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The Association Between the Type, Context, and Levels of Physical Activity Amongst Adolescents

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Background: Little is known about how the type and context of physical activity behaviors varies among adolescents with differing activity levels. The aim of this study was to assess differences in the type and context of physical activity behaviors in adolescents by level of objectively measured physical activity. ***Methods:*** Cross-sectional analysis of 2728 adolescents (1299 males, 1429 females) participating in the Avon Longitudinal Study of Parents and Children (ALSPAC). The mean (SD) age was 13.8 (+0.1) years. Physical activity was measured using an Actigraph over 7 days. Adolescents were categorized into tertiles of activity (less, moderately, highly active) using counts/min and min/d of moderate-to-vigorous activity (MVPA). Activity type was reported using the Previous Day Physical Activity Recall (PDPAR). Differences in the type and context of activity by activity level were analyzed using Chi squared. ***Results:*** Highly active boys reported more job, outside, and sports activities on school days ($P < .05$), and more sports activities on nonschool days ($P < .05$). Highly active girls reported more outside activities on school days ($P < .05$). ***Conclusions:*** Identifying the type and context of physical activity behaviors associated with more active adolescents, can help inform policy and physical activity interventions aimed at increasing activity levels in adolescents.

Keywords: epidemiology, accelerometry, school and nonschool, longitudinal studies, questionnaires

Low levels of physical activity are ubiquitous in Western societies and have major implications for health.[1] Despite recommendations that children and adolescents spend 60 minutes per day in moderate-to-vigorous physical activity (MVPA),[1] a large proportion of children and adolescents fail to achieve these levels.[2,3] This may impact public health, as a physically active childhood has many established benefits, including improved bone health,[4] a reduced risk of obesity,[5,6] and a lower risk of developing type II diabetes.[7] A physically active childhood has also been linked to higher activity levels in later life.[8,9]

It has also been reported that boys are generally more active than girls, and participate in greater amounts of MVPA.[10,11] It is also known that boys and girls exhibit different daily patterns of physical activity.[12] However, very little is known about how the type and context of physical activity varies between adolescents of differing activity levels. Research to date has shown that school and after school based physical activity programs have a mixed impact on the physical activity levels of children and adolescents.[13–15] There is limited evidence on the associations between the school and after school environment, and the physical activity levels of adolescents.[16,17] Hence, our understanding of the range of determinants likely to influence adolescent's activity levels is incomplete.[18] Knowledge of the type and context in which active adolescents achieve their higher activity levels has the potential to improve our ability to formulate more effective interventions and public health policies.

The aim of this study was therefore to assess differences in the type and context of physical activity in adolescents of differing objectively measured activity levels.

Methods

Study Population

The analysis was conducted using data from adolescents participating in the Avon Longitudinal Study of Parents and Children (ALSPAC), a birth cohort study located in the southwest of England (http://www.alspac.bris.ac.uk).[19] A total of 14541 pregnant women were recruited, resulting in 14062 live births, with an estimated due date between April 1991 and December 1992.[19] Detailed data have since been collected from the children, their mothers, and partners. From age 7 onwards, the children have been invited to attend research clinics, in order for further physiological and psychometric data to be collected.[18,19] All adolescents who attended the ALSPAC study clinic at age 13 were asked to wear an Actigraph accelerometer

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for 7 days. Data were collected during January 2005 to October 2006. Ethical approval for the study was obtained from the ALSPAC Law and Ethics Committee, and Local Research Ethics Committees.

