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# The contribution of active travel to children's physical activity levels: cross-sectional results from the ALSPAC study

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## Abstract

**Objective—**To assess the association between active travel to school and physical activity (PA) in a large population-based sample of 11-year old children.

**Method—**Cross-sectional analyses using data from the Avon Longitudinal Study of Parents and Children (Bristol, UK), collected in 2002-2004. The analyses include all children providing valid data on objectively-measured PA (Actigraph accelerometer), and having parent-proxy reported data on travel mode (walk, cycle, public transport, car) and distance to school (N=4688).

**Results—**43.5% of children regularly walked or cycled to school (i.e. on every or most days). Compared with car travelers, walking to school was associated with 5.98 (95%CI: 3.82-8.14) more minutes of moderate-to-vigorous PA (MVPA) on weekdays in those living 0.5-1 miles from school, and with 9.77 (95%CI: 7.47-12.06) more minutes in those living at 1-5 miles. This equates to 24.6 to 40.2% of the average daily minutes of MVPA. Only modest differences were observed in those living <0.5 mile from school.

**Conclusion—**Children who regularly walk to school are more active during the week than those travelling by car, especially if the distance is >0.5 mile. Increasing participation in active travel might be a useful part of an overall strategy to increase population PA.

### Keywords

Physical Activity; ALSPAC; school travel; children; walking

## INTRODUCTION

There is growing evidence that lack of physical activity during childhood is predisposing children to the development of obesity and chronic health conditions later in life (Department of Health, 2004, World Health Organization, 2004). In addition, physical activity levels in children are believed to be too low (Andersen et al., 2006, Dollman et al., 2005, Gordon-Larsen et al., 2004, Riddoch et al., 2007). This may be the result of reductions in multiple domains of physical activity, such as physical education, active travel and

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organized sport (Dollman et al., 2005). To date, research into the promotion of physical activity levels has mostly focused on increasing sports participation, physical activity in general or modifications to physical education classes, most of which have had limited success (van Sluijs et al., 2007). Travel to school has been identified as a possible target for increasing physical activity levels in children (Tudor-Locke et al., 2001). Active travel to school appears to offer an opportunity for many children to engage in physical activity and is recommended as a daily activity for school-aged children (Department of Health, 2004). Population-based data however shows that between 1985/86 and 2006 the percentage of UK primary-school children who regularly walk to school has decreased from 67 to 52%, whereas the percentage travelling by car increased from 22 to 41% (Department for Transport, 2002, Department for Transport, 2007). Over the same time, the average distance primary school children travel from home to school has increased from 1.1 to 1.5 miles (Department for Transport, 2002, Department for Transport, 2007). Similar trends are evident in the US (McDonald, 2007) and Australia (Salmon et al., 2005, van der Ploeg et al., 2008).

Previous work has shown that active travel is associated with higher overall activity levels, with differences predominantly observed on weekdays and especially in children from the age of 9 years,(Cooper et al., 2005, Cooper et al., 2003, Faulkner et al., 2009, Saksvig et al., 2007, Sirard et al., 2005) an age from which independent mobility tends to increase (O'Brien et al., 2000). However, these studies mostly included small sample sizes, studied non-representative or selective groups, dichotomized groups into active and non-active travelers, and did not consider the potential dose-response relationship with distance travelled. Uncertainty remains as to whether active travel also contributes to higher activity levels outside travel times (Faulkner et al., 2009). We therefore sought to identify whether active travel to school is associated with physical activity in a large population-based sample of 11 to 12-year old British children.

## METHODS

### Study population

The Avon Longitudinal Study of Parents and Children (ALSPAC) is a prospective birth cohort study into determinants of childhood health. The study has been described in detail elsewhere (see also: http://www.alspac.bris.ac.uk) (Golding et al., 2001). In brief, 14,541 pregnant women living in one of three Bristol-based health districts in the former County of Avon (UK) with an expected delivery date between April 1991 and December 1992 were enrolled in the study. During pregnancy and throughout childhood detailed information was collected using amongst others self-administered questionnaires and at research clinics. Ethical approval for the study was obtained from the ALSPAC Law and Ethics Committee and Local Research Ethics Committees.

