys in cluster 1 ($n = 93, 19.2\%$) are characterised by high levels of homework ($z = 1.35, 118 \text{ min day}^{-1}$) and a trend towards below average levels of television/

video viewing ($z = -.43, 114 \text{ min day}^{-1}$). A quarter (24.7%) of the boys meet the physical activity recommendation of 1 h per day (although this figure may be higher if activity during the school day had also been assessed). Half the boys (51.6%) watched less than 2 h of television/videos per day and very few (1.1%) watched more than 4 h. Based on this description this cluster was labelled ‘sedentary homeworkers’.

Cluster 2 ($n = 97, 20\%$) comprised boys who, compared to their peers, reported high levels of socialising behaviours ($z = 1.17, 120 \text{ min day}^{-1}$) and below average levels of television/video viewing ($z = -.54, 106 \text{ min day}^{-1}$). Almost half of the boys (48.5%) meet the physical activity recommendation of 1 h per day. The majority (61.9%) of the boys watched less than 2 h of television/videos per day and none watched more than 4 h. This cluster was labelled ‘semi-active socialisers’.

Cluster 3 ($n = 144, 30.1\%$) comprised boys whose leisure time was dominated by high levels of television/video viewing ($z = 1.03, 222 \text{ min day}^{-1}$) and a trend towards low levels of sports ($z = -.43, 22.6 \text{ min day}^{-1}$). About a quarter of the boys (26.4%) meet the physical activity recommendation of 1 h per day. Very few (2.1%) boys watched less than 2 h of television/videos per day but 34% watched more than 4 h. This cluster was labelled ‘sedentary television watchers’.

Cluster 4 ($n = 75, 15.4\%$) comprised boys who, compared to their peers, report high levels of sports ($z = 1.52, 127 \text{ min day}^{-1}$) and a trend towards lower levels of socialising ($z = -.44, 28 \text{ min day}^{-1}$). Almost all of the boys (98.7%) meet the physical activity recommendation of 1 h per day. Approximately half (53.3%) watched less than 2 h of television/videos per day and only 4% watched more than 4 h. This cluster was labelled ‘actives’.

Table 1 Correlation matrix for selected sedentary behaviours and physical activity for boys and girls

Variable	2	3	4	5	6
<i>Boys</i>					
1. Computer use	-.14	-.10	-.02	-.12	-.08
2. Socialising behaviours	1.00	.04	-.17	-.21	-.05
3. Working		1.00	-.10	-.11	-.08
4. Television/video viewing			1.00	-.19	-.16
5. Homework				1.00	-.16
6. Sports					1.00
<i>Girls</i>					
1. Computer use	-.04	.01	.04	-.11	-.03
2. Socialising behaviours	1.00	-.14	-.17	-.30	-.16
3. Working		1.00	-.01	-.04	-.08
4. Television/video viewing			1.00	-.13	-.20
5. Homework				1.00	-.02
6. Sports					1.00

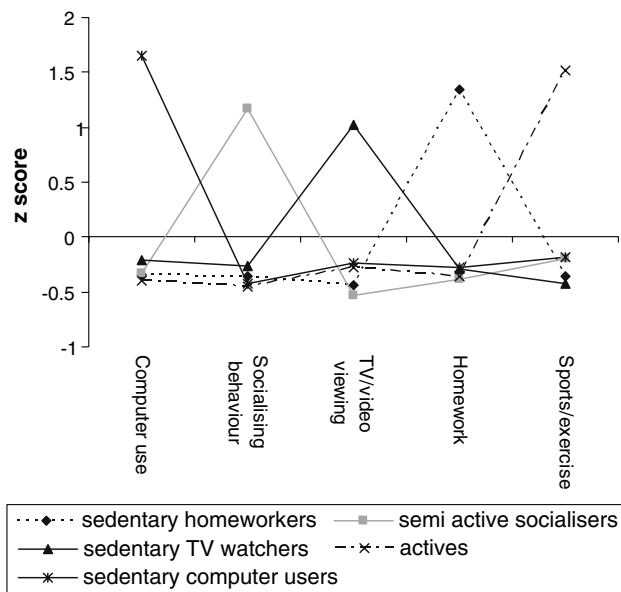


Fig. 1 Standard scores of cluster centroids on sedentary behaviour and sports/exercise among boys