Measurement

Physical Activity. Physical Activity was measured at about age 14 years using the Actigraph accelerometer (Actigraph; LLC, Fort Walton Beach, Fl), worn over a 7-day period. Data were collected from January 2005 to October 2006. The Actigraph is an electronic motion sensor comprising a single plane (vertical) accelerometer, which is small and light and was worn on the right hip. Actigraphs were initialized to start recording at 5 AM on the day following each clinic visit. A measurement epoch of 1 minute was used, and the adolescents were asked to wear the Actigraph during waking hours and only to take it off for showering, bathing, or any water sports.[20] A daily timesheet was provided to record the times the Actigraph was put on and taken off, and the reason for doing so. Participants were also asked to record any times (in minutes) that they swam or cycled each day. Actigraphs were posted back, and data were downloaded using the Actigraph Reader Interface Unit and software.[20] The Actigraph has been comprehensively validated for use with children and adolescents, against heart-rate telemetry,[21] indirect calorimetry,[22,23] and doubly labeled water.[24]

Derivation of Physical Activity Variables. Two physical activity variables were calculated; total physical activity, measured as the average accelerometer counts/min over the period of valid recording, and the average minutes of MVPA recorded per valid day of activity measurement. Minutes of MVPA per day, was selected as the primary outcome variable as current physical activity recommendations are framed in terms of time spent each day in MVPA[1] and we have previously shown that MVPA may be a more important determinant of obesity than counts/min.[25] The cut point for MVPA (3600 counts/min) were derived from a calibration study of 246 children in which Actigraph counts/min were compared with oxygen uptake.[26] Data were considered valid if the Actigraph had been worn for at least 10 hours per day for at least 3 of the 7 days. This is a level previously shown as providing good power and reliability.[20] Ten or more minutes of consecutive zeros were regarded as periods in which the monitor was unworn, and these were deleted from each file.[27] If on any one day the average counts/min was less than 150 or the average counts/min more than 3 SDs above the mean,[28] we excluded this day of recording because we considered this level of physical activity to be behaviorally implausible.[20] Although a weekend day was not specified to fulfill validity criteria, 84% of children had at least 1 weekend day of recording.[20] Participants were categorized into gender-specific tertiles of activity, (T1 = less active; T2 = moderately active; T3 = highly active) firstly by min/d of MVPA and secondly by counts/min. Gender specific tertiles were used as boys are consistently shown to be more active than girls,[11,29] and have different patterns of physical activity.[12] Analyses were conducted for both sets of data, and MVPA and counts/min were adjusted for the accelerometer season of wear, and MVPA for the average minutes wear time. As the results for the counts/min and min/d of MVPA showed a similar pattern, we report only the results for MVPA.

Questionnaire Data. During the research clinic visit, participants completed a computer based questionnaire in which they recorded their previous day's activities. For all participants, the day for which activity information was collected was 2 days before the first day of accelerometer measurement. The tertiles of activity from the accelerometers were generated after completion of the questionnaire. The questionnaire was based on the Previous Day Physical Activity Recall questionnaire (PDPAR),[30] adapted to be suitable for British children. Questions on the amount and intensity of physical activity were omitted as the purpose was to provide information on the type and context of activities. The questionnaire took around 10 minutes to complete. Six different categories of activities were presented to the children; each category had a drop down list of activities. Comprehensive lists of activities were compiled from available databases of children's activities, including other questionnaires, national surveys, Sport England databases. Participants were asked to tick the activities in which they had participated, during the previous day. For each selected activity, they also reported the time of day it was performed. Table 1 shows the 6 different categories of activity that were included in the questionnaire. Table 2 shows the different times of day, on a school day and nonschool day, that were included in the questionnaire.

Statistical Analysis

Means and standard deviations (SD) were calculated for normally distributed variables, medians, and interquartile ranges (IQR) were calculated for variables not normally distributed. Each activity reported by the child was recorded as 1 'occasion' of activity. The total number of reported occasions of activity was then calculated within each of the 6 activity categories. The total number of reported occasions of activity was calculated for each child in each tertile and this data were used for the analysis. This process was repeated for school and nonschool days, appropriate to the day the participant was reporting, and also within each time segment of the day. Differences between the proportions of activities in activity tertiles were analyzed using the Chi squared test. MVPA was adjusted for minutes worn to account for variations in wear time and both MVPA and counts/min were adjusted for season of measurement. All statistical analyses were conducted using SPSS v.14 for Windows and Stata 10.