### Data collection procedures at age 11

The child's main carer (not necessarily the biological mother) completed a questionnaire when the child was approximately 11 years old. In addition, at age 11 all children were invited to attend the clinic, where a range of clinical measures were taken, they completed questionnaires and were asked to wear an MTI Actigraph AM7164 accelerometer (Actigraph) afterwards.

### Outcome measure – physical activity

The Actigraph is a uniaxial accelerometer and has been validated in both children and adolescents against indirect calorimetry (Melanson and Freedson, 1995) observational techniques (Fairweather et al., 1999) and energy expenditure measured by doubly labeled

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water (Ekelund et al., 2001). Actigraphs monitors were set to measure acceleration (expressed as counts) at a 1-minute epoch. Children were instructed to wear the monitor on the right hip using a waist band during waking hours for seven consecutive days, only to be taken off for showering, bathing, or any water sports. Monitors were returned by post. A valid day was defined as providing data for at least ten hours per day (excluding sequences of 10 or more minutes with consecutive zero counts), and children were only included in the analyses if they provided at least three valid days of recording (Mattocks et al., 2008).

Two physical activity outcome variables were derived: 1) Total physical activity was the average accelerometer counts per min (counts/min) over the full period of valid recording; 2) Time spent in moderate-to-vigorous physical activity (MVPA) was the average number of minutes of MVPA per valid day, using a population specific cut off of 3600 counts/min (Mattocks et al., 2007). For both outcome measures we derived variables for the total week, and separately for week and weekend days. We additionally derived average physical activity (in counts/min) during all individual hours of the day on weekdays (between 7am and 10pm).

### Exposure measure – travel mode

A newly developed question asked the main carer to report on the child's usual travel mode to and from school at age 11, independent of season. For journeys to and from school separately, the carer indicated whether or not the child used one of six forms of transport (car/walking/cycling/public transport/school bus/wheelchair/other) and the frequency of use in two categories: 'every or most days' or 'some days'. Main mode of transport was determined by selecting the mode with the highest reported frequency. If two or more travel modes were reported to occur equally frequently, the travel mode with the lowest energy expenditure per distance traveled was selected in the following order: 'walking'; 'cycling'; 'public transport/school bus/wheelchair/other'; 'car'. Single mode trips could be identified in 97.6% of participants; only a few reported walking or cycling equally frequent as traveling by either car, public transport of school bus. Travel mode to school correlated highly with travel mode from school (Spearman correlation: 0.815, $p<0.001$) and thus only the variable travel mode to school was used for the analyses.

### Covariates

At age 11, the main carers were asked to indicate the distance to school in one of four categories by answering the question 'How far away is school?'. Answer categories were 'less than 1/2 mile (1km)'; 1/2-1 mile (1-2 km)'; 1-5 miles (2-8 km)'; and 'more than 5 miles (8 km). The day the child started wearing the Actigraph monitor was used to determine age and season. At the 11-year clinic, height was measured using a Harpenden stadiometer and weight in light indoor clothing using a Tanita TBF 305 body fat analyzer. Body mass index (BMI) was calculated as weight (in kilograms) divided by height squared (in metres). The 32-week antenatal questionnaire asked the mother to record the actual occupation of both herself and her partner, which were used to allocate them to social-class groups (classes I to V with III split into non-manual and manual, with V being the lowest category) using the 1991 census classification (Office of Population Censuses and Surveys, 1991). When the social class of the mother and partner differed, the lower of the two was used. The two highest and two lowest categories were grouped for analyses purposes. Child's ethnicity was self-reported by the mother at birth and collapsed into a dichotomous variable ('White' vs. 'Non-white').

