THE EFFECTS OF CAR USE ON CHILDREN'S PHYSICAL ACTIVITY PATTERNS

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1. INTRODUCTION

Widespread concern about rising levels of car use by children is often coupled with observations that children are becoming less active and that levels of overweight and obesity are increasing. Amongst the many policy interventions designed to promote physical activity amongst children those targeting modal shift from the car to other options such as walking and cycling would appear to deal simultaneously with car and physical activity issues. However, whilst both health and transport fields tend to link the increase in car use with the rise in obesity and decline in physical activity, these links have not been fully researched and confirmed.

This is the main focus of a project being carried out at the Centre for Transport Studies, University College London, in conjunction with partners in health related fields. This paper forms one of the first outputs of the project and is based on a preliminary analysis of a dataset that is, as yet, incomplete. However, the paper has been produced as an early contribution both to the research questions within the project, and to the development of subsequent analysis. It is also hoped to promote discussion and feedback from the wider research and policy/practice community.

2. THE RESEARCH CONTEXT: CAR USE AND CHILDREN'S PHYSICAL ACTIVITY LEVELS

Increasing car use is commonly seen to be one of a number of factors explaining decreasing levels of physical activity in both children and adults. There is ample evidence to show that car use is increasing amongst both children and adults (Mackett 2002, Mackett *et al. 2002a,c)*. Figures taken from the National Travel Survey for Great Britain (NTS) show that whilst in 1964 32% of all trips were by car by 1997/99 this had increased to 65%. Although children may make fewer trips by car than adults there has also been a significant increase in trips by children from 20% in 1964 to 47% in 1997/9. National statistics also show that cars are increasingly used for shorter journeys. According to figures from the NTS over 70% of all travel by children is now by car, contrasting with a figure of 37% in 1964. (National Travel Survey 1964, 1997/9; Mackett *et al.* 2002c).

One area of concern is the increasing use of the car to take children to school and back. Again, the NTS shows that there has been an overall increase in the proportion of primary school children taken to school whilst DiGuiseppi *et al.* (1998) show that the use of the car has for school journeys has contributed to an overall annual decrease in the amount children walk. One area where there is less quantitative research has been in the growth of structured activities. This, it is argued, has led to parents spending more time driving their children to activities (Hofferth 1999, cited in Furedi 2001).

In parallel, research on children's physical activity levels has focused on the amounts and benefit of physical activity for children. The benefits of physical activity, in terms of both short and long term, physical and psychological, for both adults and children has been well documented (see for example, Health Education Authority 1997, 1998). The review by the HEA (1997) states that a number of children and young people do not gain the amount of physical activity they need, that physical activity declines with age and that girls are less active than boys. Other research has shown that in the UK at least there is evidence of a decline in energy expenditure by young males although there is some consensus that most children are 'fit' (Armstrong and Van Mechelen 1998). One of the recommendations of the HEA review was that increases in physical activity should be through lifestyle changes, i.e. walking or cycling both of which have declined (Cooper *et al.* 2000), rather than more structured physical activity, as these were more likely to be sustained into adulthood (see also Morris and Hardman 1997). More recently government guidelines have taken the recommendations of health and physical activity experts which suggest that all children should obtain a minimum of one hours moderate level physical activity per day (Biddle *et al.* 1998).

Physical activity for children is often linked to the increase in obese or overweight children. However, although there is ample evidence to show the recent increases in obese and overweight children (Chinn and Rona 2001, Flegal *et al.* 1999, Cooper *et al.* 2000) research does not adequately demonstrate the relationship between physical activity in children and their body composition. For example, studies which have sought to test the relationship between overweight or obesity and physical activity have not found a significant correlation (Cooper *et al.* 2000; 889). Cooper *et al.* also found that 91.7% of male and 68.8% of female adults met overall guidelines for physical activity. Guidelines were achieved for 58.3% of the obese and 81.9% of the non-obese. Similar results were reported by Eston *et al.* (1998) who found obese individuals to be moderately active. However they also point out that whilst they may be moderately active, most obese individuals do not achieve higher levels of physical activity because of the constraints of their body composition. The link between sedentary lifestyle and overweight and obesity was also considered by Jebb and Moore (1999) who concluded that although there is evidence to support this link there is insufficient data to demonstrate the relative importance of energy intake and physical activity in the explanation for overweight and obesity.

However, it is acknowledged that physical activity levels decline with age, and that obesity, with its resultant health problems, can be reduced by increases, amongst other changes, in physical activity. Although the evidence linking fitness in youth to fitness in adults is lacking (Freedson 2000), there remains a reasonable belief that lifestyle habits are best learnt at a young age and that physical inactivity, if it tracks into adulthood, may have health damaging effects although the issues surrounding this logic are far from straightforward (see for example Riddoch 1998, Kohl 2000). The importance of lifestyle and the influence of the family is made by DiLorenzo *et al.* (1998) who found that social determinants were important – particularly for females – for health related behaviour such as physical activity and this is supported by others such as Baronowski *et al.* (2000) who use the phrase 'toxic environment' to describe the social conditions which can lead to physical inactivity.

Despite the absence of solid research findings that support the link between physical activity, obesity and car usage there is little doubt that these remain significant policy concerns, particularly amongst the advanced economies of the Western world. From a transport viewpoint the recommendations for promoting physical activity are in accordance with the policy need to reduce car use, for both adults and children. In particular, the decrease in the number of children walking to school has received much attention and is the target of a number of initiatives, such as Safer Routes to School, which promote walking and cycling as alternatives to the car (Sustrans, undated). In particular, in the UK there has been concern that the growth in the use of the car for taking children to school has had a direct and adverse affect on their overall levels of physical activity (Department of the Environment, Transport and Regions, 1998, paragraph 5.29).

