

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

4 Xueying Zhang (orcid: 0000-0001-5746-2191)^{1,2,3,*}, Nathan A Smith^{1,*},
5 Maksymilian T Sumowski¹, Julie M Anderson¹, Kirstie Anderson¹, Euan A
6 Badenoch¹, Sarah J Brady¹, Madeline Coleman¹, Rebecca F Coull¹, Debbie Green¹,
7 Rachael J Innes¹, Christiane M Laing¹, Rebekah Mckinley¹, Moira S Mclennan¹,
8 Stephanie Murray¹, Bethan Phillips¹, Sarah Rae¹, Sophie Rankin¹, Iman Satar¹,
9 Sarah Shanks¹, Fiona J Sim¹, Nicola Walker¹, David Howard⁴, Falko F Sniehotta⁵,
10 Diane M Jackson¹, Lobke M VaanHolt¹, Catherine Hambly^{1\$}, John R Speakman
11 (orcid: 0000-0002-2457-1823)^{1,2,6\$}

12 * These authors contributed equally to this work

13¹. Institute of Biological and Environmental Sciences, University of Aberdeen,
14 Aberdeen AB24 2TZ, UK

15². State Key Laboratory of Molecular Developmental Biology, Institute of Genetics
16 and Developmental Biology, Chinese Academy of Sciences, Beijing 100101, PRC

17³. University of Chinese Academy of Sciences, Shijingshan District, Beijing 100049,
18 PRC

19⁴. Stonehaven Medical Centre, Robert street, Stonehaven, AB39 2EL, UK

20⁵. Institute of Health & Society Faculty of Medical Sciences Newcastle University
21 Baddiley-Clark Building Richardson Road, NE2 4AX, UK

22⁶. Chinese Academy of Sciences Center of Excellence in Animal Evolution and
23 Genetics, Kunming, China

24

25 [§]Corresponding authors:

26 John R Speakman: j.speakman@abdn.ac.uk

27 Tel : +44 1224 272879

28 Post address: Institute of Biological and Environmental Sciences, University of
29 Aberdeen, Aberdeen AB24 2TZ, UK

30 Catherine Hambly: c.hambly@abdn.ac.uk

31 Tel : +44 1224 273637

32 Post address: Institute of Biological and Environmental Sciences, University of
33 Aberdeen, Aberdeen AB24 2TZ, UK

34 **Competing interests:** No support from any organization for the submitted work;
35 no financial relationships with any organization that might have an interest in the
36 submitted work in the previous three years, no other relationships or activities that
37 could appear to have influenced the submitted work.

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40 **ABSTRACT**

41 **Background/Objectives:** Childhood obesity has increased enormously. Several
42 lifestyle factors have been implicated, including decreased physical activity,
43 partially involving a decline in active travel to school. We aimed to establish the
44 association between school transport mode and physical activity levels of primary
45 6 and 7 children (aged 10 to 12). Secondary outcomes were body mass index
46 standard deviation scores, blood pressure levels and lung function.

47 **Subjects/Methods:** A cross sectional study was conducted with a total number of
48 432 children from three primary schools in North East Scotland. Actigraph
49 accelerometers were used to provide objective measures of physical activity.
50 Ninety-two children in primary 6 and 90 children in primary 7 (40 in common) had
51 adequate data. Modes of transport to school were assessed by a questionnaire. Two-
52 hundred and 17 children in primary 6 and 165 in primary 7 returned adequate
53 questionnaires. Children who used active transport modes for greater than 70% of
54 their journeys to school over the week were coded as active travellers and less than
55 30% were coded as passive travellers. All children also had height, weight, blood
56 pressure levels and lung function measured.

57 **Results:** Children who lived further away from school, and in more expensive
58 properties were more likely to travel passively to school. Actively commuting
59 children (70% walking) had significantly higher activity levels than passive
60 commuters during the 30 minutes that encompassed their journey to and from

61 school. However, there were no significant differences between active and passive
62 school travellers in total daily physical activity, BMI SDS, and both systolic and
63 diastolic blood pressure and lung function.