### Statistical analyses

The data were summarized using means and standard deviations or percentages. Linear regressions analyses using total physical activity and time spent in MVPA as the dependent variables and mode of transport as independent variable were used for all analyses. Analyses were conducted using Stata (version 9.2). A significant interaction between travel mode and distance to school was identified for various outcome measures (all $p<0.02$) and therefore all analyses were stratified by distance to school. Analyses were adjusted for sex, social class, ethnicity, BMI and season. An interaction term with sex was included to study potential differences between boys and girls. Evidence was considered to be strong if a p-value of 0.001 or less was obtained.

## RESULTS

A total of 11,952 children were invited to attend the research 11-year clinic. Of these, 7,159 (59.9%) attended, and of those attended 6,622 (92.5%) agreed to wear the Actigraph. A total of 4,688 children (70.8%) provided valid physical activity data and information on travel mode and distance to school, and these children constitute the analyses sample. Table 1 shows the descriptive characteristics of the participants included in the analyses. The proportion of active travelers decreased from 83.8 to 0.0% across the increasing distance categories (<0.5 mile, 0.5-1 mile, 1-5 miles, >5 miles) (Table 2).

Tables 3 and 4 show the results of the stratified linear regression analyses using counts/minute and minutes of MVPA as outcome measures, respectively. Modest differences between travel groups were observed in the shortest distance category, whereas no differences were observed in the longest category. In the other distance categories, walkers had higher average weekly counts/minute and accumulated more minutes of MVPA than those using the car (p-value for trend ≤0.001). Further analyses showed that compared to those using public transport, walkers in the 1-to-5 mile category were also more active overall (b: 67.6 counts/min, 95% confidence interval (95%CI): 42.1 to 93.1) and during weekdays (b: 86.2 counts/min, 95%CI: 60.2 to 112.2), and accumulated more minutes of MVPA over the whole week (b: 7.87 minutes, 95%CI: 5.71 to 10.05) and during weekdays (b: 10.10 minutes, 95%CI: 7.73 to 12.46). No differences in the associations were observed between genders.

Weekday physical activity patterns differed between travel groups in the first three distance categories (Figures 1a to 1d). In general, differences in physical activity levels were observed between car travelers and walkers, and were detected between 8-9am and 3-4pm with the size of association increasing with increasing distance travelled. During these times, walkers living between 0.5 and 5 miles from school were also more active than those using public transport.

## DISCUSSION

These analyses in a large population-based cohort of 11 to 12-year old British children demonstrate that active transport to school is a major opportunity for promoting physical activity, particularly for those who live between 0.5 and 5 miles from school. Only 43.5% of children reported regularly walking or cycling to school, which is lower than national estimates (Department for Transport, 2007) and indicates a large potential for change. Just over a quarter of children lived less than 0.5 mile from school, a distance previously identified by parents as an acceptable walking distance for children aged 5 years and over (Timperio et al., 2004). Of these children, 83.8% use an active mode of transport to school but this short travel only makes a modest contribution to their overall activity levels. These findings are in line with results from a previous study amongst a smaller population of 5-year olds with a median travel distance of less than 0.5 mile where researchers were unable to show that active travel contributed to overall activity levels (Metcalf et al., 2004).

The association between travel mode and physical activity becomes stronger with increasing distance travelled to school. The children who walk a distance between 0.5 and 5 miles to school (63.7%) accumulated 5.98 to 9.77 more minutes of MVPA on weekdays than car travelers. This is 24.6 to 40.2% of the average number of minutes of MVPA accumulated on a weekday in the total population (24.3 minutes, Table 1). These higher activity levels were only observed on weekdays and no differences between travel groups were observed outside of travel times, in contrast to previous research in British primary school children of similar age (Alexander et al., 2005, Cooper et al., 2003). These results indicate that a switch in school transport mode may lead to increased activity levels, although little is known about the effectiveness of such an intervention strategy (Ogilvie et al., 2007). The data from this study suggest that the increase in weekly minutes of MVPA may be as much as 13% if all children who currently travel to school by car or public transport and live less than 5 miles from school switched to walking.