Although the research reported in this paper starts from a transport perspective, it necessitates an interdisciplinary and collaborative approach to the study of car use, car dependency and children's physical activity and health. This paper is one of the first attempts to bring together data from these streams of work and combine them to take an overall look at the link between car use and physical activity, using measurements of body composition as an indication of present and future health[1]. As one of the first outputs from a project which is still in a data collection phase, we hope to provide some early results to promote discussion and dissemination.

3. THE CHILDREN'S CAR USE PROJECT

The work described in this paper is being carried out as part of a project entitled 'Reducing children's car use: the health and potential car dependency impacts' being carried out in the Centre for Transport Studies at University College London. It is funded by the EPSRC (Engineering and Physical Sciences Research Council) under the Future Integrated Transport (FIT) programme for three years commencing January 2001. The objectives of the project are as follows:

- To examine the effects of car use on children's physical activity and health;
- To examine the effects of car use by children on their potential long-term car dependency;
- To develop a framework to evaluate the impacts of travel-to-school initiatives systematically.

The Principal Investigator and Project Manager is Roger Mackett, Professor of Transport Studies at UCL. The research team at UCL consists of Lindsey Lucas, James Paskins and Dr Jill Turbin. Professor Neil Armstrong of the Children's Health and Exercise Research Centre at the University of Exeter and Dr Laurel Edmunds of the Department of Public Health at the University of Oxford are providing expertise on measuring

[1] Using both children's activity levels and body composition as indicators of their current and future health is not without problems. For an overview and critique see Riddoch 1998.

children's physical activity patterns and relating these to health issues. Expertise on children's health and its relationship with transport is being provided by Professor Mark McCarthy of the Department of Epidemiology and Public Health Medicine at UCL. Information about the journey to school initiatives and their implementation and potential impacts is being provided by the Environment Department of Hertfordshire County Council. Dissemination of the research findings to health professionals and subsequent recommendations on how research in this area can inform evaluation of local healthy transport initiatives is being assisted by Adrian Coggins, a Health Promotion Adviser based in Hertfordshire. The fieldwork is all based in Hertfordshire, an area to the north of London. Further information about the project is available via the World Wide Web at www.ucl.ac.uk/transport-studies/chcaruse.htm .

The project is divided into a number of sub-studies which focus on particular objectives. The major three components are:

- Questionnaire surveys of children and their parents and anthropometric measurements of the children;

- Analysis of children's physical activity patterns using RT3 portable monitors and travel and activity diaries;

- Evaluation of travel-to-school initiatives, focusing initially on walking buses (Mackett *et al.*, 2002b).

In addition planned areas of work associated with this project concern the attitudes of teenagers to the car, an analysis of the effects of car use on children's cognitive and mental development; and an analysis of the role and position of women in society and the impact of this changing role on children's car use. The work discussed in this paper relates to the first two components of the research project.

4. THE SCHOOLS SURVEYS

A major component of the Car Use research project has consisted of a questionnaire administered to pupils and their parents in ten schools in Hertfordshire. This survey has been carried out in conjunction with the local authority as part of its Safer Routes to Schools initiative. The pupil questionnaire included questions on both travel to school and elsewhere and their physical activity both in and out of school. Parent questionnaires included questions on car use within the family and attitudes towards the use of the car. Although the local authority distributed questionnaires across a range of pupils and parents in each school, the project focused particularly on three age cohorts: Cohort A (children initially in school year 4, aged 8/9 years), Cohort B (children initially school year 5, aged 9/10 years) and Cohort C (children initially in school year 7, 11/12 years). For these children questionnaires sent to parents were matched with their own responses to build up a picture of the child's physical activity and travel patterns that could be linked to parental attitudes to travel and car use.

In addition anthropometric measures were taken for children in these cohorts. This involved measurement of height in cm (to the nearest mm) using a Leicester Stadiometer and weight and body fat using Tanita bioelectrical impedance scales. This allowed for a measurement of both body mass index (BMI) and percentage body fat.

The UCL research included a total of 849 pupils in the three year-group cohorts. Table 1 below shows the response rates for each questionnaire and the anthropometric measures. The final column records those individuals within the cohorts for who all three sets of data were available. This data was prepared in May 2002 and the current dataset is actually larger than reported here, particularly for Cohort C, the older age group. As at May 2002 however, overall response rates for the three cohorts were 95% for the pupil survey, 70% in the parent survey, and 88% for the anthropometric data exercise. Complete data from all three surveys were obtained for 65% of the children. Although it is possible to use all the data for different parts of our analysis in order to ensure consistency, this paper uses only that data where we have complete records from the pupil, parent and anthropometric measures.

Table 1: The Schools Survey: Response Rates

Cohort	**Age**	**Children's questionnaire**		**Parents' questionnaire**		**Anthropometric measurements**		**All surveys**	
		No.	Response rate	No.	Response rate	No.	Response rate	No.	Response rate
A	9/10	321	98	229	70	297	91	213	65
B	10/11	324	96	241	72	304	90	227	68
C	12/13	162	87	123	66	148	79	109	58
Total		807	95	593	70	749	88	549	65

5. PHYSICAL ACTIVITY MONITORING USING RT3 MOTION SENSORS

The second major component of this research was a study of a smaller number of young people using motion sensors coupled with the use of a travel and activity diary. The schools survey provides information on a larger population but is subject to a number of constraints normally associated with such methods (Cooper *et al.* 2000, Cradock and Gortmaker 2000, Westerterp 1999, Eston *et al.* 1998). In order to gain a better understanding and more accurate picture more intensive research methods are necessary.

