Active travelling to school is not associated with increased total daily physical activity levels, or reduced obesity and cardiovascular/pulmonary health parameters in 10-12 year olds: a cross-sectional cohort study.

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ABSTRACT

Background/Objectives: Childhood obesity has increased enormously. Several lifestyle factors have been implicated, including decreased physical activity, partially involving a decline in active travel to school. We aimed to establish the association between school transport mode and physical activity levels of primary 6 and 7 children (aged 10 to 12). Secondary outcomes were body mass index standard deviation scores, blood pressure levels and lung function.

Subjects/Methods: A cross sectional study was conducted with a total number of 432 children from three primary schools in North East Scotland. Actigraph accelerometers were used to provide objective measures of physical activity. Ninety-two children in primary 6 and 90 children in primary 7 (40 in common) had adequate data. Modes of transport to school were assessed by a questionnaire. Two-hundred and 17 children in primary 6 and 165 in primary 7 returned adequate questionnaires. Children who used active transport modes for greater than 70% of their journeys to school over the week were coded as active travellers and less than 30% were coded as passive travellers. All children also had height, weight, blood pressure levels and lung function measured.

Results: Children who lived further away from school, and in more expensive properties were more likely to travel passively to school. Actively commuting children (70% walking) had significantly higher activity levels than passive commuters during the 30 minutes that encompassed their journey to and from school. However, there were no significant differences between active and passive school travellers in total daily physical activity, BMI SDS, and both systolic and diastolic blood pressure and lung function.

Conclusions: There was no evidence that more days of active travel to school had a significant influence on total physical activity, obesity and related health parameters. Public health interventions promoting active travel to school may have limited success in quelling the childhood obesity epidemic.

(300 words)

INTRODUCTION

The prevalence of obesity among children has risen considerably over the last 25 years. Global age-standardised prevalence of obesity was 5.6% in girls and 7.8% in boys in 2016 (1). It has been observed that 80% of children with obesity will also suffer from obesity in adulthood (2), and thereby have elevated risks of potentially life-threatening health complications including cardiovascular disease and type II diabetes (3). Reduced physical activity is a suggested risk factor for the development of childhood obesity that has received considerable attention, with a meta-analysis of 23 papers finding that there was a strong inverse relationship in cross-sectional studies between levels of physical activity and being overweight: although the direction of causality in this relationship is uncertain (4). Nevertheless, children who engage in at least one hour of moderate daily activity are said to gain a protective effect against obesity (5). Several governments have produced guidelines for the levels of activity in children, indicating that all children should take part in a minimum of 60 minutes of moderate to vigorous exercise every day (6). However, in most western societies, the majority of children do not meet these criteria (7).

Active forms of transport, such as walking or cycling, allow children to integrate exercise into their daily routines (8). During 2017, 51% of primary school children walked to school in the UK, a 6% decrease from 1997 levels. During this time the number of children travelling to school by car has risen to 44%. It has been suggested that this reduction in active transport is due to increasing industrialisation and traffic in cities, affecting the perceived safety of active transport methods in children (9). In a systematic review, 9 out of 13 studies provided evidence that children who actively travelled to school had higher overall levels of physical activity than those who did not (10). These findings have led to the implementation of several public health interventions, including walking school buses, aiming to elevate children's physical activity levels. This particular initiative involves children walking to school in groups, chaperoned by two adults, on a set route with pre-arranged pick up times and locations, and has been found to successfully increase the numbers of children engaging in active school travel (11). Eight out of the 13 reviewed studies used the MTI accelerometer and 2 studies used the Caltrac. Both of these two types of accelerometer are single (vertical) plane accelerometers which are limited in their ability to detect the wide variety of movements engaged in by young children (12). However, MTI were found to have lower reliability compared to GT1M (https://www.theactigraph.com/research-database/reliability-and-concurrent-validity-of-gt1m-and-mti-actigraph-accelerometers-using-a-mechanical-setup/). The other 3 studies used pedometers. However, pedometers detect only total counts or steps but cannot assess the intensity or pattern of activities performed. Given these technical limitations assessment of physical activity utilising more accurate accelerometers which can better detect the movement patterns of young children movement are required.