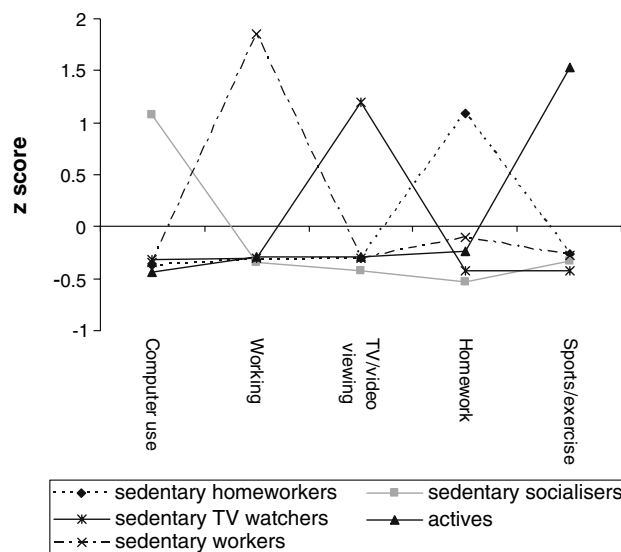


Fig. 2 Standard scores of cluster centroids on sedentary behaviour and sports/exercise among girls

Cluster 5 ($n = 75$, 15.4%) comprised boys who, compared to their peers, report high levels of computer use ($z = 1.66$, 149 min day⁻¹) and a trend towards lower levels of socialising ($z = -0.42$, 30 min day⁻¹). Two fifths of the boys (42.7%) met the physical activity recommendation of 1 h per day. Approximately half (53.3%) watched less than 2 h of television per day and only 5.3% watched more than 4 h. This cluster was labelled ‘sedentary computer users’.

Girls. Girls in cluster 1 ($n = 198$, 25.2%) are characterised by above average levels of homework ($z = 1.09$, 102 min day⁻¹) and a trend towards lower levels of

socialising ($z = -0.38$, 66 min day⁻¹). Only 13.6% of the girls meet the physical activity recommendation of 1 h per day. The majority (69.7%) of girls watched less than 2 h of television/videos per day and none watched more than 4 h. Based on this description this cluster was labelled ‘sedentary homeworkers’.

Cluster 2 ($n = 206$, 26.4%) comprised girls whose leisure time behaviour was dominated by socialising behaviours ($z = 1.07$, 154 min day⁻¹). These girls also reported lower than average levels of homework ($z = -0.53$, 35.5 min day⁻¹) and a trend towards lower levels of television/video viewing ($z = -0.43$, 91 min day⁻¹). One-fifth (20.4%) of the girls met the physical activity recommendation of 1 h per day. Most girls (74.3%) watched less than 2 h of television/videos per day and none watched more than 4 h. This cluster was labelled ‘sedentary socialisers’.

Cluster 3 ($n = 181$, 23.1%) comprised girls whose leisure time was dominated by high levels of television/video viewing ($z = 1.20$, 190.9 min day⁻¹) and a trend towards lower levels of homework ($z = -0.42$, 40.1 min day⁻¹) and sports/exercise ($z = -0.42$, 9.2 min day⁻¹). Only 8.3% of the girls met the physical activity recommendation of 1 h per day. The majority (81.8%) of the girls watched between 2 and 4 h of television/videos per day and 14.9% watched more than 4 h. This cluster was labelled ‘sedentary television watchers’.

Cluster 4 ($n = 114$, 14.5%) comprised girls who, compared to their peers, reported high levels of sport/exercise ($z = 1.54$, 75 min day⁻¹) and a trend towards lower levels of socialising behaviours ($z = -0.43$, 62.3 min day⁻¹). Almost all girls in cluster 3 (88.6%) meet the physical activity recommendation of 1 h per day. The majority of girls (70.2%) watched less than 2 h of television/videos per day and none watched more than 4 h. This cluster was labelled ‘actives’.

Cluster 5 ($n = 86$, 11%) comprised girls who, compared to their peers, reported above average levels of working ($z = 1.86$, 101 min day⁻¹). Only 17.4% of the girls met the physical activity recommendation of 1 h per day. Most girls (69.8%) watched less than 2 h of television/videos per day and none watched more than 4 h. This cluster was labelled ‘sedentary workers’.