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

68

69 (300 words)

70 **INTRODUCTION**

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

87 Active forms of transport, such as walking or cycling, allow children to integrate
88 exercise into their daily routines (8). During 2017, 51% of primary school children
89 walked to school in the UK, a 6% decrease from 1997 levels. During this time the
90 number of children travelling to school by car has risen to 44%. It has been

91 suggested that this reduction in active transport is due to increasing
92 industrialisation and traffic in cities, affecting the perceived safety of active
93 transport methods in children (9). In a systematic review, 9 out of 13 studies
94 provided evidence that children who actively travelled to school had higher overall
95 levels of physical activity than those who did not (10). These findings have led to
96 the implementation of several public health interventions, including walking
97 school buses, aiming to elevate children's physical activity levels. This particular
98 initiative involves children walking to school in groups, chaperoned by two adults,
99 on a set route with pre-arranged pick up times and locations, and has been found
100 to successfully increase the numbers of children engaging in active school travel
101 (11). Eight out of the 13 reviewed studies used the MTI accelerometer and 2 studies
102 used the Caltrac. Both of these two types of accelerometer are single (vertical)
103 plane accelerometers which are limited in their ability to detect the wide variety of
104 movements engaged in by young children (12). However, MTI were found to have
105 lower reliability compared to GT1M ([https://www.theactigraph.com/research-
106 database/reliability-and-concurrent-validity-of-gt1m-and-mti-actigraph-
107 accelerometers-using-a-mechanical-setup/](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.
108 However, pedometers detect only total counts or steps but cannot assess the
109 intensity or pattern of activities performed. Given these technical limitations
110 assessment of physical activity utilising more accurate accelerometers which can
111 better detect the movement patterns of young children movement are required.

112 In addition, the impact of active transport on health status is uncertain (13). A
113 Danish study found that children who cycled to school had fewer risk factors for
114 cardiovascular disease (CVD) such as a better cholesterol/HDL ratio, better
115 glucose metabolism, and a lower composite CVD risk factor score than those using
116 other forms of transport (14). Conversely, a large Europe wide study did not detect
117 any significant association between modes of school transport and these risk
118 factors (15). A study conducted in Norway and the Netherlands found an
119 association between mode of school transport and weight status, with children who
120 cycled having decreased odds of being overweight (OR=0.44; 95% CI= 0.21-0.88)
121 (16). But again the direction of causality from this association is unclear. A Chinese
122 study used a self-administered questionnaire to assess PA and defined those who
123 participated in sports and/or vigorous free play at least three times per week for at
124 least 30 min each time as physically active children, found that among school
125 children aged 10 years old, physically active girls had significantly higher FVC
126 than inactive girls (1.79 l vs. 1.75 l, $p<0.05$). The increase in lung function indices
127 with age were significantly higher for girls who were physically active than those
128 inactive at both surveys during the follow-up period: forced expiratory flows at
129 25% (FEF25) difference per year (dpy) (0.20 l/s vs. 0.15 l/s), forced expiratory
130 flows at 75% (FEF75) dpy (0.57 l/s vs. 0.45 l/s) and forced expiratory flows
131 between 25% and 75% (FEF25-75) dpy (0.36 l/s vs. 0.28 l/s)(17).

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

140 **METHODS**

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

155 Activity levels were measured using a combination of uniaxial GT1M (Actigraph,
156 Pensacola, FL) and triaxial GT3X accelerometer (Actigraph, Pensacola, FL).
157 These accelerometers are considered more accurate than the old MTI
158 accelerometer used in most previous studies ([https://actigraphcorp.com/research-
159 database/reliability-and-concurrent-validity-of-gt1m-and-mti-actigraph-
160 accelerometers-using-a-mechanical-setup/](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

161 in several other similar studies exploring the role of school transport modes on
162 physical activity levels (13, 19, 20). We used vertical axis data of both GT1M and
163 GT3X. Because activity counts obtained from the vertical axis were comparable
164 between the 2 models, but not when obtained from the vector magnitude (21).
165 Physical activity was measured as the number of activity counts in a selected time
166 period (epoch) which we set at 60 seconds. Data were also summed over 15 minute
167 periods when comparing whole day activities. The Actigraph monitors were
168 distributed during the spring school term, between January and March from 2012
169 to 2017. They were attached to elastic belts and worn over the iliac crest, with
170 children (and their parents) instructed that they should wear the belts for six
171 consecutive days apart from when sleeping, bathing or engaging in water-based
172 activities. The accelerometer was placed on the dominant side. Parents were
173 advised that the monitor should be kept on a flat, non-moving surface in instances
174 when it was not being worn. In addition to the general written consent to take part
175 in the study, verbal consent for wearing the accelerometer was obtained via
176 telephone conversations with the parents on the evening prior to distribution of the
177 monitors, and from the children themselves when the belts were fitted.

