Temporal and Environmental Patterns of Sedentary and Active Behaviors during Adolescents’ Leisure Time

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Abstract
Background There is great interest in young people’s overweight and obesity. Few data, however, describe when sedentary and physically active behaviors are likely to occur during the day or how these behaviors are related to location.

Purpose The purpose of this study was to describe sedentary and active leisure-time behaviors of adolescents across the day and setting.

Method Adolescents (male n=579, female n=967; aged 13–16 years) completed time-use diaries for three weekdays and one weekend day. At 15 min intervals, participants recorded what they were doing and where they were.

Results TV viewing and sports/exercise peaked at different times in the day, although TV viewing was two to three times more likely to occur than sports/exercise. TV viewing was most likely to occur during the middle to late evening. The playing of computer games was low, particularly for girls. Weekend data showed TV viewing was the most reported activity throughout the day. For boys, “being in the garden” was highly predictive of engaging in sports/exercise, but this declined rapidly with age. Motorized travel to school was reported twice as often as active travel.

Conclusion Momentary assessments of behavior, in conjunction with contemporaneous reports of environmental factors, describe important patterns of leisure-time active and sedentary behaviors in youth.

Keywords Computer use · Diary · Ecological momentary assessment · Sport and exercise · Time-use · TV viewing

Introduction
Trends in overweight and obesity in youth are often reported as direct consequences of decreased physical activity and increased sedentary behaviors, such as TV viewing [1]. Despite the high prevalence of TV viewing and the introduction of new technologies, the link between these sedentary behaviors and either physical activity or obesity in young people is the subject of much debate [2–6].

Sedentary behaviors are often thought to displace more physically active pursuits, yet the degree to which sedentary behaviors prohibit an active lifestyle in young people is equivocal [7, 8]. To better understand sedentary behaviors, it is important to investigate different sedentary pursuits alongside more active ones. Evidence to date has focussed on the incidence and prevalence of sedentary behavior when defined as a lack of physical activity or when using highly selective sedentary pursuits, such as TV viewing. Defining a sedentary lifestyle as an absence of physical activity fails to identify what people are actually doing while being sedentary, thus precluding an understanding of why these behaviors might occur. Equally, by studying sedentary behaviors in isolation, we may be misrepresenting what a sedentary or active lifestyle actually entails. Using aggregates of behavior masks the temporal and environmental context of each behavior, making it
difficult to draw accurate conclusions about specific behaviors occurring at specific time points and in specific contexts.

For these reasons, it is important to investigate when different behaviors (active and sedentary) occur throughout the time course of a day. In addition, the location occupied while behaviors are enacted is also important [9]. Investigating the environmental context alongside a temporal dimension is consistent with calls for the use of an ecological approach to health behaviors [10]. The purpose of this study, therefore, is to examine temporal patterns in sedentary and physically active behaviors and describe the settings in which these behaviors occur. The current study reports data from Project STIL—Sedentary Teenagers and Inactive Lifestyles.

Method

Sampling Design

Sampling took place across ten regions of England, one in Northern Ireland, three in Scotland, and one in Wales. The ten regions in England were sampled using Local Education Authorities (LEAs). Schools were randomly selected from each LEA. The aims and expectations of the study were outlined, and schools that agreed to take part were sent an evaluation form.

In phase 1 (March–June 2002 for England, Northern Ireland, and Wales; October–November 2002 for Scotland), one class from each of the Year (“Grade”) groups 9, 10, and 11 was chosen at random by a coordinator at the school, and each student within the chosen class was given a diary to complete in their free time.

In order to control for possible seasonal variations in behavior, a second phase of testing was carried out 6 months after phase 1. Phase 2 was September–January 2002/2003 in England, Northern Ireland, and Wales; February–May 2003 in Scotland. Each school returning phase 1 data was asked to select a second set of Year 9, 10, and 11 classes and repeat the study. It was stressed that phase 2 classes should not include any student who had previously returned data in phase 1.

Finally, a third (top-up) phase of testing was carried out 12 months after phase 2 in order to increase the sample size in regions where diary returns were low. Phase 3 took place in October–November 2003 in England, Northern Ireland, and Wales only. Schools selected for phase 3 had not previously been approached to take part in the study and therefore did not include anyone who had completed phases 1 or 2. Ethical clearance was obtained from the first author’s university.