Discriminant Function Analyses

Discriminant function analyses were conducted to establish whether there were differences between the clusters on selected explanatory variables. Discriminant function analysis requires that each group should have a unique profile on the independent variables used and it is recommended that the most appropriate independent variables are those that differ across at least two groups (Tabachnick and

Table 2 Average time (min/day) in leisure time behaviours and proportion achieving guidelines for physical activity and television/video viewing between clusters for boys and girls

Boys cluster	Computer use	Socialising behaviours	TV/video viewing	Homework	Sports/exercise	% reaching PA guideline ^a	% watching TV/video <2 h/day	% watching TV/video ≥4 h/day
1 Sedentary homeworkers	34.7	32.9	113.6	117.9	26.1	24.7	51.6	1.1
2 Semi-active socialisers	35.2	119.9	105.7	36.1	34.9	48.5	61.9	0
3 Sedentary TV watchers	42.1	38.4	222.3	40.0	22.6	26.4	2.1	34.0
4 Actives	31.6	28.2	125.1	37.1	127.0	98.7	53.3	4.0
5 Sedentary computer users	148.5	29.7	128.2	41.0	35.6	42.7	53.3	5.3

Girls cluster	Working	Socialising behaviours	TV/video viewing	Homework	Sports/exercise			
1 Sedentary homeworkers	12.0	65.8	98.5	102.0	14.4	13.6	69.7	0
2 Sedentary socialisers	10.9	153.8	90.9	35.5	12.2	20.4	74.3	0
3 Sedentary TV watchers	12.6	69.5	190.9	40.1	9.2	8.3	3.3	14.9
4 Actives	13.1	62.3	99.1	47.8	75.3	88.6	70.2	0
5 Sedentary workers	101.1	67.9	98.1	53.2	13.9	17.4	69.8	0

^a 1 h of physical activity per day. Physical activity = sports & exercise plus active travel (does not include activity during the school day)

Fidell 2007). The original set of variables was therefore investigated using one-way ANOVA or χ^2 to establish that this criteria was met (p was set at 0.1 to avoid premature removal of potentially important discriminators). The results of these preliminary investigations showed that for boys only % time inside, % time with friends, age, and ethnicity were different between at least two clusters. These four variables were therefore carried forward to the discriminant analysis. For girls, the variables carried forward were % time with friends, % time inside, ethnicity, age, and technology density.

Nine cases (1.9%) in boys and 53 (6.7%) in girls had missing data on at least one variable and were dropped from the analyses (Tabachnick and Fidell 2007). Missing data appeared to be randomly scattered throughout groups. A further four cases (0.8%) for boys and 25 cases (3.4%) for girls were dropped as either univariate or multivariate outliers. For the remaining 471 boys and 707 girls, evaluation of the multivariate assumptions suggested no threat to multivariate analysis. The final samples were randomly divided into an analysis sample (~60%) and a hold-out validation sample (~40%).

Boys. Using the analysis sample, four discriminant functions were calculated, with a combined $\chi^2 = 133.68$

($df = 16$), $p < .05$, effect size (partial n^2) = 0.16. However, only the first three significantly contributed to discrimination between the clusters. The three functions accounted for about 29%, 9% and 6% of the total relationship between predictors and clusters. The three discriminant functions accounted for 71.6%, 17.2% and 10.3%, respectively, of the between group variability. As can be seen from the group centroids for the three discriminant functions (Table 3), the first discriminant function maximally separates cluster 4 (actives) from clusters 1 (sedentary homeworkers), 3 (sedentary television watchers) and 5 (sedentary computer users), with cluster 2 (semi-active socialisers) falling in between. The second discriminant function discriminates cluster 1 (sedentary homeworkers) from clusters 3 (sedentary television watchers) and 5 (sedentary computer users). The third discriminant function discriminates between cluster 2 (semi-active socialisers) and cluster 4 (actives).