178 The average activity counts per minute and the percentages of time spent in
179 sedentary, moderate and vigorous activity intensities were calculated using the
180 Actilife 6.8.0 software and the most widely used cut-off values derived from a
181 validation study in children (22). The subjects were instructed to wear the monitor

182 for 7 consecutive days during waking hours. Data from the first day's wear was
183 discarded to prevent unreliable data due to the potential for a child to respond to
184 wearing the monitor. Subjects were required to have worn the Actigraph for at least
185 7 hours (420 minutes) on a minimum of two days to be included in the analysis of
186 physical activity levels. On average of 5 monitoring days were analysed in this
187 study. A non-wear period was defined as 10 consecutive minutes of zero activity
188 counts per minute. It has been suggested that it is unrealistic to expect children of
189 this age to remain sufficiently still for no activity counts to be detected for such a
190 length of time and this criteria has also been adopted by previous studies (8).
191 Activity data was also separated between weekdays and weekends, allowing for
192 comparison between the two to ascertain the contribution of school transport
193 methods on physical activity levels. The physical activity data were not normally
194 distributed, so we performed a log transformation. We performed retrospective
195 power analysis of both primary 6 and 7 PA data. For whole day data with 15mins
196 as the measurement interval, Data from 89 children on weekdays and 76 children's
197 weekend data in primary 6, and 83 children's weekday data and 76 children's
198 weekend data in primary 7 were included in the power analyses. With 80% power
199 at $\alpha = 0.05$, the power analysis indicated that we could detect an 8.7%
200 difference between active and passive groups in primary 6 weekdays data, a 12.4%
201 difference in primary 6 weekends data, 8.8% difference in primary 7 weekdays
202 data and 11.3% difference in primary 7 weekends data.

203 Information on mode of school transport was obtained using the questionnaire in
204 which parents were asked to complete a table detailing the various methods of
205 transport to school that had been used for each journey to and from school over the
206 previous week. For most children this included 10 journeys to and from school,
207 and 20 journeys for those children who went home at lunch time. The options of
208 transport modes given were “walk”, “bike”, “bus” and “car”. Some children attend
209 a pre- and post-school centre (after-school club) and are then transported to school
210 in a bus from the centre and these were coded as using the “after school club bus”.
211 Modes of transport to the after school club were not recorded. Children were coded
212 as active travellers if they used active transport modes for greater than 70% of their
213 journeys to school over the week. Passive travellers in contrast made less than 30%
214 of the journeys using active means. Children who fell between these criteria
215 (between 30 and 70%) were excluded from analysis. In total in p6 183 children
216 were classified as passive or active travellers, and in p7 151 were classified. Not
217 all these children had adequate accelerometry data. When we excluded those
218 without accelerometry data this left 92 children in primary 6 and 90 children in
219 primary 7 retained in the analysis. Only 40 children were common to both groups.
220 This was dependent on which parents returned the questionnaires and which
221 children recorded good accelerometry data in each year. Forty-nine percent of the
222 accelerometer data was in the same week as the questionnaire information. 14% of
223 the data was within 1 month, 7% data within 2 months and the remaining 30% of

224 data within 3 months. The distance travelled to school was determined using the
225 postcodes provided when the children were enrolled into the study, updated by the
226 schools when children moved addresses. The child's home and school postcodes
227 were entered into an online calculator ([http://www.freemaptools.com/distance-
228 between-uk-postcodes.htm](http://www.freemaptools.com/distance-between-uk-postcodes.htm)), to evaluate the distance between the two points in
229 kilometres (km). These were calculated from the shortest route along a road
230 network using geographic information systems (GIS) technology. Children may
231 have utilised pathways that do not follow the road network as shortcuts, and thus
232 we ground truth tested the actual routes by directly observing the paths children
233 might take and adjusted these distances accordingly.