Table 1 Categories of Activity and Activity Examples, Presented in the PDPAR Questionnaire

Category of activity	Example of activity
Housework	Tidying up, meal preparation, gardening
Outside activities	Skateboarding, riding a bike
Active job	Paper round, Girl Guides, Scouts
Sedentary time	Listening to music, homework, computer games
Sports participation	Netball, table tennis, football
Active travel (walk)	Car, cycling, bus

Table 2 Times of the Day on School and Nonschool Day, Presented in the PDPAR Questionnaire

Time of day	School day	Nonschool day
1	Get up—start school	Getting up—breakfast
2	Start school—lunch	Breakfast—lunch
3	Lunch break	Lunch—evening meal
4	Lunch—end school	Evening meal—going to bed
5	End school—evening meal	
6	Evening meal—going to bed	

Results

A total of 11,267 adolescents were invited to the 13-year clinic, of which 6152 attended. Questionnaire data were obtained from 4344 and accelerometer data from 3759. Questionnaire and accelerometer data were available from 3304 adolescents. Participants with less than 600 minutes per day of valid accelerometer data over a period of at least 3 days were excluded from the analysis, N = 576 (302 boys and 274 girls). Some small differences have previously been found between the characteristics of those who provided valid accelerometry data and those who did not. There were differences in terms of age, weight, body mass index, sex, and pubertal status; however, the size of these differences was small.[20] The final sample with complete and valid data from both accelerometer and questionnaire was 2728 children (1299 boys and 1429 girls). This represents 44% of those attending the clinic.

Questionnaire data representing a school day were collected from 1715 participants (840 boys and 875 girls), and from 1013 participants (459 boys and 554 girls) on a nonschool day. The questionnaire stipulates school days and nonschool days only, and the accelerometer records data on a weekday and weekend day only. Although we are unable to report whether the questionnaire data were collected on a week or weekend day, 84% of the children had at least 1 weekend day of accelerometer recording. The mean (SD) age of the participants was 13.8 (±0.1) years therefore they are referred to as 14 year olds. Table 3 shows the descriptive and physical activity data for those participating in the study. It can be seen that boys had higher levels of total activity compared with girls. Table 4 shows the minutes of MVPA by tertile, on both school days and nonschool days. Figures 1 and 2 show the distribution of physical activity by activity type and activity tertile, on school and nonschool days, for boys and girls.

In comparison with less and moderately active boys, highly active boys reported more job, outside, and sports activities on school days, and sports activities on nonschool days. In comparison with less and moderately active girls, highly active girls reported more outside activities on school days. Overall, differences between the activity tertiles were greater on school days compared with nonschool days.

Tables 5 to 8 show the frequency of activity occasions, across tertiles, at different time periods on school days and nonschool days. There were no differences observed among boys or girls of differing physical activity levels, and the frequency of physical activity participation.

Analyses were also conducted for physical activity tertiles defined by counts/min. The frequency of physical activity occasions observed for counts/min was broadly similar to those for the average mins/day of MVPA, (data not shown).

Table 3 Descriptive Statistics of Physical Activity Levels by Gender

	All	Boys	Girls	
	N = 2728	N = 1299	N = 1429	*P*
Age (years)*	13.8 (0.1)	13.8 (0.1)	13.8 (0.1	*P* = 1.00
Total physical activity (counts/min)	478 (377–609)	539 (425–677)	431 (345–536)	< 0.001
Total physical activity weekdays (counts/min)	490 (386–624)	563 (440–693)	426 (331–543)	< 0.001
Total physical activity weekend (counts/min)	399 (274–582)	426 (285–626)	375 (268–532)	< 0.001
MVPA (min/day)	19 (11–31)	23 (14–36)	17 (9–26)	< 0.001
MVPA weekdays (min/day)	21 (12–34)	25 (15–39)	18 (10–28)	< 0.001
MVPA weekend (min/day)	11 (4–24)	13 (5–29)	9 (3–20)	< 0.001
Total wear time (min/day)*	790 (55.2)	793 (56.3)	787 (54.1)	< 0.001
Weekday wear time (min/day)*	804 (62.5)	806 (62.6)	802 (62.4)	< 0.001
Weekend day wear time (min/day)*	747 (79.7)	756 (81.1)	738 (77.3)	< 0.001