Participants

Of the 1,604 participants who returned diaries, 62% were girls, reflecting a gender bias ($\chi^2=84.92, df=1, p<0.01$). Of the returned diaries, girls were more likely to provide complete data ($\chi^2, (n=1,612)=21.61, p=0.0001$). Sixty-two 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 ($\chi^2 (1, n=1,612)=17.23, p=0.0001$), 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 a response rate 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, for Project STIL, 5,400 surveys were sent to 45 schools. If all surveys were distributed at all schools, the overall response rate for boys and girls was 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. The conditions of our ethical clearance did not allow us to collect information about those who were eligible but chose not to participate. For this reason, it is not known whether nonparticipants differed from participants.

The final sample comprised 1,493 participants, of which 85% completed all 4 days of assessment, with the remaining 3%, 4%, and 7% completing 1, 2, and 3 days of diary assessment, respectively. Table 1 presents the demographic characteristics of the final sample, and Fig. 1 shows a participant inclusion hierarchy.

Instrumentation: Ecological Momentary Assessment Diary

Participants completed a self-report diary of “free time” outside of school hours. Because the focus of our study involved behaviors that could be regarded as “volitional,” behaviors in school were not assessed. The self-report diary is based on principles of ecological momentary assessment (EMA) and allowed for the recording of behaviors and locations that young people engage in each day [9].

Participants were instructed to complete the diary for four randomly assigned days (three weekdays and one weekend day). At 15-min intervals, participants wrote down their main behavior in response to a single item: “What are you doing now?” At each interval, participants also responded to the closed-response item of “Where are you?” Participants selected one location from a list of 12. For each weekday, 44 time samples were obtained (one every 15 min from 0700 to 0845 hours and from 1500 to 2345 hours). For the weekend day, 68 time samples were obtained (one every 15 min from 0700 to 2345 hours).
behaviors were coded into 22 mutually exclusive categories. These were derived from our own focus group research data with teenagers concerning how English youth spend their free time. To estimate the time spent in each behavior category, at each location, 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 (one interval = 15 min). The data were then aggregated further to produce a mean, in minutes per day. The outcome variables for all analyses are minutes per day engaged in 22 categories of behavior, in 13 locations, as shown in Table 2. The percentage of behavioral reports was calculated for each behavior at each time period and location. Descriptive data are provided to meet the purpose of the study, that is, to describe patterns of behaviors across the day. Results are analyzed and reported separately for weekdays and weekend days because they have different structures and are likely to lead to different behavioral choices. Gender- and age-specific data are also reported because prior evidence suggests that they are important moderators of physical activity [8] and sedentary behaviors [5, 11]. For clarity, behaviors are organized into the following categories: travel (motorized and active), sports/exercise (physical activity excluding active travel), technology-based sedentary behaviors (TV viewing, computer use, computer/internet), socializing sedentary behaviors (talking with friends/family, hanging out, on telephone), and homework. Other behaviors assessed included hobbies, non-school reading, unstructured play, and paid work.

**Data Analysis** Behaviors were coded into 22 mutually exclusive categories. These were derived from our own focus group research data with teenagers concerning how English youth spend their free time. To estimate the time spent in each behavior category, at each location, 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 (one interval = 15 min). The data were then aggregated further to produce a mean, in minutes per day. The outcome variables for all analyses are minutes per day engaged in 22 categories of behavior, in 13 locations, as shown in Table 2. The percentage of behavioral reports was calculated for each behavior at each time period and location. Descriptive data are provided to meet the purpose of the study, that is, to describe patterns of behaviors across the day. Results are analyzed and reported separately for weekdays and weekend days because they have different structures and are likely to lead to different behavioral choices. Gender- and age-specific data are also reported because prior evidence suggests that they are important moderators of physical activity [8] and sedentary behaviors [5, 11]. For clarity, behaviors are organized into the following categories: travel (motorized and active), sports/exercise (physical activity excluding active travel), technology-based sedentary behaviors (TV viewing, computer use, computer/internet), socializing sedentary behaviors (talking with friends/family, hanging out, on telephone), and homework. Other behaviors assessed included hobbies, non-school reading, unstructured play, and paid work.

**Results**

Temporal Patterns in Free-Time Behavior

*Weekday* For each 15-min interval, the frequency of each behavior was computed. These data represent the percentage of behaviors occurring at that time period, thus results reported are necessarily descriptive.

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**Table 1** Demographic characteristics of the sample

<table>
<thead>
<tr>
<th>Gender</th>
<th>Number</th>
<th>Percent</th>
<th>Mean</th>
<th>SD</th>
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<tr>
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<td>385</td>
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<tr>
<td>Year 11</td>
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<td>15.8</td>
<td>0.51</td>
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</tbody>
</table>

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**Fig. 1** Participant inclusion hierarchy

![Participant inclusion hierarchy](image-url)
Motorized transport was most common before school for both boys (37% of occurrences at 0815 hours) and girls (40%). At 0830 hours, active travel comprised 15% of all behaviors reported. Motorized travel in the early morning peak was more than double that of active travel. During the immediate after-school period (1530 to 1615 hours), reports of motorized transport were fewer than before school. Active travel during the after-school period showed a small increase, suggesting that many pupils are within walking distance of school but are more likely to be driven there in the morning.