In addition, the impact of active transport on health status is uncertain (13). A Danish study found that children who cycled to school had fewer risk factors for cardiovascular disease (CVD) such as a better cholesterol/HDL ratio, better glucose metabolism, and a lower composite CVD risk factor score than those using other forms of transport (14). Conversely, a large Europe wide study did not detect any significant association between modes of school transport and these risk factors (15). A study conducted in Norway and the Netherlands found an association between mode of school transport and weight status, with children who cycled having decreased odds of being overweight (OR=0.44; 95% CI= 0.21-0.88) (16). But again the direction of causality from this association is unclear. A Chinese study used a self-administered questionnaire to assess PA and defined those who participated in sports and/or vigorous free play at least three times per week for at least 30 min each time as physically active children, found that among school children aged 10 years old, physically active girls had significantly higher FVC than inactive girls (1.79 l vs. 1.75 l, $p<0.05$). The increase in lung function indices with age were significantly higher for girls who were physically active than those inactive at both surveys during the follow-up period: forced expiratory flows at 25% (FEF25) difference per year (dpy) (0.20 l/s vs. 0.15 l/s), forced expiratory flows at 75% (FEF75) dpy (0.57 l/s vs. 0.45 l/s) and forced expiratory flows between 25% and 75% (FEF25-75) dpy (0.36 l/s vs. 0.28 l/s)(17).

During 2018/19 the UK government will be investing an additional £620,000 of funding into the ‘walk to school’ project delivered by Living Street, which aims to increase the number of children walking to school. The aims of our study were to investigate the factors correlated with mode of school transport and the associations between mode of school transport and physical activity levels in primary school children aged between 10 and 12 in the UK using direct measures of activity using accelerometers. Secondary outcomes were the association of mode of transport and BMI SDS, blood pressure levels and lung function.

METHODS

This study was conducted in the context of a long running primary school based study, known as the Scottish Lifestyle Organised Sports and Health (SLOSH) project. The SLOSH project was granted ethical approval in November 2006 by the Grampian Local Research Ethics Committee 2 (06/S00802/118). Children were recruited into the SLOSH project from three primary schools in a small town outside of Aberdeen with a population of around 11,600. Children were recruited prior to enrolment into school. Informed written consent was obtained from a parent or guardian. The SLOSH study is a longitudinal study covering years 1 to 7 at primary school, however for the purposes of this analysis children from primaries 6 and 7 (aged 10-12) were included, resulting in 432 (47.5% girls, 52.5% boys) children who had consented to the overall project, from a potential population of 700. In each year we gave all the parents questionnaires about their children's transport to school habits and invited a subset to also have their physical activity monitored by accelerometry.

Activity levels were measured using a combination of uniaxial GT1M (Actigraph, Pensacola, FL) and triaxial GT3X accelerometer (Actigraph, Pensacola, FL). These accelerometers are considered more accurate than the old MTI accelerometer used in most previous studies (https://actigraphcorp.com/research-database/reliability-and-concurrent-validity-of-gt1m-and-mti-actigraph-accelerometers-using-a-mechanical-setup/) (18). The GT3X logger has been used in several other similar studies exploring the role of school transport modes on physical activity levels (13, 19, 20). We used vertical axis data of both GT1M and GT3X. Because activity counts obtained from the vertical axis were comparable between the 2 models, but not when obtained from the vector magnitude (21). Physical activity was measured as the number of activity counts in a selected time period (epoch) which we set at 60 seconds. Data were also summed over 15 minute periods when comparing whole day activities. The Actigraph monitors were distributed during the spring school term, between January and March from 2012 to 2017. They were attached to elastic belts and worn over the iliac crest, with children (and their parents) instructed that they should wear the belts for six consecutive days apart from when sleeping, bathing or engaging in water-based activities. The accelerometer was placed on the dominant side. Parents were advised that the monitor should be kept on a flat, non-moving surface in instances when it was not being worn. In addition to the general written consent to take part in the study, verbal consent for wearing the accelerometer was obtained via telephone conversations with the parents on the evening prior to distribution of the monitors, and from the children themselves when the belts were fitted.