One in ten children reported living more than 5 miles away from school, all of whom travelled either by car or public transport. Alternative strategies to a shift in transport mode would be needed to increase this group's physical activity levels. It has previously been suggested that those travelling by public transport would be able to engage in more physical activity than those travelling by car as they would have to walk or cycle to the bus stop (Besser and Dannenberg, 2005, Merom et al., 2006), a hypothesis not confirmed in this study. Only 8.3% of public transport users and 7.6% of car travelers reported walking or cycling equally frequently (data not shown) and could be classified as combined travelers. One approach might be to encourage more children using motorized transport to walk part of the way to school, although the effectiveness of such a strategy has not yet been evaluated. Feasible and acceptable travel distances will differ depending on travel mode (walk, cycle), environmental factors and social norms,(McMillan, 2005) but travelling a distance of 5 miles by foot or bike may never be feasible for this population. To further refine the potential of school travel interventions, future work should consider distance to school in more detail, for example by using objectively measured distance and narrower distance categories, to help identify feasible travel distances and their likely physical activity benefits.

This is the largest and most comprehensive study to date on the association between travel mode and physical activity levels in children, and the first to consider the moderating influence of distance between home and school. This study benefits from using a large population-based sample, an objective measure of physical activity and assessing various travel modes to school. Limitations include the use of an unvalidated measure of parent-reported distance to school in broad categories,(Macintyre et al., 2008), the unvalidated measure of travel mode which does not allow for assessing trip frequency, the low proportion of ethnic minority children and the cross-sectional nature of the analyses. Social class assessed at birth was used as an indicator of socioeconomic position. Additional analyses using more recent indicators of socioeconomic position (maternal education at 97 months and council tax band at 122 months) did not alter the conclusions (data not shown). Previous analyses showed small differences between children providing valid physical activity data and those that did not (Mattocks et al., 2008), which together with cohort attrition may have resulted in an unrepresentative sample. Cut points to define minutes in MVPA were derived from a validity study conducted within the specific sample (Mattocks et al., 2007) and are higher than previously reported cut points (Freedson et al., 2005). This and the use of different types of monitors makes comparison with previously published studies difficult, and may explain why differences observed in this study are smaller than previously reported (Cooper et al., 2003, Saksvig et al., 2007, Sirard et al., 2005). The study only included a small sample of cyclists, resulting in wide confidence intervals. Overall




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patterns were similar to walkers but cyclists' activity levels may have been underestimated as a result of the measure of physical activity (Corder et al., 2007).

## CONCLUSIONS

In conclusion, this study showed that the prevalence of walking and cycling to school in a British sample is low but that walking to school travel contributes substantially to the physical activity levels of those who live more than 0.5 mile from school. Promoting active travel to school might therefore be a feasible strategy to promote increases in physical activity levels in large populations of children. Further public health strategies should focus on encouraging children who live a walkable distance from school to change their mode of transport, as well as identifying alternative strategies of physical activity promotion for those living close to school and for those children for whom active travel to school is not a feasible choice. These interventions should be evaluated using methodologically sound approaches in order to investigate whether a shift in transport mode does indeed lead to increased levels of overall physical activity.