Reports of sports/exercise peaked in the early evening, whereas TV/video viewing peaked much later. At 2130 hours, boys reported watching TV more than at any other time (44% of all reports). For girls, viewing peaked at 2145 hours (31%). These data suggest that TV and sports/exercise are more likely to occur at different times of the day, thus reducing, but not eliminating, the likely competition between them.

The playing of computer games by boys was fairly consistent across the evening hours, although it comprised only 5–8% of behaviors for each time period between 1630 and 1900 hours, 16–20% of behaviors for boys and 11–23% for girls was homework, with peaks for boys at 1645 hours (20.5%) and for girls at 1915 hours (23.4%). For socializing sedentary behaviors, occurrences were quite low with the exception of talking with friends before school. This peaked at 0845 hours with 15% of behavioral reports for boys and 16% for girls. In the evening, talking and phoning had a smaller occurrence for girls, whereas this was quite unlikely for boys, who preferred socializing (“hanging out”) with friends. Overall, these behaviors were

![Fig. 2 Occurrences of technology-based sedentary behaviors and sports/exercise by boys during weekdays](Image)
much less likely to occur in comparison to TV viewing, homework, and sports/exercise.

Regarding age trends, boys in Year 9 had fewer reports of motorized travel at 0815 hours but had a higher peak of TV viewing later in the evening than those in Year 11. This latter finding was partly explained by the older boys taking part in more diverse behaviors. Younger boys did not differ from older boys in their weekday sports/exercise, but older girls showed less involvement than their younger counterparts. Although travel patterns were similar between Year 9 and 11 girls, the older girls had a higher number of reports showing use of the internet in the middle of the evening.

Weekend patterns were more varied than during a school weekday. For boys, sports/exercise accounted for 10–16% of behaviors during the day, whereas for girls this reached only 5–7%. Concerning technology-based sedentary behaviors, 26% of behaviors for boys in the evening, peaking at 40% at 2030 hours, were TV viewing. Girls had 30% of behaviors as TV viewing between 2015 and 2200 hours, but their use of the computer was low. Both boys and girls demonstrated a propensity for morning TV at weekends.

Consistent with prior research on sedentary behaviors in youth [7], girls reported more socializing sedentary behaviors than boys. “Hanging out” with friends accounted for 24–25% of behaviors between 1400 and 1500 hours for girls.

Age differences were evident such that boys in Year 9 were more likely than those in Year 11 to be watching TV, especially in the evening (peaking at 45% at 2100 hours). Similarly, girls in Year 9 watched more TV in the evening than those in Year 11. Younger boys showed slightly more sport and computer game behaviors than their older counterparts. Younger girls reported more occurrences of sports/exercise throughout the day than older girls.

The Location of Free-Time Behavior

Environmental factors may prompt or facilitate some active or sedentary behaviors, while others may act as inhibitors [12]; thus, it is important to assess the environmental context of behaviors [9]. We calculated the percentage of behaviors occurring at each location.

Weekday Results showed that during a weekday, if in the communal living room of their house, 71% of behaviors for boys and 67% for girls was watching TV, showing this location to be highly predictive of this sedentary behavior. Having a TV in one’s bedroom has been identified as a predictor of higher TV viewing [13]. For those with TVs in their bedroom, 18% of behaviors in this location for girls and 28% for boys was watching TV.

For physically active pursuits, locations outside of the house were important, as shown in Fig. 4. Gender differences are striking with boys much more likely than girls to report physical activity when they were outside. When in the garden/yard, for example, girls played some sport (35% of reports) but also engaged in behavioral hobbies (23%) and unstructured play (16%), only some of which are likely to be physically active. Conversely, boys predominantly used the garden/yard for sport (69% of reports) and unstructured play (15%). Strong age trends also emerged for physical activity in the garden/yard (see Fig. 5).

Weekend Results for the weekend showed that, if in the living room, 72% of behaviors for boys and 68% for girls was TV viewing. Figures were slightly higher for boys in
Year 9 (75%) compared with those in Year 11 (69%), whereas for girls, age differences were not evident. We found that 24% of behaviors in one’s bedroom were TV viewing for girls and 32% for boys when analyzing data for those who had TVs in their bedroom. This was higher for boys in Year 9 (36%) than Year 11 (30%) and for girls in Year 9 (24%) than Year 11 (16%). Participation in sports/exercise by key locations is shown in Fig. 4.