The average activity counts per minute and the percentages of time spent in sedentary, moderate and vigorous activity intensities were calculated using the Actilife 6.8.0 software and the most widely used cut-off values derived from a validation study in children (22). The subjects were instructed to wear the monitor for 7 consecutive days during waking hours. Data from the first day's wear was discarded to prevent unreliable data due to the potential for a child to respond to wearing the monitor. Subjects were required to have worn the Actigraph for at least 7 hours (420 minutes) on a minimum of two days to be included in the analysis of physical activity levels. On average of 5 monitoring days were analysed in this study. A non-wear period was defined as 10 consecutive minutes of zero activity counts per minute. It has been suggested that it is unrealistic to expect children of this age to remain sufficiently still for no activity counts to be detected for such a length of time and this criteria has also been adopted by previous studies (8). Activity data was also separated between weekdays and weekends, allowing for comparison between the two to ascertain the contribution of school transport methods on physical activity levels. The physical activity data were not normally distributed, so we performed a log transformation. We performed retrospective power analysis of both primary 6 and 7 PA data. For whole day data with 15mins as the measurement interval, Data from 89 children on weekdays and 76 children's weekend data in primary 6, and 83 children's weekday data and 76 children's weekend data in primary 7 were included in the power analyses. With 80% power at alpha = 0.05, the power analysis indicated that we could detect an 8.7% difference between active and passive groups in primary 6 weekdays data, a 12.4% difference in primary 6 weekends data, 8.8% difference in primary 7 weekdays data and 11.3% difference in primary 7 weekends data.

Information on mode of school transport was obtained using the questionnaire in which parents were asked to complete a table detailing the various methods of transport to school that had been used for each journey to and from school over the previous week. For most children this included 10 journeys to and from school, and 20 journeys for those children who went home at lunch time. The options of transport modes given were “walk”, “bike”, “bus” and “car”. Some children attend a pre- and post-school centre (after-school club) and are then transported to school in a bus from the centre and these were coded as using the “after school club bus”. Modes of transport to the after school club were not recorded. Children were coded as active travellers if they used active transport modes for greater than 70% of their journeys to school over the week. Passive travellers in contrast made less than 30% of the journeys using active means. Children who fell between these criteria (between 30 and 70%) were excluded from analysis. In total in p6 183 children were classified as passive or active travellers, and in p7 151 were classified. Not all these children had adequate accelerometry data. When we excluded those without accelerometry data this left 92 children in primary 6 and 90 children in primary 7 retained in the analysis. Only 40 children were common to both groups. This was dependent on which parents returned the questionnaires and which children recorded good accelerometry data in each year. Forty-nine percent of the accelerometer data was in the same week as the questionnaire information. 14% of the data was within 1 month, 7% data within 2 months and the remaining 30% of data within 3 months. The distance travelled to school was determined using the postcodes provided when the children were enrolled into the study, updated by the schools when children moved addresses. The child's home and school postcodes were entered into an online calculator (http://www.freemaptools.com/distance-between-uk-postcodes.htm), to evaluate the distance between the two points in kilometres (km). These were calculated from the shortest route along a road network using geographic information systems (GIS) technology. Children may have utilised pathways that do not follow the road network as shortcuts, and thus we ground truth tested the actual routes by directly observing the paths children might take and adjusted these distances accordingly.