Abbreviations: MVPA, moderate-to-vigorous physical activity.

Note. P-values relate to sex differences. Data are median and interquartile range (IQR). Asterisk indicates data are mean and standard deviation (SD).

Table 4 Physical Activity Levels, Mins/d of MVPA, by Activity Tertile

		T1: less active		T2: moderately active		T3: highly active	
	Total	N	Median (IQR)	N	Median (IQR)	N	Median (IQR)
School day							
All	1715	571	9 (6, 12.2)	572	20.5 (17.4, 23.5)	572	36.7 (31.2, 46.4)
Boys	840	280	12 (8, 15.1)	280	25 (21.2, 28.2)	280	42.2 (36.2, 51.5)
Girls	875	291	7.4 (4.8, 9.8)	292	17 (14.6, 19.5)	292	30.5 (26.2, 38.2)
Nonschool day							
All	1013	337	7.3 (4.1, 10)	338	18.1 (15.3, 21.4)	338	37.1 (30.3, 46.7)
Boys	459	153	9.3 (5.1, 12.3)	153	21 (17.7, 25.6)	153	42.1 (34.6, 47.7)
Girls	554	184	6.3 (3.5, 8.4)	185	15.9 (13, 18.8)	185	30.8 (25.2, 41.6)

Discussion

The main finding of this study is that most active boys participated in more job, outside, and sport related activities on school days, and sports activities on nonschool days than the least active boys. The most active girls participated in more outside activities on school days than the least active. The frequency of activity participation during different time periods of the day was unrelated to boy's or girl's activity tertile. Time spent in sedentary activities was also unrelated to the boy's or girl's activity tertile.

Comparison With Other Studies

Involvement in paid work during adolescence has previously been associated with lower levels of leisure time physical activity in youth.[31] In this study involvement in an active job or volunteer work was associated with higher activity. It may be that any reduction in leisure activity resulting from the job may be compensated for by increases in activity in other domains (eg, informal play). The activities considered as 'job' activities were a mixture of both paid (eg, paper-round) and unpaid (eg, Boy Scouts) activities, which might be conducted either indoors or outdoors. A positive association between the time spent outdoors and increased physical activity has previously been suggested[32] and our results are in agreement with this.

A key and consistent finding in this study is that the more active boys reported playing more sport. It has previously been suggested that leisure time physical activity and sport may be important contributors to higher physical activity levels.[33] Further, studies exploring environmental correlates of physical activity have shown that participation in school PE classes and after-school community recreation programs are linked to higher levels of activity.[34] Our results reinforce the potential importance of formal or informal participation in sport as a means of achieving higher activity levels in boys of this age.

In addition to the positive associations discussed above, some of the areas where we detected no associations are also worthy of mention. Previous studies investigating TV viewing and its relationship to physical activity have typically reported weak associations.[35,36] This study