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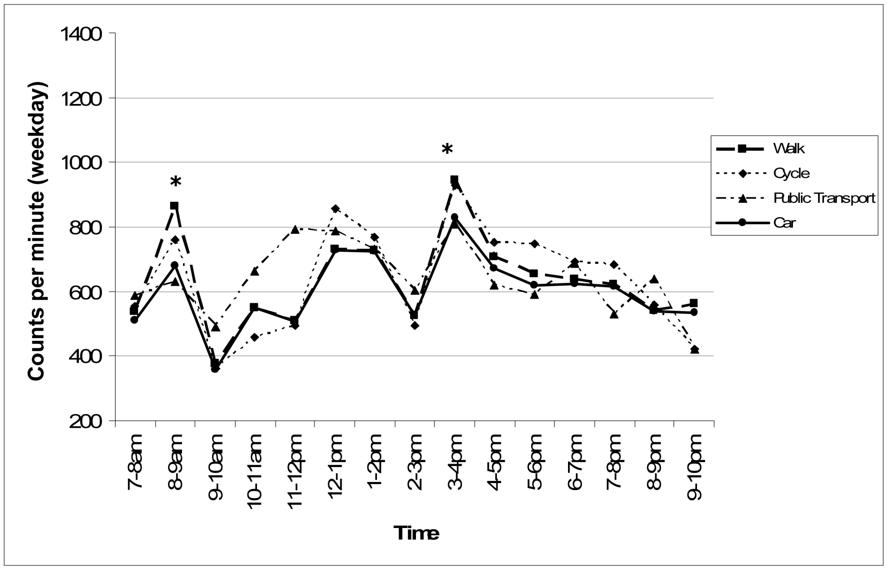
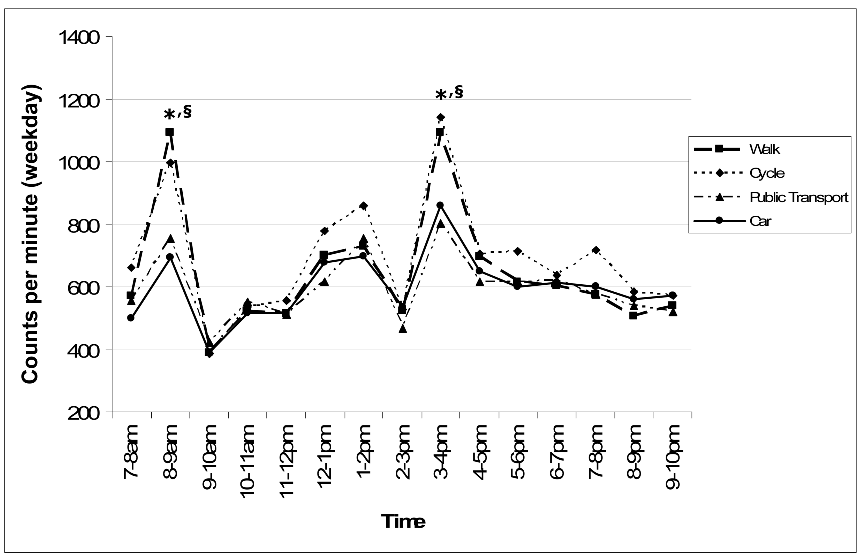
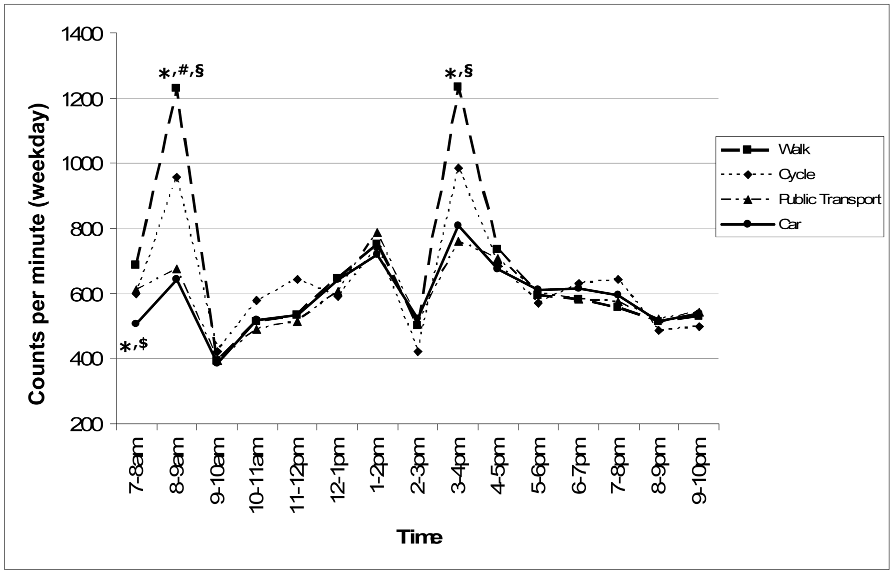
A: Less than 0.5 mile (N=1219)