The structure (loading) matrix of correlations between predictors and discriminant functions (Table 4) suggests that the best predictors for distinguishing between ‘actives’ and ‘sedentary homeworkers’, ‘sedentary television watchers’ and ‘sedentary computer users’ (function 1), are % time spent inside and % time spent with friends. Active boys spend less time inside (mean % = 74.1) than sedentary

Table 3 Group centroids by cluster for boys and girls

Cluster	Function		
	1	2	3
<i>Boys</i>			
1 Sedentary homeworkers	.49	.59	-.19
2 Semi-active socialisers	-.61	.21	.34
3 Sedentary television watchers	.42	-.25	-.11
4 Actives	-1.23	-.14	-.30
5 Sedentary computer users	.38	-.21	.28
<i>Girls</i>			
1 Sedentary homeworkers	-.56	.33	-.12
2 Sedentary socialisers	.66	.08	-.11
3 Sedentary television watchers	-.33	-.52	.00
4 Actives	.49	-.06	.04
5 Sedentary workers	-.03	.25	.57

Table 4 Structure (loading) matrix by discriminant function for boys and girls^a

Variable	Function		
	1	2	3
<i>Boys</i>			
% time inside	.95	.09	.16
Ethnicity	.18	.73	-.54
% time with friends	-.56	.34	.65
Age	.04	.61	.26
<i>Girls</i>			
% time inside	-.81	-.11	.01
% time with friends	.68	.32	-.27
Age	-.04	.82	.47
Ethnicity	.27	-.33	.76
Technology density	.16	-.53	.17

^a Values below 0.4 are not interpreted (Hair et al. 2006)

homeworkers (mean % = 90.1), sedentary television watchers (mean % = 88.8), and sedentary computer users (mean % = 89.4). Active boys spend more time with friends (mean % = 30.8) than sedentary homeworkers (mean % = 21.5), sedentary television watchers (mean % = 18.1), and sedentary computer users (mean % = 23.4). The results suggest that the best predictors for distinguishing between ‘sedentary homeworkers’ and ‘sedentary television watchers’ or ‘sedentary computer users’ (function 2) are ethnicity and age. Specifically ‘sedentary homeworkers’ were older and more likely to be from ethnic minorities. Distinguishing between ‘sedentary socialisers’ and ‘actives’ appears to be best done on the basis of ethnicity and % time spent with friends. Specifically ‘sedentary socialisers’ are less likely to be from ethnic minorities (9.6% cf. 10.5%) and to spend more time with their friends (32.9% cf. 30.8%). Loadings less than 0.40 are not interpreted (Hair et al. 2006).

Classification rates from the functions were significantly larger than those expected by chance in both the original (41.5%) and hold out (38.7%) samples using the propor-

tional chance criterion (Hair et al. 2006) and Press’s Q statistic (original sample $Q = 78.91$, $p < .01$; holdout sample $Q = 43.46$, $p < .01$). However, when examining the hit rates of individual groups it emerges that clusters 1 (sedentary homeworkers), 2 (sedentary socialisers) and 5 (sedentary computer users) fall below the threshold hit ratios in at least one classification approach suggesting that they should be the focus of improving classification, possibly by the addition of independent variables (Hair et al. 2006).

Girls. Using the analysis sample four discriminant functions were calculated, with a combined $\chi^2 = 159.07$ ($df = 20$), $p < .05$ effect size (partial n^2) = 0.12. However, only the first three significantly contributed to discrimination between the clusters. The three functions accounted for about 20%, 10% and 4% of the total relationship between predictors and clusters. The three discriminant functions accounted for 62.2%, 25.3% and 9.3%, respectively, of the between group variability. As can be seen from the group centroids for the three discriminant functions (Table 3) the

first discriminant function maximally separates clusters 2 (sedentary socialisers) and 4 (actives) from clusters 1 (sedentary homeworkers) and 3 (sedentary television watchers). The second discriminant function discriminates cluster 1 (sedentary homeworkers) from cluster 3 (sedentary television watchers). The third discriminant function discriminates between clusters 1 (sedentary homeworkers) and 2 (sedentary socialisers) and cluster 5 (sedentary workers).

The structure (loading) matrix of correlations between predictors and discriminant functions (Table 4), suggests that the best predictors for distinguishing between ‘sedentary socialisers’ or ‘actives’ and ‘sedentary homeworkers’ or ‘sedentary television watchers’ are % time spent inside and % time spent with friends. ‘Sedentary socialisers’ and ‘actives’ spend less time inside (mean % = 85.7 and 83.2 respectively), and more time with their friends (mean % = 34.3 and 28.0 respectively), than ‘sedentary homeworkers’ or ‘sedentary television watchers’ (% time inside: mean % = 91.9 and 91.4; % time with friends mean % = 24.6 and 20.8 respectively). The results suggest that the best predictors for distinguishing between ‘sedentary homeworkers’ and ‘sedentary television watchers’ are age and technology density in the home. Specifically ‘sedentary homeworkers’ were older (14.8 cf. 14.4 years) and had less technology per household room (1.0 cf. 1.3). Distinguishing between ‘sedentary workers’ and ‘sedentary homeworkers’ or ‘sedentary socialisers’ appears to be best done on the basis of age and ethnicity. Specifically ‘sedentary workers’ are less likely to be from ethnic minorities (3.6% cf. 20.6% and 13.3% respectively), and are older (15.1 years cf. 14.8 and 14.7 years respectively).