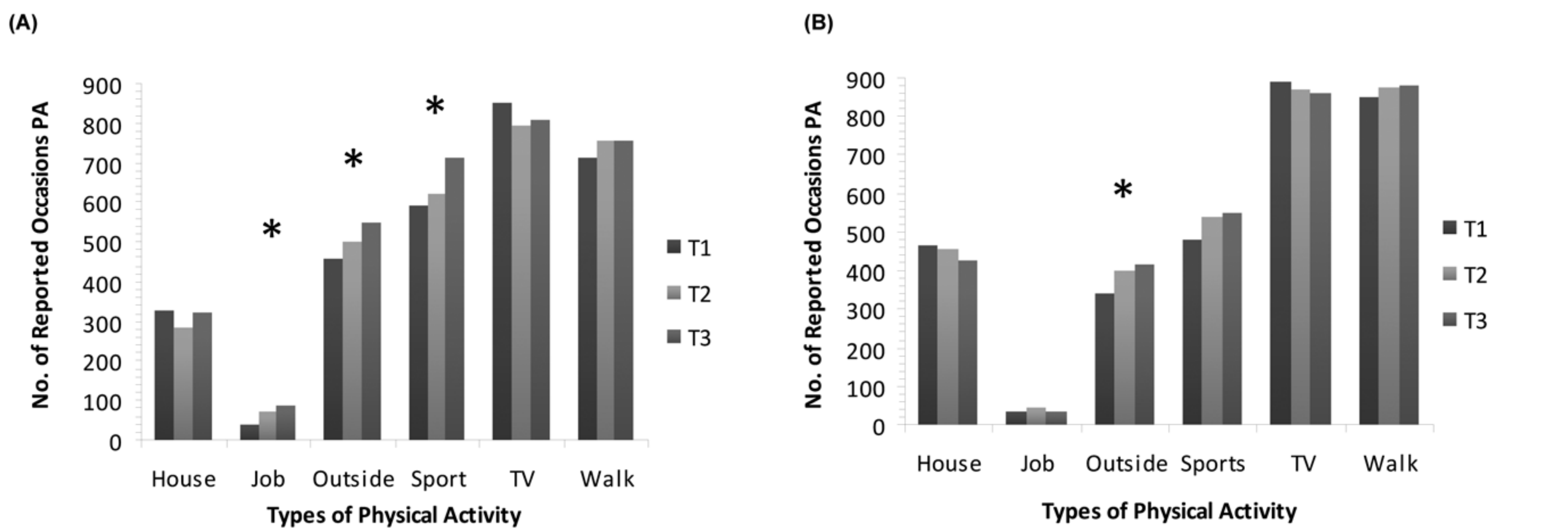

Figure 1 — Frequency of reported PA occasions, by activity tertile, among boys (A) and girls (B) on a school day. Activity tertiles delineated by accelerometer average mins/d of MVPA. * Indicates differences between activity tertiles, $P < .05$. T1 = least active tertile.