Discussion

The purpose of this study was to further the understanding of sedentary and physically active behaviors of young people by describing trends across time of day and location. This will help (a) identify whether sedentary and active behaviors can coexist within the “lifestyle” of a young person, and (b) identify environmental settings that are most likely to be associated with specific behaviors.

Temporal Dimension

Overall, it is clear from our data (see Figs. 2 and 3) that both active and sedentary behaviors have temporal features that may be important for understanding why young people choose some behaviors over others. In addition, evidence shows that some behaviors compete for similar time periods, while others may be able to coexist to some extent.

For weekdays, there is a greater likelihood that motorized travel will occur in place of active travel before school. These behaviors directly compete against each other as young people must travel to school by some mode of transport. Therefore, for the same time period and notwithstanding that some young people live too far from school to walk or cycle, there is scope for some transfer from a sedentary behavior to an active alternative. This is supported by our data that show that the immediate after-school period involves fewer occurrences of motorized travel than the period before school. This might be explained by some parents transporting their children to school on their way to work but then not being able to collect them on their return. A recent review suggests that targeted behavior change programs might be effective in promoting a shift from car use to walking [14]. Given the current concern about pediatric obesity, any additional energy expenditure might be beneficial.

There has been a view expressed in the academic and popular media that TV viewing and new technologies are replacing more active leisure-time pursuits, often expressed through the “couch potato” metaphor [13, 15–18]. Our time-use data for weekdays suggested that, while TV viewing was most likely to occur in the middle to late evening, sports/exercise participation tended to peak earlier in the evening. This suggests that the two behaviors may be able to coexist, at least to a certain extent and for some children [7, 19], thus supporting other evidence for a general lack of relationship between the two behaviors [4, 8]. Certainly for young people, one would not expect extensive involvement in sports/exercise late in the evening. That said, boys and girls are much more likely to be watching TV at all time periods after school than any other behavior, with reports of TV viewing being at least twice for boys and three times for girls that of reports of sports/exercise. For those not being particularly active or those who are sedentary at times of the day when physical activity is more likely [20], substituting physical activity for TV or any other sedentary behavior is likely to be beneficial for health. On the other hand, simple estimates of how much TV is being viewed by adolescents may mask important patterns across the day, some of which could be “acceptable,” while others may be “unacceptable” from the viewpoint of physical activity.

Contrary to popular belief, use of the computer, particularly for playing games, was relatively low and certainly for girls in respect of computer games. Given the rapidly changing nature of such sedentary behaviors, these need further monitoring. Sedentary socializing was unlikely during most evening periods. However, about 20% of behaviors in the early to middle evening involved homework. Despite the sedentary nature of this behavior, including some use of the computer, few would argue that it should be reduced or replaced with physical activity. This supports the argument that sedentary behaviors cannot be looked at in isolation.

In summary of weekday behaviors, prominent sedentary behaviors are TV viewing, homework, and motorized transport. While active alternatives to motorized transport...
are possible for many, temporal data show a complex patterning of sedentary and physically active behaviors in which TV and sports/exercise show some independence across time.

Weekend behaviors were more varied than during the school week. Nevertheless, trends were discernable with moderate percentages of behaviors being reported as sports/exercise throughout the day for boys but much less for girls. Indeed, girls were twice as likely to be watching TV during the morning than being active through sports/exercise, with boys showing an equal propensity for TV viewing and sports/exercise throughout the day. Girls showed a higher preference for sedentary socializing, while boys preferred computer games, although the latter had only a small-to-moderate chance of occurring. With girls’ preference for socializing, there would appear to be opportunities for more active pursuits based on peer support and friendship. For example, Sallis et al. [8] show that support from significant others and sibling physical activity are clearly and positively associated with participation in physical activity in adolescents, although these findings do not differentiate by gender. However, Biddle et al. [21] did show that parental and family support was associated with higher levels of physical activity in adolescent girls. Further work is required to identify what types of activities might be attractive for girls in supportive social settings.

A consistent finding across weekdays and weekend days is that younger children are more likely to watch TV than their older counterparts yet also are more likely to be physically active. This again supports the view that TV viewing and physical activity are at least partially independent and, second, sedentary behaviors need to be looked at in combination rather than in isolation, as well as alongside more active behaviors [3].

Location

Given the importance currently given to environmental influences on physical activity [22], it is important to understand how location may be associated with sedentary and active behaviors in the current sample. Results showed two clear trends. First, location had a strong link to TV viewing, and second, physical activity occurred more often outside.