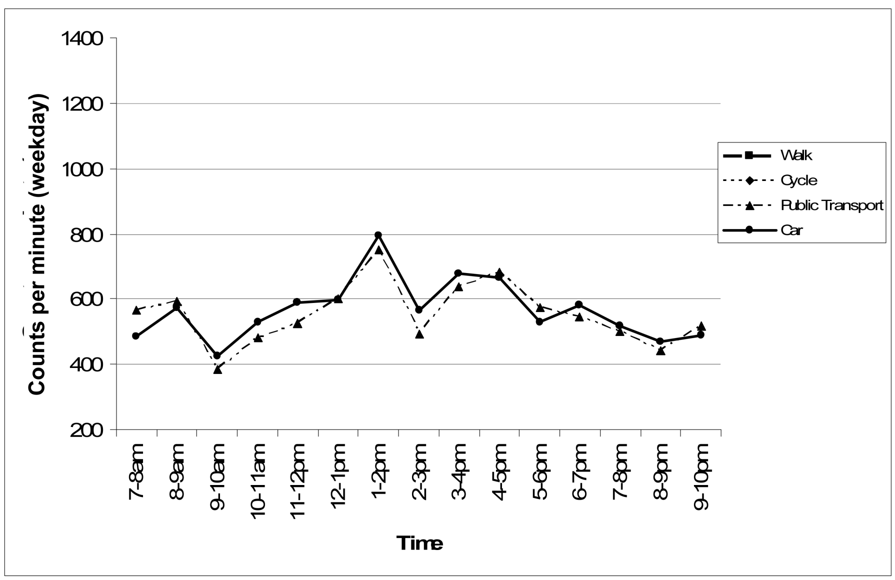



B: 0.5 to 1 mile (N=1205)



C: 1 to 5 miles (N=1779)




D: More than 5 miles (N=485)

**Figure 1.**

Average hourly counts per minute on weekdays per travel mode, stratified by distance category in 11 to 12-year old children.

*: Statistical significant difference for walkers vs. car users (p<0.001);

§: Statistical significant difference for walkers vs. public transport users (p<0.001);

$: Statistical significant difference for public transport vs. car users (p<0.001);

#: Statistical significant difference for cyclists vs. car users (p<0.001).

Data were collected as part of the ALSPAC study in the Bristol area between 2002 and 2004.

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## Table 1

Descriptive characteristics of ALSPAC sample included in analyses.

| | Boys | Girls | Total sample |
|---|---|---|---|
| N (%) | 2247 (47.9%) | 2441 (52.1%) | 4688 |
| Age in years (mean, SD) | 11.8 (0.2) | 11.8 (0.2) | 11.8 (0.2) |
| Ethnicity (%non-white) | 3.2 | 3.7 | 3.4 |
| Social class* (%) | | | |
| - I/II | 31.6 | 29.7 | 30.6 |
| - III non-manual | 28.0 | 27.5 | 27.7 |
| - III manual | 25.8 | 26.0 | 25.9 |
| - IV/V | 14.6 | 16.9 | 15.8 |
| BMI (kg/m2) (mean, SD) | 18.7 (3.1) | 19.2 (3.4) | 19.0 (3.3) |
| Travel mode to school (%) | | | |
| - walk | 43.0% | 40.1% | 41.5% |
| - cycle | 3.3% | 0.8% | 2.0% |
| - public transport | 21.2% | 21.4% | 21.3% |
| - car | 32.4% | 37.8% | 35.2% |
| Distance to school (%) | | | |
| <0.5 mile | 27.1% | 25.0% | 26.0% |
| 0.5-1 mile | 26.4% | 25.0% | 25.7% |
| 1-5 miles | 36.9% | 38.9% | 38.0% |
| >5 miles | 9.6% | 11.1% | 10.4% |
| **Physical activity outcome measures** (mean, SD) | | | |
| Daily counts per minute | | | |
| - whole week | 660.4 (185.7) | 548.7 (150.9) | 602.2 (177.5) |
| - weekdays | 666.5 (192.1) | 548.7 (152.9) | 605.1 (182.5) |
| - weekend days | 635.4 (256.3) | 545.0 (216.7) | 589.1 (241.0) |
| Minutes MVPA per day | | | |
| - whole week | 28.4 (17.0) | 18.2 (11.6) | 23.1 (15.3) |
| - weekdays | 29.9 (18.6) | 19.1 (12.7) | 24.3 (16.7) |
| - weekend days | 23.7 (20.4) | 15.0 (14.9) | 19.2 (18.3) |