Height was measured using a portable commercial Seca Leicester stadiometer (HAB International, Northampton) and weight using digital Seca scales. These measurements allowed calculation of body mass index (BMI). These were converted to BMI SDS using the UK90 growth reference charts (23). Children were classed as overweight or obese according to the SIGN (Scottish Intercollegiate Guidelines Network) guidelines, which state that children who are above or equal to the 85th percentile should be classified as overweight, while those above or equal to the 95th percentile are classified as obese. Blood pressure measurements were performed using a validated sphygmomanometer (Omron digital automatic blood pressure monitor), which recorded systolic blood pressure and diastolic blood pressure. Generally, measurements were made in the morning although a few were made in the early afternoon. Children were measured in pairs. They sat quietly for a few minutes before the measure, during which they were told what we were doing, that the machine would squeeze their arm tightly but there was nothing to worry about. A single measure was generally taken, although if we considered this might be erroneous, for example if the child moved during the measurement, it would be repeated (less than 5% of cases). One child was measured while the other watched and then they swapped places. Lung function was assessed using a spirometer (Micro Medical CareFusion). The children were asked to wear a nose clip to prevent them from breathing through their nose during the test. Each child was then asked to take in a deep breath and to blow the air out into a mouthpiece that was connected to spirometer. The spirometer measured how much and how fast the air was blown out. The children repeated the test at least three times to get their best, most consistent result. Various parameters relating to expiration function were obtained including FVC (L), Forced Expiratory Volume 1 sec (FEV1, L), Ratio of FEV1 to FVC (%FEV1), Peak Expiratory Flow (PEF, L/s), MEF 75 (L/s), and MEF 25, 50, are flow at 25%, 75% respectively. %FEV1 is used in the diagnosis of obstructive and restrictive lung disease. It has been reported that lung function increases as a response to PA. So %FEV1 was also used to study the impact on pulmonary function as a health benefit of PA.

Council tax banding of the property where each pupil resided was used as a measure of socioeconomic status. This information is publically available and was provided by the local government and is based on the value of the housing stock (on April 1st 1991). Details of the council tax banding system are available at www.aberdeenshire.gov.uk/counciltax/charges.asp#bands.

All the collected data, as well as subjects' personal details, were stored in an encrypted file on Microsoft 2010 Excel. Anonymity was ensured by using only an 8-digit identification code for each subject. Furthermore, physical activity data and health measurement data were stored on separate spreadsheets to maintain confidentiality. Only individuals directly involved in the study had access to these documents and files.

The Patient and Public Involvement statement

No patients were directly involved in the design of this study. All the pupils involved were research partners in all aspect of the study including identifying the original research question. All the pupils` parents helped with inform consent, questionnaires and help with pupils wearing the accelerometer belt. The results will be disseminated to all study participants parents via email. The authors will disseminate the results via conference presentation. Funding bodies and other journal editors internationally will be encouraged to use the result.

STATISTICAL ANALYSES

Statistical analyses were performed using Minitab 18. Because we had a mix of repeated and non-repeated measures we decided to analyse the data for p6 and p7 separately. This way the data in each year were completely independent. There were insufficient data to perform a longitudinal analysis. We used one way ANOVA to compare whether there was a difference in demographic characteristics between sex and across the three schools. Binary logistic regression was used to check the factors that influenced the mode of transport. Independent t-tests were performed on BMISDS, blood pressure levels and lung functions of two transport groups. A mixed effect model was used to analyse the difference in the average 15 mins PA levels (mean 15 mins ActiGraph outputs (counts per epoch)), including group (active or passive, fixed), time of day (fixed), ID (random), group*time, ID (group) as factors. A mixed effect model was also used to analyse the difference in the 1 minute commuting time PA levels (1 min counts), with group (fixed), time of day (fixed), ID (random), group*time, ID(group) as factors. For the physical activity intensity comparison, we used t-tests to compare the difference of each PA intensity levels (percentage of total physical activity) between two transport groups. All tests conducted were two-sided and significance was set at the 5% level ($p<0.05$).

RESULTS

Subject recruitment

A total of 700 children were enrolled at the three schools that participated during the study period and 432 (47.5% girls, 52.5% boys) of these were consented into the SLOSH project. Hence 62% of all the children living in the town were involved in the project. For the purposes of this study, children`s data from primary 6 (n=426) and primary 7 (n=427) were included. The flow of children through the study is outlined in Figure1.