The use of accelerometers can remedy some of the problems in over reporting by recording human movement. The use of accelerometers, particularly multi-dimensional accelerometers has been widely documented (Cooper *et al.* 2000[2], Westerterp 1999, Eston 1998) with studies demonstrating the usefulness of accelerometers for research into physical activity[3].

[2] In particular, Cooper *et al.* (2000) provide an overview of the research and validation studies that have been conducted into the use of accelerometers.

[3] Chen and Sun Ming (1997) found the triaxial accelerometer to underestimate energy expenditure for sedentary, moderate and some activities. This research finding is not wholly supported by other trials

The accelerometer used in this study was the RT3 manufactured by Stayhealthy, USA. It is a tri-axial accelerometer, i.e. it measures movement in three directions. The RT3 is a direct successor to the Tri-trac R3D. The RT3 measures human movement on three planes and combines these into a total of vector magnitude (VM). In this study the RT3 was set to record movement on a minute-by-minute basis[4]. Rowlands *et al.* (1999) developed cut-offs of VM relating to different levels of physical activity and these cut-offs have been used in this paper[5].

The RT3 is the size of a small pager (7x5x8cm) and is worn at the hip using either a purpose made holster or belt. It can be worn without difficulty for all but water-based activities. In this study volunteers were asked to wear the monitor from a Wednesday through to a Sunday evening. Although a number of studies (Cooper *et al.* 2000) have used a seven day period, results over this shorter time period have also been shown to be reliable for multi-dimensional accelerometers. The travel and activity diary was kept from Thursday morning through to Sunday evening. Events from the travel and activity diary are mapped onto the data from the RT3 so that it will be possible to isolate and analyse specific time periods, events or journeys.

Physical activity monitoring was targeted at two of our cohort groups: Cohort B (those children who were originally between the ages of 9/10 years) and Cohort C (those originally between 11/12 years). At the time of the monitoring these children had moved into the next school year and were aged 10/11 years or 12/13 years respectively. Volunteers were recruited from schools that had participated in the original survey. In total 148 children were monitored between April and the end of July 2002. There are plans to monitor additional volunteers in Winter/Spring 2003. Table 2 below provides information on the volunteers by age group and gender. Anthropometric measures were collected for all children who took part in the physical activity monitoring.

Table 2: RT3 Activity Monitoring Participants

Cohort	**Males**	**Females**	**Total**
Cohort B (aged 10-11 years)	35	30	65
Cohort C (aged 12 – 13 years)	41	42	83
Total	76	72	148

Data entry of travel and activity data for Cohort C is not yet complete and for this reason Cohort C has been omitted from the findings presented in this paper. This, of course, means that there is no cross-sectional analysis available for the RT3

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although there remain some areas where motion sensors may underestimate energy expenditure, in particular strength related activities.

[4] The RT3 can be set to record on a second-by-second or minute-by-minute basis. Depending on whether the RT3 records for the three dimensions separately, this gives a run time varying from 9 hours through to 21 days.

[5] The paper by Rowlands *et al.* used measures of VM from the TriTrac-R3D, the forerunner to the RT3, to determine activity level cut-offs in 8-10 year olds. The RT3 has been designed as a direct successor to the TriTrac (Stayhealthy website, 2002) and it is assumed that the cut off points will be identical or very similar.

monitoring component of the research at this time. Although data was collected from 65 children in cohort B, 13 records were incomplete. In the following analysis, where total time is critical only the 52 records that contain a full four days of monitoring have been included.

6. PRELIMINARY RESULTS

The results presented in this paper have been considered under four headings: car use and dependency; physical activity levels; physical activity levels and body composition; and physical activity levels and car use/dependency. Where possible results from both the school's survey and the RT3 monitoring have been presented. However, the RT3 analysis is not yet available for car use and dependency and has been omitted from the first and final sections of the results. As already mentioned, all these results are preliminary. Results that use indices (survey results) are subject to review although broad trends would not be expected to change.

Car Use and Dependency

One of the objectives of this project is to examine the way in which parents use the car and the impact this has on their children. As a start to this analysis the questionnaires to pupils and parents have been analysed to ascertain the level of car ownership and use within the sample. More detailed information on travel patterns will be available through the analysis of travel and activity diaries as part of the RT3 monitoring study. However, at this point it is useful to identify broad descriptive trends which may have an impact on children's physical activity.

One simple measure of car use and dependency is the number of cars per household. Table 3 records this information for the sample and compares this to national and regional figures.

Table 3: Household car ownership (percentages)

	0 cars	1 car	2+ car	Total
Sample of children in Hertfordshire	2	29	66	100
Great Britain – whole population	28	45	26	100
Great Britain – households with two adults plus children	9	47	44	100
South-East England – whole population	20	48	32	100

Sources: Schools survey of children in Hertfordshire, 1998/2000 National Travel Survey, and Focus on Personal Travel, Department of Transport, Local Government and the Regions, 2001 (The Stationery Office, London).