Data were collected as part of the ALSPAC study in the Bristol area between 2002 and 2004.

*Social class assessed at birth. Abbreviations: BMI: body mass index; MVPA: moderate-to-vigorous physical activity; SD: standard deviation.

## Table 2

Prevalence of difference modes of transport per distance travelled to school (numbers in cells are N, % within distance category).

| | Car | Public transport | Cycle | Walk | Overall |
|---|---|---|---|---|---|
| **<0.5 mile** | 189<br>*15.5%* | 9<br>*0.7%* | 19<br>*1.6%* | 1002<br>*82.2%* | 1219<br>*100%* |
| **0.5-1 mile** | 399<br>*33.1%* | 55<br>*4.6%* | 42<br>*3.5%* | 709<br>*58.8%* | 1205<br>*100%* |
| **1-5 miles** | 859<br>*48.3%* | 653<br>*36.7%* | 33<br>*1.9%* | 234<br>*13.2%* | 1779<br>*100%* |
| **≥5 miles** | 203<br>*41.9%* | 282<br>*58.1%* | 0 | 0 | 485<br>*100%* |

Data were collected as part of the ALSPAC study in the Bristol area between 2002 and 2004.

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### Table 3

Association between mode of travel to school and levels of physical activity (**average daily counts per minute**) in 11-yr old children, stratified by reported distance travelled to school (reference category is car).

| | Whole week | | | Weekdays | | | Weekend days | | |
|---|---|---|---|---|---|---|---|---|---|
| | *b* | *95%CI* | *p-value* | *b* | *95%CI* | *p-value* | *b* | *95%CI* | *p-value* |
| <0.5 mile (N=1082) | | | | | | | | | |
| - public transport | −57.4 | −193.0; 78.2 | 0.41 | −59.8 | −198.9; 79.2 | 0.40 | −49.6 | −243.4; 144.1 | 0.62 |
| - cycling | −4.7 | −88.0; 78.7 | 0.91 | −10.9 | −96.4; 74.5 | 0.80 | −0.6 | −120.2; 119.0 | 0.99 |
| - walking | 24.6 | −2.6; 51.9 | 0.08 | 27.3 | −0.6; 55.2 | 0.06 | 11.6 | −30.1; 53.3 | 0.59 |
| 0.5-1 mile (N=1050) | | | | | | | | | |
| - public transport | 7.8 | −40.3; 56.0 | 0.75 | 3.2 | −46.7; 53.0 | 0.90 | 4.4 | −65.9; 74.7 | 0.90 |
| - cycling | 54.1 | −1.5; 109.8 | 0.06 | 50.7 | −7.0; 108.1 | 0.09 | 71.9 | −14.1; 158.0 | 0.10 |
| - walking | **39.1** | **18.1; 60.2** | **<0.001** | **51.9** | **30.1; 73.7** | **<0.001** | −11.1 | −42.7; 20.5 | 0.49 |
| 1-5 miles (N=1568) | | | | | | | | | |
| - public transport | −6.0 | −23.6; 11.6 | 0.50 | −7.9 | −25.8; 10.1 | 0.39 | 3.4 | −23.3; 30.1 | 0.80 |
| - cycling | 37.9 | −22.0; 97.8 | 0.22 | 45.6 | −15.5; 106.6 | 0.14 | 2.8 | −86.9; 92.5 | 0.95 |
| - walking | **61.6** | **36.9; 86.2** | **<0.001** | 78.4 | **53.2; 103.5** | **<0.001** | 4.8 | −32.3;41.9 | 0.80 |
| ≥5 miles* (N=424) | | | | | | | | | |
| - public transport | −6.2 | −37.3; 24.8 | 0.69 | −9.0 | −40.4; 22.3 | 0.57 | 12.0 | −38.4; 62.4 | 0.64 |