Classification rates from the functions were significantly larger than those expected by chance in both the original (41.5%) and hold out (38.7%) samples using the proportional chance criterion (Hair et al. 2006) and Press’s Q statistic (original sample $Q = 124.27$, $p < .01$; holdout sample $Q = 47.29$, $p < .01$). When examining the hit rates of individual groups it emerges that cluster 4 ‘actives’ and cluster 5 ‘sedentary workers’ fall below the threshold hit ratios suggesting that these two groups should be the focus of improving classification, possibly by the addition of independent variables (Hair et al. 2006).

Discussion

The present results confirm that young people engage in a variety of leisure time behaviours, the majority of which are sedentary. The low intercorrelations between sedentary behaviours demonstrate again that youth sedentariness is complex and is unlikely to be accurately represented by one behaviour (e.g., television viewing) (Marshall et al.

2002). Although their lifestyles are multifaceted, the results of the cluster analysis show that adolescents have one activity that predominates within their lifestyle. This suggests the potential need for different behavioural targets in interventions to reduce sedentary behaviour in sub groups of the adolescent population.

In only a small proportion of adolescents is sports and exercise the leading leisure-time pursuit and few outside the ‘active’ cluster are likely to be sufficiently active. This is especially true for girls. Understanding why adolescents in these other clusters prefer sedentary behaviours, what needs they serve for them, and whether these needs could still be met within a more active context will be important as we attempt to facilitate more active lifestyles within adolescents.

On average television/video viewing takes up at least an hour and a half per day in all clusters, but very few boys and no girls outside the ‘sedentary television watchers’ clusters would be considered to engage in excessive levels of television viewing (>4 h/day; American Academy of Pediatrics 2001). Even within the ‘sedentary television watchers’ clusters, the majority watch between 2 and 4 h a day, with only 34% of boys and 15% of girls in these clusters exceeding 4 h per day. These findings suggest that for a significant proportion of children, television viewing may not be considered problematic, though as part of an overall lifestyle television makes a substantial contribution to the time spent being sedentary, particularly in light of the time available once school is taken out of the day. From a public health perspective, reducing the time spent in television across the whole adolescent population could have a meaningful effect on total sedentary time providing that this television time is replaced by something more active and not simply replaced by more time spent on their other most favoured sedentary activity. Having said that, targeting a reduction in *multiple* sedentary behaviours is likely to be most efficient because it would reach more individuals by drawing attention to a class of behaviours which they engage in, rather than simply one behaviour which may not be of importance to them. In fact the most effective strategies are likely to be those that encourage both a reduction in a broad range of sedentary behaviour and an increase in physical activity (Summerbell et al. 2004). Effectiveness may also be enhanced by targeting a reduction in sedentary behaviours at times of the day when they are most likely to compete with active behaviours (e.g., in the hours immediately after school). The importance of such temporal targeting is implicit within the recent Australian Government guidelines for a limit of 2-h of screen-based sedentary behaviours during daylight hours (Australian Department of Health and Ageing 2005).

Similar to previous findings with children (Sallis et al. 2000), the discriminant function analysis demonstrated that

active adolescents spend more time outside and more time with friends than their sedentary counterparts (except the ‘sedentary socialisers’ in girls). Being inside, as one might expect, appears to restrict physical activity and provides a greater opportunity to engage in a range of sedentary behaviours. These findings suggest that a social, outdoor behavioural setting may result in more physical activity among adolescents, thus interventions may need to account for this by providing appropriately supportive environments. Demographic correlates did not discriminate the active clusters from the sedentary clusters, but age and ethnicity did discriminate between sedentary clusters partially supporting the results of Gordon-Larson et al. (2000) who found socio-demographic variables (ethnicity and socio-economic status) to be the strongest correlates of screen-based sedentary behaviour. Socio-economic status is also a correlate of television viewing in youth (Gorely et al. 2004).