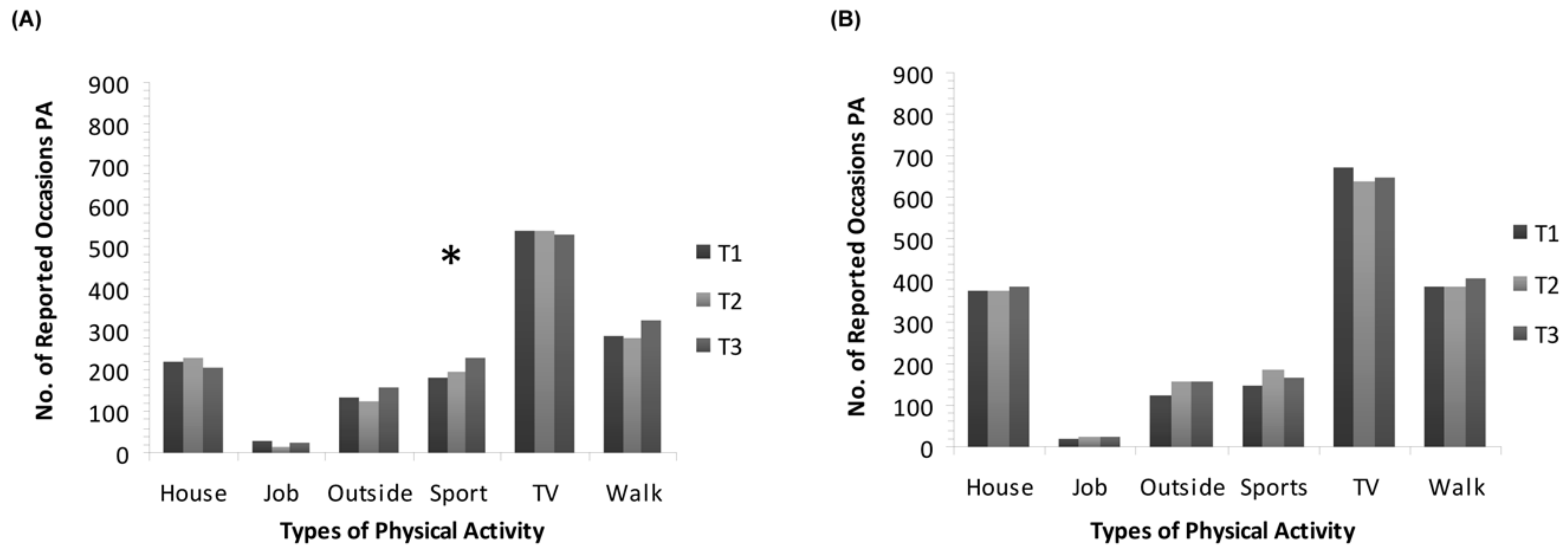

Figure 2 — Frequency of reported PA occasions, by activity tertile, among boys (A) and girls (B) on a nonschool day. Activity tertiles delineated by accelerometer average mins/d of MVPA. * Indicates differences between activity tertiles, $P < .05$. T1 = least active tertile.

Table 5 Daily Distribution of Boys' Physical Activity by Activity Tertile, Mins/d of MVPA, on a School Day

	Total occasions of physical activity performed at 6 different times on a school day					
	Getting up—start school	Start school—lunch	Lunch break	Lunch—end of school	End school—evening meal	Evening meal—go to bed
T1: less active	759	270	466	145	819	523
T2: moderately active	745	300	481	153	794	552
T3: highly active	796	322	488	150	879	597
Observed differences between T1, T2, and T3	$X^2 = 1.81$, df = 2, $P = .40$	$X^2 = 4.58$, df = 2, $P = .10$	$X^2 = 0.53$, df = 2, $P = .77$	$X^2 = 0.22$, df = 2, $P = .90$	$X^2 = 4.59$, df = 2, $P = .10$	$X^2 = 4.99$, df = 2, $P = .08$

Table 6 Daily Distribution of Girl's Physical Activity by Activity Tertile, Mins/d of MVPA, on a School Day

	Total occasions of physical activity performed at 6 different times on a school day					
	Getting up—start school	Start school—lunch	Lunch break	Lunch—end of school	End school—evening meal	Evening meal—go to bed
T1: less active	782	225	453	129	856	617
T2: moderately active	782	264	471	141	900	634
T3: highly active	800	270	466	146	870	611
Observed differences between T1, T2, and T3	$X^2 = 0.27$, df = 2, $P = .87$	$X^2 = 4.72$, df = 2, $P = .09$	$X^2 = 0.37$, df = 2, $P = .83$	$X^2 = 1.10$, df = 2, $P = .58$	$X^2 = 1.15$, df = 2, $P = .56$	$X^2 = 0.46$, df = 2, $P = .80$

Table 7 Daily Distribution of Boy's Physical Activity by Activity Tertile, Mins/d of MVPA, on a Nonschool Day

	Total occasions of physical activity performed at 6 different times on a school day			
	Getting up—breakfast	Breakfast—lunch	Lunch—evening meal	Evening meal—go to bed
T1: less active	320	374	385	299
T2: moderately active	301	380	409	287
T3: highly active	335	395	415	327
Observed differences between T1, T2, and T3	$X^2 = 1.82$, df = 2, $P = .40$	$X^2 = 0.61$, df = 2, $P = .74$	$X^2 = 1.25$, df = 2, $P = .54$	$X^2 = 2.77$, df = 2, $P = .25$