The children in the sample live in households with very high levels of car ownership, with 66% owning two or more cars and only 2% living in households without a car. The high levels of car ownership reflect the relatively high levels in the South-East

Region which is a wealthy part of Britain, but it also suggests that children may be a causal factor in the high levels of car ownership. The work patterns of parents often determine car use and ownership and this will be examined in future work on this project.

However the proportion of children being taken to school by car – 38% - is in line with the same proportion nationally. Nationally, about 53% of children walk to school (Mackett *et al.* 2002c). As can be seen in Table 4, for our sample this figure is 50%. The table also shows that a high proportion of children are taken to after school activities by car. The growth in structured activity tends to be associated both with a decline in unstructured or free play outside the home and with additional car journeys. In itself, this does not mean that children are less active, however, it does raise the question of whether structured activities that necessitate car use are contributing overall to car dependency. Figures for both school and after school travel reveal the low use of the bicycle as a mode of transport for children.

An earlier paper produced as part of this project explores these figures in more detail (Mackett *et al.* 2002) and shows that although car use to school declines with age it does not result in an increase in walking and the reduced car use is almost entirely accounted for by the increase in the use of public and school transport. This earlier paper also shows that only 28% of journeys to school by car are made solely for this purpose whilst 47% are made as part of a journey to work, i.e. the child or children are dropped off on the way to a place of work. This figure may explain the difficulty of promoting some interventions aimed at encouraging children to walk to school. Other research under this project suggests that working parents are often the most impervious to measures which impinge on their time constraints or flexibility, for example the set route and time of a walking bus[6].

Table 4: Travel to School and After School Activities

	Trips to school		**Trips to after-school activities**	
	Number	%	Number	%
Car	210	38	340	62
Walk	272	50	110	20
Cycle	4	1	18	3
Bus	63	12	7	1
No response	-	-	74	13
Total	549	100	549	100

Whilst it is relatively easy to demonstrate car use, it is much harder to explore whether some households are more car dependent than others. As a starting point to the development of an indicator that will reveal different levels of car dependency, questions on the parent questionnaire were grouped and a ‘car dependency’ scale was created. Whilst this is subject to further development and refinement the information in Table 5 presents the results of this first attempt. The indicator is measured on a scale of 0 to 5, where 0 would mean the car is not considered as the only means of

[6] This issue will be discussed more fully in a forthcoming paper presenting a case study evaluation of four walking buses in the Hertfordshire area.

transport available (although it does not imply a car is never used) and 5 would mean that the car is used for most trips that involve travel from the home.

Table 5: Car Dependency Indicator

Car Dependency Scale	Frequency	Percent
0	18	3.3
1	86	15.7
2	121	22.0
3	70	12.8
4	88	16.0
5	166	30.2
Total	549	100.0

This indicator tends to reinforce earlier results which point to a high level of car use amongst a significant number of parents/households in the sample. Further work to distinguish factors which influence car dependency such as number of cars per household, ages and age ranges of children, full and part-time working patterns, and household location will be examined in the future. This car dependency indicator is used in the later analysis which looks at car dependency and physical activity.

Children's Physical Activity Levels

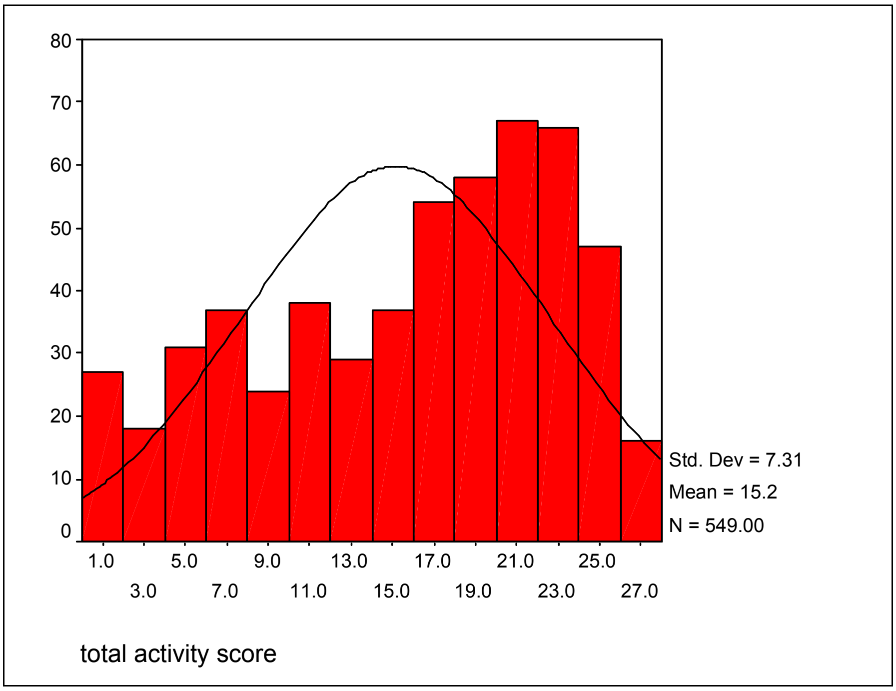
Survey Results

The questionnaire administered to pupils contained a number of questions which related to travel patterns and physical activity. Pupils were asked to indicate their level of physical activity at different times of the school day (including travel to and from school), and record structured activities which took place out of school hours. An indicator of physical 'activity' was constructed by weighting different answers taking an average VM[7]. Future refinements would include adjusting the weighting to take account of age and gender. This approach, whilst not as accurate as the use of an accelerometer does allow for an analysis of a larger sample than is possible using the RT3 accelerometer alone. However, it should be noted that it does not measure physical activity as such, but only illuminates different levels of physical activity between children (i.e it can be used to distinguish less and more physically active children).