Although we assessed a range of potential explanatory variables only a few actually provided any discriminatory power between clusters. While the emergent discriminant functions correctly classified people overall at a rate better than chance, there is a need for more work examining the correlates of the different adolescent lifestyles. Careful consideration must be given to the social and physical environmental factors which potentially impact on each lifestyle (Gordon-Larsen et al. 2000). Availability of screen-based technology within the home was only important in discriminating between ‘sedentary homeworkers’ and ‘sedentary television watchers’ in girls. Could it be that some things in the environment are so pervasive that they no longer exert a strong influence on behaviour? Perhaps what is needed is a better understanding of why some young people ignore particular stimuli within a behavioural setting and others do not. Addressing this issue will likely involve the understanding of behavioural preferences and needs within individuals.

Although ecological momentary assessment offers benefits in terms of its ability to capture a range of behaviours, it remains a self-report approach with the potential for socially desirable responses, it is time consuming and places a higher burden on respondents compared with retrospective recalls. Also individuals with psychological or behavioural problems, or with low literacy, may be less able to understand diary instructions or comply with the recording schedule (Dunton et al. 2005). There is potential for interval-contingent sampling to cause a systematic bias in either overestimation or underestimation of behaviour. While our own unpublished pilot work suggests this may be true for behaviours only of very short duration (e.g., cleaning teeth) which are not the focus of this paper, there is a lack of published evidence to fully support our assumptions. Although we have an estimate of how close to the 15 min reporting schedule the participants responded,

and these appear believable, it is not possible to know the true compliance with the schedule in the pencil-and-paper diaries employed (Smyth and Stone 2003). Deviation from the diary schedule may influence the validity of reports as the effects of memory bias will be introduced. New technologies (e.g., palm-top computers, electronic diaries and mobile phones) allow time-stamping of records and are recommended for future studies, however, the practicalities of using these in large studies need to be addressed (Smyth and Stone 2003). Intensity of behaviours was not assessed, as the focus of the study was the frequency and duration of behaviour, and this is acknowledged as a limitation when discussing physical activity outcomes. Notwithstanding these limitations of the ecological momentary assessment diary, the method also provides extensive rich data not available through most other methods.

A potential limitation relates to the sampling design employed which creates dependency within the data (e.g., compared to children from a different school (or class), children from the same school (or class) are more likely to be similar to one another in behaviour as they share the same school environment, teachers and group norms). However, even for behaviours performed at school research suggests that the school level intra-class correlation is very small (Murray et al. 2004) and because we only measured behaviour outside of school we expect the school level intra-class correlation to be even smaller. Different compliance rates across schools may have influenced results. The explanatory variables employed failed to shed much light on characteristics of young people with different lifestyles. This could be due to measurement error and a lack of variability in responses, however more research is needed to characterise individuals engaging in different lifestyles.

In summary, the present study confirms that young people have multi-faceted lives that largely involve sedentary behaviours. It represents an initial step in understanding how various behaviours blend together to form overall active or sedentary lifestyles. Understanding the components of ‘overall’ lifestyles is likely to lead to the development of interventions and strategies that promote more effective and sustainable behaviour change (Nelson et al. 2005). However, further research is required to examine the modifiable determinants of different sedentary lifestyles among young people.

References

- American Academy of Pediatrics (2001). Policy statement: Children, adolescents and television (RE0043). *Pediatrics*, 107(2), 423–426.
- Baranowski, T. (1985). Methodologic issues in self-report of health behavior. *Journal of School Health*, 55(5), 179–182.
- Department for Education and Skills (2004). Statistics of education: Schools in England 2004 edition. Retrieved 26 July 2005 from