Characteristics of the sample

An overview of the demographic characteristics of the pupils in the study is presented in Table 1A (primary 6) and Table 1B (primary 7). The mean age was 10.59±0.02 years in primary 6 and 11.64±0.02 in primary 7. The mean BMI SDS was 0.31 ± 1.2 kg/cm^2 in primary 6 and 0.33 ± 1.2 kg/cm^2 in primary 7. On average their BMI was significnatly higher than the UK average in 1990 (P6 $t = 4.30$ $p < 0.001$; P7 $t = 4.71$ $p < 0.001$). The systolic blood pressure was 115.9±1.2 mm Hg and diastolic blood pressure was 67.8±0.9 mm Hg in primary 6 while the systolic blood pressure was 116.4±1.4 mm Hg and diastolic blood pressure was 65.6±1.0 mm Hg in primary 7. Both of the blood pressure measurements were within the normal range (systolic blood pressure 102-120 mm Hg, diastolic blood pressure 61-80 mm Hg). The %FEV1 was 85±1% in primary 6 and 84±1% in primar y 7. An %FEV1 of 80% predicted a normal spirometry, so children in our study have normal airflow in both primary 6 and 7. These characteristics were not significantly different between sexes or across schools (Supplementary materials). The data were therefore pooled across sexes and schools. The average distance travelled to school was 1.75 km.

Factors influencing mode of transport

Of the 217 children in primary 6 that provided both questionnaires and health data, 127 (58.5%) were categorised as active and 56 (25.8%) were categorised as passive travellers. Seventy percent of actively commuting children used walking as the main form of transport (see supplementary materials). In the binary logistic regression analysis, children who lived further away from school had greater odds of being passive travellers than the children who lived nearer to school (OR=2.67; 95% CI=1.71-4.18). Moreover, children from higher council tax band properties (F-H) had a greater odds of being passive travellers than the children in the low council tax bands (A-E) (OR=1.51; 95% CI=1.11-2.06) (Figure 2A). Hence, children who lived further from school or from more affluent families were more likely to use passive school transport in primary 6. For the 165 children in primary 7 that provided questionnaires, 104 (63.0%) were categorised as active and 47 (28.5%) were categorised as passive travellers. In P7 68% of actively commuting children used walk as main form of transport (supplementary materials). In the binary logistic analysis, only the distance to school significantly affected mode of transport, with children who lived further from their school having a greater odds ratio of being passive traveller than the children who lived nearer to school (OR=1.91; 95% CI=1.27-2.87) (Figure 2B). In primary 7 council tax band of their residence was not a significant factor (OR=1.31; 95% CI=0.93-1.83).

Association of mode of transport with BMI SDS, blood pressure level and lung function.

The BMI SDS, and blood pressure and lung functions parameters of the active and passive travellers are summarised in Table 2A for primary 6 and Table 2B for primary 7. There were no significant differences between active or passive travellers for any of these parameters.

Association of mode of transport and physical activity levels.

As detailed in Figure 1, of the 141 children in primary 6 who wore an Actigraph to measure their physical activity, some of children were not considered as active or passive travellers because they fell out of the 30%-70% threshold of journeys to be made by active or passive means. In total, 65 children were coded as active travellers, while 27 were considered passive travellers. So the total number of children in primary 6 included in the detailed accelerometry analysis was 92. There were 153 children in primary 7 that wore an Actigraph and had suitable data. In total, 70 were categorised as active and 20 were passive travellers.

Commuting time physical activity levels differ between active and passive travellers.