In total, it was possible to gain between 0 and 28 'points' relating to physical activity. All scores were possible and were in fact were achieved. Scores tended to be skewed to the lower end of the scale (N=549, mean=15.2, sd=7.31). The bar chart in Figure 1 provides a summary of this data.

[7] Average VM scores were taken from an analysis of the RT3 data collected for the two age cohorts included in this part of the study. Clearly this does not take into account variations between children. However, as a crude measure of activity it can be applied to large populations.

Figure 1: Bar Chart to show frequency of Physical Activity Scores



Whilst it is apparent that the scores are skewed to the lower end of the scale, there are also a large number of individuals who do not score well. As a general rule a score of 18 would represent a reasonably active child although minimum levels of physical activity may be gained below this point.

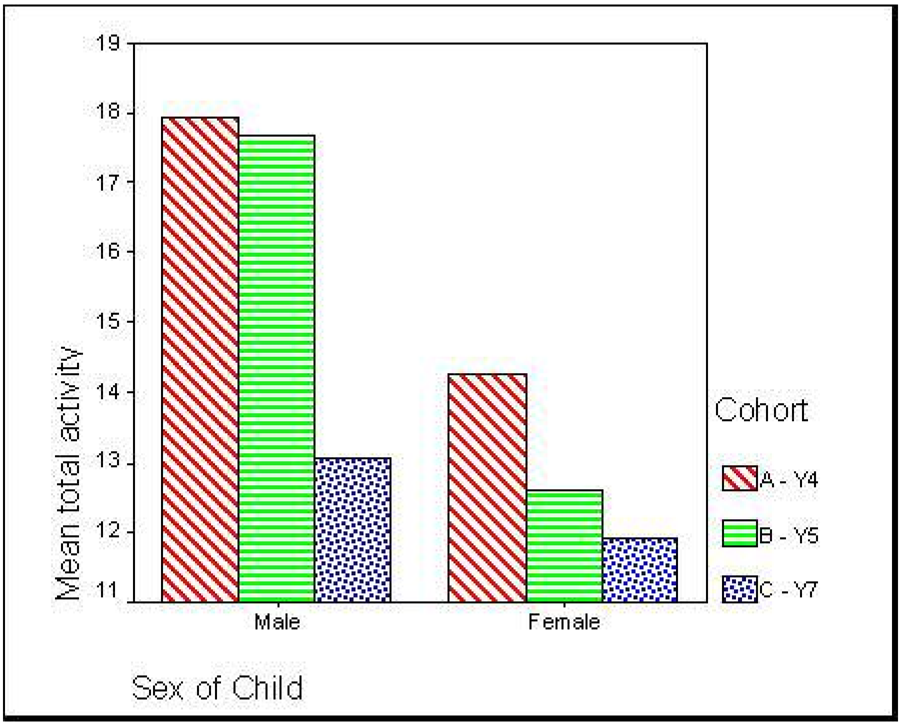
Physical activity score shows a drop over cohort for both boys and girls, a finding consistent with other research as detailed earlier. This can be seen clearly in Table 6 below which shows physical activity score by both gender and cohort. A more detailed reading of the scores reveals that this is nearly always accounted for by decreased physical activity in the school day, particularly for girls. The move to secondary school would seem to be associated with a change in the way both girls and boys spend break times.

Table 6: Physical Activity Scores by cohort and gender

		Male			Female		
		A -Y4	**B - Y5**	**C - Y7**	**A - Y4**	**B - Y5**	**C - Y7**
Total activity score	Minimum	0.00	0.00	0.00	0.00	0.00	0.00
	Maximum	27.00	27.00	28.00	26.00	27.00	25.00
	Mean	17.91	17.69	13.06	14.25	12.58	11.90
	Std Deviation	5.58	6.71	7.08	7.37	8.02	6.91

Statistical testing of this data reveals that the drop off in physical activity score is significant for the both boys and girls between Cohort A and C ($p<0.00025$), but only between Cohort B and C for boys ($p<0.00025$). The reduced significance for girls may be explained either by their lower levels of physical activity to start with, or perhaps because the drop off in girl's physical activity occurs at a younger age than was measured by this study. The relationship between gender, cohort and mean physical activity score is shown diagrammatically in the following bar chart.

Figure 2: Bar Chart to show Mean Physical Activity Score by Gender and Cohort



RT3 Motion Sensor Results

The RT3 measures human movement in three dimensions and computes these to an overall measure of vector magnitude (VM). Although comparisons of total VM are useful for some analyses, the following uses the cut-offs developed by Rowlands *et al.* (1999). Table 7 below provides a comparison between weekdays and weekends for Cohort B and shows that for every level of physical activity (other than vigorous) weekdays record more time than weekends (nb. resting time is not shown here).

Table 7: Levels of Physical Activity by Week Day and Week End

Activity Level		**weekend**	**weekday**
		N = 52	
Very light	Mean (minutes)	408	464
	Std Deviation	141	114
Light	Mean (minutes)	193	209
	Std Deviation	55	49
Moderate	Mean (minutes)	77	87
	Std Deviation	41	34
Vigorous	Mean (minutes)	32	46
	Std Deviation	27	26
Very vigorous	Mean (minutes)	2	2
	Std Deviation	6	3

Although the results clearly show the difference in physical activity levels between weekdays and weekends, it should be noted that the standard deviation in some of the categories is large in comparison to the mean totals. The variation between children at nearly all levels is extremely large and the table does not adequately represent these differences.