Table 8 Daily Distribution of Girl's Physical Activity by Activity Tertile, Mins/d of MVPA, on a Nonschool Day

	Total occasions of physical activity performed at 6 different times on a school day			
	Getting up—breakfast	Breakfast—lunch	Lunch—evening meal	Evening meal—go to bed
T1: less active	422	474	472	361
T2: moderately active	420	480	493	378
T3: highly active	442	468	487	385
Observed differences between T1, T2, and T3	$X^2 = 0.69$, df = 2, $P = .71$	$X^2 = 0.15$, df = 2, $P = .93$	$X^2 = 0.48$, df = 2, $P = .79$	$X^2 = 0.81$, df = 2, $P = .67$

did not find any meaningful differences between the TV viewing habits of adolescents by activity tertile. Similar to previous studies of TV watching where gender differences have been typically small,[36] we found no gender differences in TV viewing. These findings therefore suggest that the frequency TV viewing is not necessarily associated with an inactive lifestyle. In particular the practice of using the frequency of TV viewing as a marker of a sedentary lifestyle may be inappropriate.[37]

Active travel has also been previously suggested as an important way to increase physical activity levels in children.[38] We have previously reported that children who travel to school by car accrue more minutes of MVPA during the school week than children who travel by car.[39] However we found no differences in the frequency of active travel by activity tertile in this study. This contrast may be due to age difference (12 years vs. 14 years) or due to the differences in the questions asked regarding active travel. There is mixed evidence to support a positive association between active travel and increased physical activity levels.[40] It may be that the distance and duration of active travel is a critical factor in determining whether adolescents actively commute, and the data from this study is unable to shed any light on this. It is likely that both individual and environmental factors have important influences on adolescents' active commuting patterns.[38]

We found no differences in the reported activities among boys or girls by time of day. These findings are inconsistent with the results of a recent study which found that 40% of nonschool physical activity occurred between the hours 15.30 and 18.30.[41] The findings are also inconsistent with a further study that reported positive associations between physical activity and attendance at after-school community activity programs.[34]

Strengths and Limitations

Key strengths of the study are the large sample size, and the use of accelerometers to objectively measure physical activity. Limitations include potential bias caused by cohort attrition and nonresponse. Due to the large volume of data collected, it was not possible to examine each Actigraph file individually to check for errors, although files with apparently anomalous values were checked when they were imported into the Access Macro. Spurious files were also removed at the data cleaning stage (see Methods section). This may have resulted in some spurious files being accepted as valid. Valid accelerometer data were more likely to come from those of more socially advantaged backgrounds.[20] We have previously reported however, that both of these potential sources of bias are likely to be minimal.[3] It is acknowledged that accelerometers are unable to accurately record swimming, climbing, lifting, and cycling activities; however, a previous ALSPAC study of the same children when they were aged 12[18] found that removing those children who reported swimming and cycling (by self report) from the analysis did not change the results. Further limitations are: the 1-minute epoch used in this study may reduce the amount of vigorous activity reported since children typically move in short discontinuous bursts;[23] the computer based questionnaire provided a retrospective account of activity, which may lead to some misreporting;[42] there was no distinction in the questionnaire whether the 'previous day' was a weekday or weekend day.

Conclusions

This study has demonstrated some clear differences in the type and context of activities among adolescents, by tertile of objectively measured physical activity. Job, outside and sports activities were more commonly reported among the more active adolescents, and may be the means by which they achieve their higher activity levels. These findings may have implications for public health, as physical activity interventions could be more effective if targeted at specific activities. Although the school environment provides a monitored and structured environment in which to implement interventions, it seems that consideration of physical activity behaviors outside of the school environment may also be necessary to achieve a long term, sustained increase in boys' and girls' physical activity levels.

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