All of the children started school around 9:00 am and finished by 15:15 pm and the average distance from home to school was 1.75 km. Based on Willis' study, the average walking speed for children under 15 years is 5.0 kph (24), so most of the children would finish their commuting within half an hour. We restricted the first comparative analysis to 8:30 - 9:00 am and 15:15 - 15:45 pm. For the morning commuting time of primary 6 children, time of the day, ID (group) and group*time interaction were the most significant factors (F_{time}=6.17, $p<0.001$; $F_{ID\ (group)}$ = 18.26, $p<0.001$, $F_{group*time}$ = 2.29, $p<0.001$). There was also a significant group effect (F_{group}=4.97, $p=0.029$). On average active travellers had 319 more activity counts than passive travellers during this period and were therefore 35.8% more active. Group, time of the day, ID (group) and group*time interaction explained 46.1% of the variation in primary 6 morning commuting PA. For primary 7 morning commuting, time of the day, ID (group) and group were the most significant factors (F_{time}=3.05, $p<0.001$; $F_{ID\ (group)}$ = 13.96, $p<0.001$, F_{group}=17.28, $p<0.001$) but there was no significant effect of group*time interaction ($F_{group*time}$ = 1.12, $p=0.303$) (Figure 4A). In primary 7, 40.8% of the variation in activity levels was explained by group, time of the day, ID (group) and group*time interaction. On average active travellers had 527 more counts than passive travellers during this period, and were hence 69.4% more active (Figure 4B).

However, for the primary 6 afternoon commuting time, there was a significant difference for time of the day, ID (group) and time*group interaction (F_{time}=6.68, $p<0.001$; $F_{ID\ (group)}$ = 16.85, $p<0.001$, $F_{group*time}$=2.36, $p<0.001$). Together these factors explained 43.4% of the variation in PA. On average active travellers had 169 more counts than passive travellers during this period and were therefore 17.7% more active. (Figure 4C). For the afternoon commuting of primary 7, the most significant factors were time of the day, ID (group) and time*group interaction (F_{time}=14.94, p<0.001; $F_{ID\ (group)}$ = 13.92, p<0.001, $F_{group*time}$=3.01, p<0.001), and there was also a significant difference between the two groups (F_{group}=5.83, p=0.018) (Figure 4D). On average active travellers had 289 more counts than passive travellers during this period and were therefore 30.3% more active. Hence, during both the morning and afternoon commuting periods in both primary 6 and 7 we detected that children who were active commuters were more physically active than passive commuters.

No difference of total daily physical activity levels between the groups.

We calculated the counts for every 15 mins over the whole 6 days period of measurement of each child, divided into weekdays and weekends. The patterns of average 15 mins physical activity measurement are illustrated in (Figure 3A). During the weekdays, all three schools started at around 9:00 am and finished by 15:15 pm. Also they all had a morning break at around (10:30-11:05 am) and lunch time around (12:15-1:30 pm). These breaks corresponded to peaks in physical activity across the day. We analysed the data collected between 7:00 am-22:00 pm for weekdays and 8:25 am – 21:45 pm for weekends. In Primary 6 weekdays, time of the day and individual ID were the most significant factors influencing PA levels (F_{time}=15.57, p<0.001; $Z_{ID\ (group)}$=5.79, p<0.001) and the group*time interaction was also significant (F=1.51, p=0.007) but there were no significant effects of travel group (F_{group}=0.01, p=0.911) (Figure 3A). The result was similar for weekend primary 6 activities with time and ID being the most significant factors (F_{time}=3.80, p<0.001; $Z_{ID\ (group)}$ = 5.49, p<0.001) but there were no significant effects of group and group*time interaction (F_{group}=0.63, p=0.429; $F_{group*time}$ = 0.81, p=0.829) (Figure 3C). The results were similar for children in primary 7, during the weekdays time and ID were also the most significant factors (F_{time}=11.18, p<0.001; $Z_{ID\ (group)}$ = 5.24, p<0.001), and the group* time interaction was also significant ($F_{group*time}$ = 1.64, p=0.001). But there were no significant effects of group (F_{group}=2.96, p=0.089) (Figure 3B). During the weekend, time of the day and ID were the most significant factors (F_{time}=4.77, p<0.001; $Z_{ID\ (group)}$ = 5.36, p<0.001) but there were no significant effects of group and group*time interaction (F_{group}=0.06, p=0.805; $F_{group*time}$ = 1.02, p=0.442) (Figure 3D). The group factor was not significant in both primary 6 and primary 7 during both weekdays and weekends (p>0.05).