The differences between boys and girls is also apparent in the RT3 data. Table 8 below shows that boys spend longer at both moderate and vigorous levels of physical activity. Statistical tests show this to be significant although there is no significance in the differences between other physical activity levels.

Table 8: Mean Time for Physical Activity Levels by Gender

	Gender	No.	Mean	Std. Deviation
Very light	Male	29	447.28	156.267
	Female	23	421.92	60.152
Light	Male	29	195.22	45.804
	Female	23	207.73	45.279
Moderate	Male	29	90.61	36.196
	Female	23	71.18	26.111
Vigorous	Male	29	47.38	24.561
	Female	23	28.15	12.437
Very vigorous	Male	29	2.16	3.160
	Female	23	2.02	4.075

Although the above figures tell us something about the differences between girls and boys and point to key variations in physical activity levels, they do not tell us much about what proportion of the sample are obtaining optimum levels of physical activity. To examine this in more detail we took, as a guideline, the recommendation that all young people should participate in one hour of moderate physical activity every day (HEA 1997, Biddle *et al.* 1998). Using RT3 motion sensor data an analysis was carried out to ascertain what proportion of children met these targets on a daily basis. This required a measure how long individuals engaged in at least moderate physical activity. Again, the analysis uses the cut-off points for levels of physical activity described by Rowlands *et al.* (1999).

The following table shows the frequency for the number of days the minimum level of physical activity was met. It should be noted that this does not take into account that some children may be extremely active on one day and then less active on another. Children who do not gain one hour of moderate physical activity per day may in fact still achieve this as an average over a number of days and further analysis will explore this.

Table 9: Number of Days that Minimum Levels of Physical Activity Were Met

One hour of moderate activity achieved on:	Frequency	Percent
0 of 4 days	2	3.8
1 of 4 days	1	1.9
2 of 4 days	7	13.5
3of 4 days	15	28.8
All 4 days	27	51.9
Total	52	100.0

Whilst only a small number of children fail to achieve the minimum levels of physical activity on any of the days a significant number of them (48.1%) would seem not to achieve these levels on all four days. The minimum requirement is only met by just around half of the sample. If the totals for achieving minimum levels on 3 or 4 days are combined then a sizeable number reach the minimum levels (80.7%) and it may be better to look at overall averages rather than daily averages. However, if weekend and weekdays are considered separately then an interesting pattern is revealed, as shown in Table 10 below.

Table 10: Weekday and Weekend Differences for Minimum Levels of Physical Activity

Number of days that minimum was met over weekdays

	Frequency	Percent
0 of 2 days	8	15.4
1 of 2 days	15	28.8
Both days	29	55.8
Total	52	100.0

Number of days that minimum was met over the weekend

	Frequency	Percent
0 of 2 days	3	5.8
1 of 2 days	3	5.8
Both days	46	88.5
Total	52	100.0

Far more children achieve the minimum recommended physical activity at the weekend than during the week, even though earlier analysis has shown that children are less active overall at the weekend. Further analysis which looked at time spent at moderate or above levels of physical activity found that although more children reach the minimum levels of physical activity at the weekend, they are actually more active in terms of time spent at moderate or above levels of physical activity during the week. The mean number of minutes spent at moderate or above is 135 for the weekdays and 111 for the weekend. A paired samples t-test shows that the difference between the two is significant ($t=3.188$, $df=51$, $p=0.0015$). The amount of time spent at moderate or higher levels of physical activity during the week is also positively correlated with time spent at the weekend ($r=0.595$, $N=52$, $p<0.00025$). Again, the sample size is perhaps too small to be certain of these results, particularly as the ranges in this dataset are so large, but they do suggest that the more active children are consistently so.

Further analysis, using the larger sample, will provide more solid results by gender. Our initial enquiries revealed that a greater proportion of boys (66%) than girls (35%)

achieve the minimum recommendation on all four days and that boys are more active overall than girls. Girls also tend to be more active at the weekend than they are during the week, with only 39% of girls achieving the minimum physical activity levels during the week as opposed to 87% at the weekend. However, all these findings would need further testing before results are available and there are key differences in the range and standard deviation from the mean for boys and girls which require further clarification. Whilst it may be useful to provide mean scores by gender, this masks a huge variation within gender that really necessitates further analysis.

Body Composition against Age and Gender

An important part of this research project is to look at the relationship between car use, physical activity and body composition. Data relating to body composition was collected for the three cohorts taking part in the survey and for the participants in the RT3 monitoring study. Measures of body composition based on BMI and Bio-electrical impedance are available and will be utilised. However, the relationships and data reported here make use only of BMI, where BMI is calculated as $BMI(kg.m^{-2}) = \frac{Weight(kg)}{Height(m)^2}$. The categories used rely on the cut-offs developed by Cole *et al.* (2000). Table 11 summarises the BMI data for the survey sample, whilst Table 12 provides this for the RT3 monitoring participants.