- http://www.dfes.gov.uk/rsgateway/DB/VOL/v000495/schools_04_final.pdf
- Department of Health (2004). At least five a week: Evidence of the impact of physical activity and its relationship to health. A report from the Chief Medical Officer. Retrieved from <http://www.dh.gov.uk/PublicationsAndStatistics/Publications/PublicationsLibrary/fs/en>
- Department of Health and Ageing (2005). Australia's physical activity recommendations for children and young people. Retrieved 19 September 2006 from <http://www.health.gov.au>
- Dunton, G., Whalen, C., Jamner, L., Henker, B., & Floro, J. (2005). Using ecologic momentary assessment to measure physical activity during adolescence. *American Journal of Preventive Medicine*, 29(4), 281–287.
- Epstein, L. H., & Roemmich, J. N. (2001). Reducing sedentary behaviour: Role in modifying physical activity. *Exercise and Sport Sciences Reviews*, 29, 103–108.
- Field, A. (2005). *Discovering statistics using SPSS* (2nd edn.). London: Sage.
- Gordon-Larsen, P., McMurray, R. G., & Popkin, B. M. (2000). Determinants of adolescent physical activity and inactivity patterns. *Pediatrics*, 105, 1–8.
- Gorely, T., Marshall, S., & Biddle, S. (2004). Correlates of TV viewing in adolescents. *International Journal of Behavioural Medicine*, 11, 152–163.
- Gorely, T., Marshall, S., Biddle, S., & Cameron, N. (in press). The prevalence of leisure time sedentary behaviour and physical activity in adolescent girls: An ecological momentary assessment approach. *International Journal of Pediatric Obesity*.
- Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2006). *Multivariate data analysis* (6th edn.). Upper Saddle River, NJ: Pearson Prentice Hall.
- Heath, E., Coleman, K., Lensegrav, T., & Fallon, J. (2006). Using momentary time sampling to estimate minutes of physical activity in physical education: Validation of scores for the system for observing fitness instruction time. *Research Quarterly for Exercise and Sport*, 77(1), 142–146.
- Henning Broderson, N., Steptoe, A., Williamson, S., & Wardle, J. (2005). Sociodemographic, developmental, environmental, and psychosocial correlates of physical activity and sedentary behavior at age 11 to 12. *Annals of Behavioral Medicine*, 29(1), 2–11.
- Marshall, S. J., Biddle, S. J. H., Sallis, J. F., McKenzie, T. L., & Conway, T. L. (2002). Clustering of sedentary behaviours and physical activity among youth: A cross-national study. *Pediatric Exercise Science*, 14, 401–417.
- Marshall, S., Gorely, T., & Biddle, S. (2006). A descriptive epidemiology of screen based media use among youth: A review and critique. *Journal of Adolescence*, 29, 333–349.
- Murray, D., Catellier, D., Hannan, P., Treuth, M., Stevens, J., Schmitz, K., Rice, J., & Conway, T. (2004). School-level intraclass correlation for physical activity in adolescent girls. *Medicine and Science in Sports and Exercise*, 36(5), 876–882.
- Nelson, M., Gordon-Larsen, P., Adair, L., & Popkin, B. M. (2005). Adolescent physical activity and sedentary behavior: Patterning and long-term maintenance. *American Journal of Preventive Medicine*, 28(3), 259–266.
- Sallis, J., & Owen, N. (2002). Ecological models of health behavior. In K. Glanz, B. Rimer, & F. Marcus Lewis (Eds.), *Health behavior and health education* (pp. 462–484). Jossey-Bass: San Francisco.
- Sallis, J., Prochaska, J., & Taylor, W. (2000). A review of correlates of physical activity of children and adolescents. *Medicine and Science in Sports and Exercise*, 32, 963–975.
- Saudargas, R. A., & Zanolli, K. (1990). Momentary time sampling as an estimate of percentage time: A field validation. *Journal of Applied Behavior Analysis*, 23, 533–537.
- Schmitz, K. H., Lytle, L. A., Phillips, G. A., Murray, D. M., Birbaum, A. S., & Kubik, M. Y. (2002). Psychosocial correlates of physical activity and sedentary leisure habits in young adolescents: The teens eating for energy at school study. *Preventive Medicine*, 34(2), 266–278.
- Smyth, J., & Stone, A. (2003). Ecological momentary assessment research in behavioral medicine. *Journal of Happiness Studies*, 4, 35–52.
- Stone, A., & Shiffman, S. (2002). Capturing self-report data: A proposal for reporting guidelines. *Annals of Behavioral Medicine*, 24(3), 236–243.
- Summerbell, C. D., Ashton, V., Campbell, K. J., Edmunds, L., Kelly, S., & Waters, E. (2004). *Interventions for treating obesity in children (Cochrane Review)*. Chichester: John Wiley.
- Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th edn.). Boston, MA: Pearson Allyn & Bacon.
- Welk, G., Corbin, C., & Dale, D. (2000). Measurement issues in the assessment of physical activity in children. *Research Quarterly for Exercise and Sport*, 71(2), 59–73.