No differences of physical activity intensity levels between the two groups.

Using the data set for children which met the criteria for active or passive travellers, independent t-tests showed that there was no significant differences in the proportion of total time spent on sedentary, light, moderate vigorous or very vigorous activity between passive or active travellers for both primary 6 and 7 when data was combined for the whole wear time over school days and weekends (Independent t-test for primary 6 Sedentary t =1.17, p = 0.25; Light t = -2.08, p = 0.043; Moderate t=-0.49, p=0.63, Vigorous t = -0.44, p = 0.66, very vigorous t=0.28 p=0.78; Independent t-test for primary 7 Sedentary t =-1.33, p = 0.195; Light t = 0.55, p = 0.590; Moderate t=1.54, p=0.136, Vigorous t = 2.69, p = 0.009, very vigorous t=-0.87 p=0.395) (Figure 5).

DISCUSSION

Commuting time physical activity but not the total daily physical activity differed between active and passive travellers

In both primary 6 and 7, active travel increased activity levels during the 30 minutes of the morning and afternoon commutes. This demonstrates two things. First, active travel does positively impact children's activity levels at the time of the travel is undertaken. Second, we can be confident about the assignations of the parents about the travel modes of their children in this study. Despite this we found no significant differences in mean total daily activity levels between the children who used active modes of school transport, and those who used passive modes, regardless of the distance actively travelled. The power analysis suggested we could detect around a 10% difference between active and passive group, however there was on average less than 5% of difference between active and passive groups. This indicates that the impact of the extra physical activity while travelling to and from school was compensated for, because the passive travellers were more active at other times of day. Indeed on average, an active journey to school only constituted 7.8% of the children's overall daily activity levels, meaning that there was more than adequate potential for the children to increase their activity at other points in the day.

Other studies in the UK have also failed to detect any impact of travel mode on daily activity levels (25, 26), but these data contradict several other studies that have indicated that active transport does affect overall activity (8, 15, 20, 27-32). A study in Edinburgh in 2004, for example, suggested that walking to school resulted in 25.9 additional minutes spent in moderate to vigorous activity on weekdays compared to travelling by car or bus (27). Their study sample was slightly older than the one recruited in this project (13-14 years). Age is a particularly important factor as modes of school transport are thought to have a larger impact on activity levels as children grow older, due to their declining overall activity (27). Several other studies also included teenagers in their sample which may account for the different results (28, 29). Notably those previous studies which did not detect any significant difference between active and passive groups both included children in the early years of primary school (25, 26). Other studies found differences in one sex but not overall differences across the whole sample (29-31). Additionally two of the studies used pedometers to measure physical activity, which may make the results of these studies difficult to compare to those obtained in this study (32-34). Although pedometers measure the total number of steps during the time it is worn, they are unable to detect the intensity of the activity undertaken (12).

Factors that influenced how children travelled to school

From the factors studied the ones that influenced how the children in primary 6 travelled to school included the distance from home to the school and, independently, the level of affluence in their family, as reflected in the value of the property they lived in. However, when children were in primary 7, distance was the only factor that influenced how the children travelled to school. Distance may be important because it increases the probability that the children may need to negotiate dangerously busy roads on their school journeys. At age 10-12 children most invariably travel to school unaccompanied by an adult, and so concerns over traffic safety may lead parents to transport their children rather than allowing them to walk. Alternatively the time to walk long distances may be prohibitive. In addition, less affluent families are less likely to own cars and therefore their children may have no option but to walk or cycle to school.

In the current study, in concordance with other studies, a shorter distance between home and school was the strongest predictor of active travel mode choices (35-37). Two Australian studies reported that children were more likely to walk or cycle to school at least once a week, if they lived within 800 metres of their school (38, 39). As the distance from home to school increases, the proportion of children using active transport drops sharply. Those who lived within one mile of school were more likely to walk compared to those that live one to 1.5 miles or further away. Lower rates of active travel to school has also been shown associated with increasing household income and increased car ownership in another study (37), and those students from higher social economic status households were more likely to travel to school by car than to walk (40, 41). However in our study, affluence was a factor only for children in primary 6.