TV viewing was highly likely if respondents were in the living room. While this is predictable, it does suggest that if reductions in TV viewing are sought for some people, this context may be a target for interventions. For example, encouraging use of other locations may help to reduce time in front of the TV, and alternative behaviors in the living room may also be prompted. Although many of these are likely to be sedentary, such as listening to music or reading, they may help reduce what appears to be an over-reliance on one behavior, characterized by “habit” through cueing and automaticity [23].

In addition to the living room, the bedroom may also be an important location for TV viewing, supporting conclusions by others [13]. Not only were 20–30% of behaviors in the bedroom reported as TV viewing, only a minority of boys (21%) and girls (31%) did not have TV sets in their bedroom. A clear implication is that removal of TV sets from bedrooms might reduce TV viewing, although this will not guarantee a reduction in sedentary behavior as other sedentary pursuits may be adopted as a substitute. However, behavioral contingencies for TV viewing are likely to be more easily enforced in communal contexts, and young people may be less able to control viewing habits when there is only one television in the home.

Being outside, either in the garden/yard or another outside location, was clearly associated with physically active behaviors, especially for boys. In addition, physical activity occurred in “another inside area” equally for boys and girls. First, it appears that previous findings are confirmed in respect of time spent outside being associated with greater physical activity [8]. However, we found that occurrences of physical activity in these locations was less for girls and declined with age for both genders. Outside areas need to be made as attractive as possible to prompt active play for both genders and all ages. Although not able to show this with our data, we suspect that many streets are now less attractive for play than some years ago due to excess traffic flow or the parking of motor vehicles, although relationships are likely to be complex [24, 25]. Local parks may compensate to some degree, but the location is likely to be less convenient than playing in the street outside one’s house and, in some cases, may be perceived as unattractive and even dangerous [26].

Interestingly, when girls reported being in “another inside location,” they were reasonably likely to be physically active. This suggests that being inside had some attraction for physical activity. This could be for reasons of the activity itself (e.g., dancing, table tennis) or due to self-presentational concerns about playing or being active outside [27]. This needs further investigation. Indeed, girls showed little likelihood of sports/exercise during the weekend in the locations of school or town (outside), unlike the boys. This questions the current provision for girls in such locations.

It is clear that playing outside becomes less desirable as adolescents age. While this is not surprising (few adults play outside on the street or in the garden unless with children!), it is important to identify the transition from street or garden/yard play to other locations for physical activity. These might include settings that are not close to home and involve structured fee-based activities that are dependent on financial and transportation resources of parents.
Although this study has reported detailed behavioral data across settings from a sample recruited nationally, limitations are evident. First, the diary is burdensome on participants, and this may have accounted for a sample biased towards girls and younger adolescents. Second, because we sampled in schools, we did not have data from the school vacation period in the summer—a time when activity levels might be expected to exceed those at other times of the year or, indeed, that they can watch more unsupervised television. However, we did sample across 9 months of the year, and we found little evidence of seasonal trends. Another limitation is that we focused only on the time spent outside of the formal school day. While the time spent at school is characterized by behaviors that are largely non-volitional, there is opportunity for volitional behavior during lunch and break/recess times. Although young people may have limited access to certain sedentary pursuits during these periods, this is still a time where young people are able to choose what they do. Moreover, because young people are likely to engage in physical activity and sedentary behavior during school instruction hours, our data almost certainly underestimate the time spent in many activities when extrapolating beyond leisure time. Because previous research has documented the paucity of health-enhancing physical activity accrued during school hours in this age group [28], our data may have particular public health significance. Finally, a limitation of our method is that only one behavior was requested for each time period. It is possible that multiple sedentary and active behaviors take place in the 15-min periods or two behaviors can take place simultaneously, such as eating and watching TV.

Conclusions

Sedentary lifestyles among youth are of increasing concern to public health. However, few empirical research studies have attempted to document the sedentary behaviors of young people. The present study used EMA to measure sedentary behavior and physical activity in young people. This methodology is useful because it helps reduce self-report bias in behavioral recall and enables contemporaneous reports of when and where behaviors occur. Our data reveal that highly prevalent sedentary behaviors, such as TV viewing, may be able to occur within a physically active lifestyle. This is partly because they demonstrate different temporal patterns across the day. TV viewing was the most prevalent sedentary behavior but was most likely to occur during the evening hours when physical activity is less likely. Physical activity was most likely to occur in outside environments, especially for boys.

Future research should attempt to identify and corroborate trends in the temporal and environmental contexts of youth sedentary behavior. Using a micro-behavioral approach to examine sedentary lifestyles in young people provides unique information for interventions designed to reduce sedentary behavior and increase physical activity in young people.

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References