NOTE: total N=4124 due to missing data in covariates. Analyses adjusted for: sex, body mass index, social class at birth, ethnicity, and season of physical activity measurement;

*: cycling or walking not reported in this category.

Data were collected as part of the ALSPAC study in the Bristol area between 2002 and 2004.

Abbreviations: 95%CI: 95% confidence interval; b: unstandardized beta coefficient.

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## Table 4

Association between mode of travel to school and levels of physical activity (**minutes of moderate-to-vigorous physical activity**) in 11-yr old children, stratified by reported distance travelled to school (reference category is car).

| | **Whole week** | | | **Weekdays** | | | **Weekend days** | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***b*** | ***95%CI*** | ***p-value*** | ***b*** | ***95%CI*** | ***p-value*** | ***b*** | ***95%CI*** | ***p-value*** |
| <0.5 mile (N=1082) | | | | | | | | | |
| - public transport | −6.35 | −18.20; 5.49 | 0.29 | −6.65 | −19.53; 6.22 | 0.31 | −6.83 | −21.64; 7.99 | 0.37 |
| - cycling | 1.61 | −5.57; 8.90 | 0.66 | 0.15 | −7.77; 8.06 | 0.97 | 5.02 | −4.13; 14.16 | 0.28 |
| - walking | 2.90 | 0.52; 5.28 | 0.02 | 2.98 | 0.39; 5.56 | 0.02 | 2.03 | −1.16; 5.22 | 0.21 |
| 0.5-1 mile (N=1050) | | | | | | | | | |
| - public transport | −0.62 | −5.10; 3.87 | 0.79 | −0.40 | −5.22; 4.54 | 0.88 | −1.57 | −7.11; 3.98 | 0.58 |
| - cycling | 5.14 | −0.04; 1033 | 0.05 | 4.49 | −1.21; 10.2 | 0.12 | 7.07 | 0.29; 13.86 | 0.04 |
| - walking | **4.75** | **2.79; 6.71** | **<0.001** | **5.98** | **3.82; 8.14** | **<0.001** | 0.63 | −1.85; 3.13 | 0.62 |
| 1-5 miles (N=1568) | | | | | | | | | |
| - public transport | −0.09 | −1.58; 1.41 | 0.91 | −0.33 | −1.96; 1.31 | 0.70 | 0.75 | −1.25; 2.75 | 0.46 |
| - cycling | 1.69 | −3.41; 6.78 | 0.52 | 1.33 | −4.23; 6.89 | 0.64 | 1.29 | −5.44; 8.02 | 0.71 |
| - walking | **7.79** | **5.70; 9.89** | **<0.001** | **9.77** | **7.47; 12.06** | **<0.001** | 1.58 | −1.20; 4.36 | 0.27 |
| ≥5 miles* (N=424) | | | | | | | | | |
| - public transport | 0.65 | −1.90; 3.20 | 0.62 | 0.36 | −2.33; 3.05 | 0.79 | 2.16 | −1.59; 5.90 | 0.26 |

NOTE: total N=4124 due to missing data in covariates. Analyses adjusted for: sex, body mass index, social class at birth, ethnicity and season of physical activity measurement;

*: cycling or walking not reported in this category.

Data were collected as part of the ALSPAC study in the Bristol area between 2002 and 2004.

Abbreviations: 95%CI: 95% confidence interval; b: unstandardized beta coefficient.