Active travelling to school was not associated with reduced obesity and cardiovascular/pulmonary health parameters

Although active travelling to school transiently increased physical activity during the morning commute, relative to passive travelling, this elevation had no impact on total daily activity. Similarly we found no effect of active transport on reduced levels of obesity or improvements in markers of cardiovascular health in both primary 6 and 7.

Unlike the present study, a study in Colombia suggested that active school transport had the potential to reduce an individual's risk of becoming overweight (OR=0.5, 95% CI=0.3-0.8, $p<0.05$). However, the age range of 11-18 years in the Colombian study means that it is not directly comparable with the sample we studied (42). A systematic review found only one study reporting an association between active school transport and decreased body weight, which emphasises the fragility of the evidence directly implicating modes of transport in obesity development (10). The one exception was a Danish study which suggested that children who cycled to school had significant improvements in their cholesterol/HDL ratio, glucose metabolism, and a lower composite CVD risk factor score compared to children using other means of transport (14).

Strengths and weaknesses

The main strength of this study was that we used an objective measurement system based on accelerometers to monitor activity levels, rather than relying, as many studies of physical activity do, on questionnaires. Moreover, because we were able to include a relatively large fraction of the children living in an entire town the study was not strongly biased towards any particular income group.

Nevertheless, because this was a cross sectional observational study and not an intervention a weakness is that it is not possible to infer direct causality in the observed associations. In particular, since we found an association between affluence and mode of transport in the p6 children it is possible that those more affluent children that were more likely to be passively transported were also encouraged to exercise by their parents at other times of day – offsetting the difference during the commute time. However, while this is possible we consider it unlikely. In p7 children affluence was not a factor associated with travel mode, yet we observed the same trends. It is unlikely therefore that affluence was an important confound. We cannot however with the present design rule out the potential for other confounding factors that we didn’t quantify. An additional weakness was that while the total sample of children was quite large the sample providing both usable accelerometery data, and returned questionnaires on transport mode, was relatively small.

Explanations and policy implications

Active transport of children to school has become a political issue with the UK government investing in schemes that promote active transport. In the light of these campaigns parents may feel guilty about passively transporting their children to school, which they may do primarily because of road and other safety concerns. The data collected here suggests that the elevation of activity by active transport may be ephemeral, and lead to no wider benefits in terms of total physical activity or impacted health issues such as obesity, blood pressure and lung function.

CONCLUSION

In both primary 6 and 7 (aged 10-12), children who lived further away from school, or who lived in more expensive properties were more likely to travel passively to school. Active commuting children had significantly higher activity levels than passive commuters during the commuting time that encompassed their journey to school. However, there were no significant differences between active and passive school travellers in total daily physical activity (during weekdays or weekends). There was no evidence that active school transport had a significant influence on obesity, blood pressure or lung function in these children. These data suggest that public health interventions promoting active travel to school at ages 10-12 may have limited success, and that parents should not feel guilty for passively transporting their children to and from school in this age range. Clearly randomised controlled trials comparing active to passive transport are needed to provide stronger evidence about the efficacy of ‘walk to school’ schemes to promote activity and improve health outcomes.

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Contributors: JRS designed the SLOSH study and did the initial ethical review application. CH and JRS had overall project oversight and responsibility. NAS, MTS, RFC, BP, NW, KA, SR, SJB, MC, IS, RJI, EAB, FJS, JA, SM, DG, SS, SS, CL, RM and MM, collected the data. FFS, DMJ, LMV, CH and JRS were individual project supervisors. XYZ and NAS performed data cleaning and verification. XYZ and JRS analyzed the data. XYZ, CH and JRS wrote the manuscript. The other authors contributed to the interpretation of the results and critical revision of the manuscript for important intellectual content and approved the final version of the manuscript. All authors have read and approved the final manuscript. The University of Aberdeen is the study guarantor.

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Data sharing: Requests for access to data should be addressed to JRS.

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