Table 11: BMI by Gender and Cohort – Survey Sample

Table 11a: Males in the Survey

		BMI category			Total
Cohort		**Normal**	**Overweight**	**Obese**	
A - Y4	**Count**	101	15	5	121
	Row %	83.5%	12.4%	4.1%	100.0%
	Col %	40.4%	29.4%	55.6%	39.0%
B - Y5	**Count**	95	25	1	121
	Row %	78.5%	20.7%	.8%	100.0%
	Col %	38.0%	49.0%	11.1%	39.0%
C - Y7	**Count**	54	11	3	68
	Row %	79.4%	16.2%	4.4%	100.0%
	Col %	21.6%	21.6%	33.3%	21.9%
All cohorts	**Count**	250	51	9	310
	Row %	80.6%	16.5%	2.9%	100.0%
	Col %	100.0%	100.0%	100.0%	100.0%

Table 11b: Females in the Survey

		BMI category			Total
Cohort		**Normal**	**Overweight**	**Obese**	
A - Y4	**Count**	72	13	7	92
	Row %	78.3%	14.1%	7.6%	100.0%
	Col %	38.7%	34.2%	46.6%	38.5%
B - Y5	**Count**	79	21	6	106
	Row %	74.5%	19.8%	5.7%	100.0%
	Col %	42.4%	55.3%	40.0%	44.4%
C - Y7	**Count**	35	4	2	41
	Row %	85.4%	9.8%	4.9%	100.0%
	Col %	18.8%	10.5%	13.3%	17.2%
All cohorts	**Count**	186	38	15	239
	Row %	77.8%	15.9%	6.3%	100.0%
	Col %	100.0%	100.0%	100.0%	100.0%

Table 12: BMI by gender and cohort – RT3 monitoring sample cohort B

		BMI category			Total
		Normal	**Overweight**	**Obese**	
Male	**Count**	29	6		35
	Row %	82.9%	17.1%		100.0%
	Col %	59.2%	40.0%		53.8%
Female	**Count**	20	9	1	30
	Row %	66.7%	30.0%	3.3%	100.0%
	Col %	40.8%	60.0%	100.0%	46.2%
Total	**Count**	49	15	1	65
	Row %	75.4%	23.1%	1.5%	100.0%
	Col %	100.0%	100.0%	100.0%	100.0%

Although figures for obese children are low in each sample, overall the figures for overweight children in all categories (adding in obese children) and for both girls and boys would seem to be higher than those reported by Chinn and Rona (2001). Chinn and Rona report a figure for English boys between 9-11 years of 12.7% and for English girls between 9 –11 years of 16.7%. The sample for Cohorts A and B (which accord with these age divisions) suggest a higher figure overall. However the figures produced by Chinn and Rona are for 1994 so it is unclear whether the above figures represent a growth in overweight or an over-representation in the sample.

The relationship between BMI and Physical Activity

A number of tests have been carried out to ascertain whether there is a negative relationship between physical activity and BMI using both the survey and RT3 monitoring data. As this analysis is in its early stages these results are not reported in this paper. However, early indications would confirm other research (for example, Cooper *et al. 2000,* Rowlands *et al.* 1999). For the survey data there is a weak relationship between total physical activity scores and BMI category although this is not significant. For the RT3 data there are no clear relationships between BMI and overall levels of physical activity. Analysis by gender for both these results did not reveal any differences in significant levels between girls and boys. Generally speaking, at the ages this research targets there would not appear to be a straightforward relationship between body composition and the amount of physical activity children engage in. Further research will attempt to clarify this further and test for relationships within groups and by other factors.

Car Dependency and Children's Physical Activity

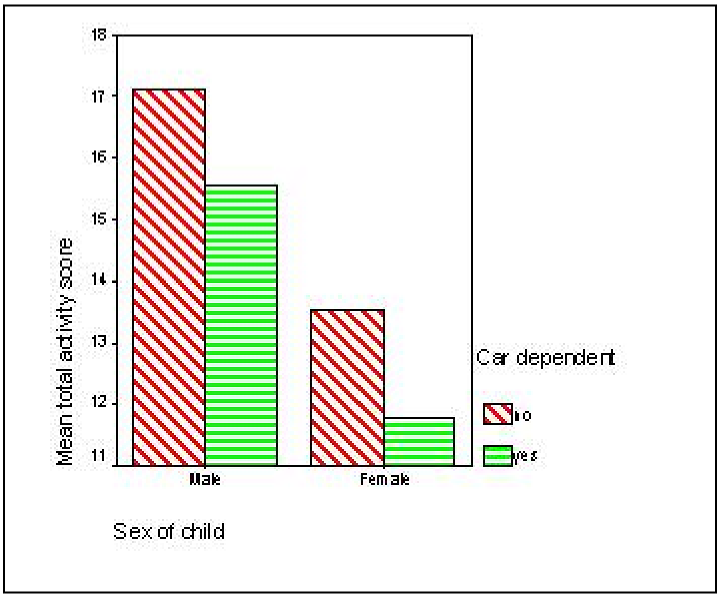
The data contained in this section is drawn entirely from the survey although future analysis will be able to utilize the more detailed travel and activity data from the RT3 activity monitoring component of the research.

As seen in the first results section above the car is used extensively by many of the children in the sample, for going to and from school and on other non-educational trips. The indicator developed to identify high car users in the sample demonstrated that 30.2% of parents fell into the highest category. This indicator was used to ascertain whether there was any relationship between high car use in families and physical activity levels in children. Whilst it should be accepted that there are many factors that contribute to physical activity, early findings do seem to suggest that there is a relationship – albeit modest - between high car usage and physical activity. There is a significant negative correlation (rho = -0.226, N = 549, $p < 0.00025$) thus physical activity would appear to go down with increased parental car dependence.

In order to test this relationship further we developed a simple Yes/No indicator for car dependence based on the car dependency of parents (5=yes, 0-4 =no) as well as taking into account whether children used other forms of transport to the car.[8] This relationship becomes stronger if we only consider those children whose parents scored 5 on the car dependence scale. The following bar chart shows the effect of car dependency on physical activity (or vice versa) by gender. There are significant - but modest - differences between the car dependent and non-car dependent group. However, this would need further analysis of the data in order to provide a more robust measurement and result and the following should be seen as illustrative of possible research findings rather than solid evidence as this stage.

[8] Again, this measure is rather crude and necessitates some refinement but nevertheless allows us to test out the relationship on a large sample in the early stages of our analysis. It is expected that further refinement and testing will take place in the future.

Figure 3: Car Dependency and Physical Activity Scores



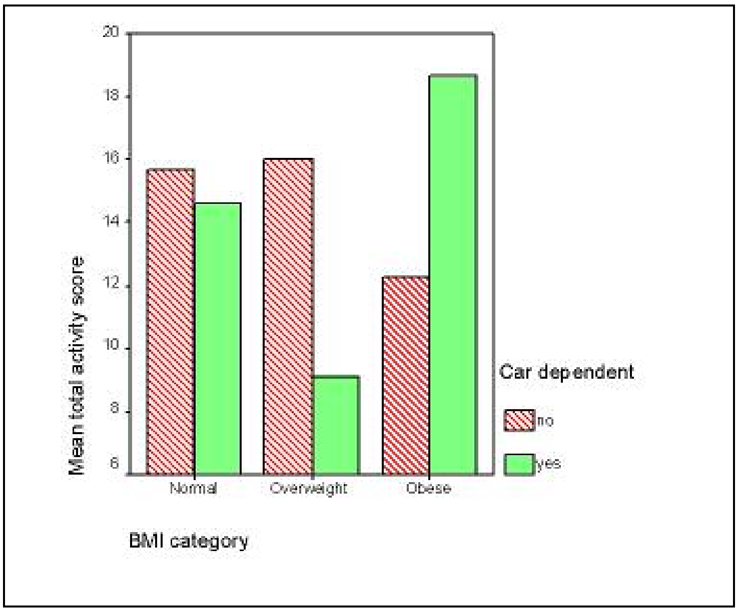
The analysis also considered whether there was any relationship between body composition and use of the car. Although a rather simple measure, the table below records use of the car to travel to school and out of school activities by body composition (where obese is included in the overweight category). As can be seen there is no relationship between car use and body composition – if anything more children of normal weight are taken by car.

Table 13: Percentage of Children by BMI by Mode of Travel

	Trips to school			Trips to after-school activities		
	Normal weight	Overweight	All	Normal weight	Overweight	All
Car	39	37	38	63	58	62
Walk	50	50	50	20	22	20
Cycle	1	1	1	3	4	3
Bus	11	12	11	2	0	1
No response	0	0	0	13	16	13
Total	100	100	100	100	100	100

An analysis of the car dependency measure with body composition (BMI) was similarly non conclusive with very little difference in mean physical activity between normal and overweight groups and an against the trend result from the obese group. Again for illustrative purposes only, this is shown below by Figure 4. Given the absence of any straightforward relationship between body composition and physical activity, this result is not surprising.

Figure 4: Car Dependency and Body Composition (BMI)



Clearly further analysis would need to take place in order to draw any firm conclusions on the relationship between physical activity and car use although it would seem apparent, in line with the results from this and other research, that there is likely to be no or little association between car use and overweight or obesity.

7. CONCLUSIONS

This paper has looked briefly at the relationship between car use, car dependency and children's physical activity and body composition. Whilst the analysis should be considered preliminary at this stage, it has raised a number of issues for further analysis and discussion.

The survey results suggest high levels of car use and ownership amongst households in the sample. Whilst this would benefit from being linked to other factors such as locational and economic and household data, current findings point to a reliance on the car as the preferred mode of travel for nearly all trips for a small but highly significant number of households. For children, this can be seen not only in the high proportion (at primary school age) taken to school by car, but also in the number of trips to outside activities. There remain real questions, of relevance to policy and research communities, as to the longer-term impact of this growing use of the car for both educational and non-educational trips.

Research findings in relation to physical activity are broadly similar to other research and reaffirm the message that most policy makers are aware of: that girls are less active than boys and that they become even less active as they mature. It also demonstrates that whilst physical activity levels cannot be related to body composition in a simple sense, this may be because a small but significant proportion of children – of all body type – do not achieve minimum levels of physical activity. This would, of course, necessitate further analysis of the data.

Whilst at this stage inconclusive, there does seem to be a relationship between household or parental car dependency and levels of physical activity. The results would seem to show that the higher the car use in the family, the lower the overall levels of physical activity. However, there is no relationship between car use, car dependency and adiposity that can be drawn out from these results. Car dependent children come in all shapes and sizes.

Some of the main concerns over car dependency remain though, particularly when we take into consideration the changes that have brought them about. The increasing use of the car to take children to structured activities is illustrative of the demise of unstructured play outside of school. As many of these structured activities do not continue into adulthood one is forced to question whether, amongst other more positive outcomes, they inadvertently contribute to car dependency.

Further research using both the survey data and the RT3 motion sensor/travel diaries intends to look much deeper into the relationship of car journeys and trips and children's physical activity levels and the type of physical activity (structured versus unstructured) they participate in. Likewise, although this paper has indicated that body composition may not be significantly related to physical activity or car use, there is still value in pursuing this to discover whether there are key differences in lifestyle and travel and physical activity between the overweight and normal weight groups, even if these are only qualitative ones.

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