234 Height was measured using a portable commercial Seca Leicester stadiometer
235 (HAB International, Northampton) and weight using digital Seca scales. These
236 measurements allowed calculation of body mass index (BMI). These were
237 converted to BMI SDS using the UK90 growth reference charts (23). Children
238 were classed as overweight or obese according to the SIGN (Scottish
239 Intercollegiate Guidelines Network) guidelines, which state that children who are
240 above or equal to the 85th percentile should be classified as overweight, while
241 those above or equal to the 95th percentile are classified as obese. Blood pressure
242 measurements were performed using a validated sphygmomanometer (Omron
243 digital automatic blood pressure monitor), which recorded systolic blood pressure
244 and diastolic blood pressure. Generally, measurements were made in the morning

245 although a few were made in the early afternoon. Children were measured in pairs.
246 They sat quietly for a few minutes before the measure, during which they were told
247 what we were doing, that the machine would squeeze their arm tightly but there
248 was nothing to worry about. A single measure was generally taken, although if we
249 considered this might be erroneous, for example if the child moved during the
250 measurement, it would be repeated (less than 5% of cases). One child was
251 measured while the other watched and then they swapped places. Lung function
252 was assessed using a spirometer (Micro Medical CareFusion). The children were
253 asked to wear a nose clip to prevent them from breathing through their nose during
254 the test. Each child was then asked to take in a deep breath and to blow the air out
255 into a mouthpiece that was connected to spirometer. The spirometer measured how
256 much and how fast the air was blown out. The children repeated the test at least
257 three times to get their best, most consistent result. Various parameters relating to
258 expiration function were obtained including FVC (L), Forced Expiratory Volume
259 1 sec (FEV1, L), Ratio of FEV1 to FVC (%FEV1), Peak Expiratory Flow (PEF,
260 L/s), MEF 75 (L/s), and MEF 25, 50, are flow at 25%, 75% respectively. %FEV1
261 is used in the diagnosis of obstructive and restrictive lung disease. It has been
262 reported that lung function increases as a response to PA. So %FEV1 was also used
263 to study the impact on pulmonary function as a health benefit of PA.
264 Council tax banding of the property where each pupil resided was used as a
265 measure of socioeconomic status. This information is publically available and was

266 provided by the local government and is based on the value of the housing stock
267 (on April 1st 1991). Details of the council tax banding system are available at
268 www.aberdeenshire.gov.uk/counciltax/charges.asp#bands.

269 All the collected data, as well as subjects' personal details, were stored in an
270 encrypted file on Microsoft 2010 Excel. Anonymity was ensured by using only an
271 8-digit identification code for each subject. Furthermore, physical activity data and
272 health measurement data were stored on separate spreadsheets to maintain
273 confidentiality. Only individuals directly involved in the study had access to these
274 documents and files.

275 **The Patient and Public Involvement statement**

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

283 **STATISTICAL ANALYSES**

284 Statistical analyses were performed using Minitab 18. Because we had a mix of
285 repeated and non-repeated measures we decided to analyse the data for p6 and p7
286 separately. This way the data in each year were completely independent. There

287 were insufficient data to perform a longitudinal analysis. We used one way
288 ANOVA to compare whether there was a difference in demographic characteristics
289 between sex and across the three schools. Binary logistic regression was used to
290 check the factors that influenced the mode of transport. Independent t-tests were
291 performed on BMISDS, blood pressure levels and lung functions of two transport
292 groups. A mixed effect model was used to analyse the difference in the average 15
293 mins PA levels (mean 15 mins ActiGraph outputs (counts per epoch)), including
294 group (active or passive, fixed), time of day (fixed), ID (random), group*time, ID
295 (group) as factors. A mixed effect model was also used to analyse the difference in
296 the 1 minute commuting time PA levels (1 min counts), with group (fixed), time
297 of day (fixed), ID (random), group*time, ID(group) as factors. For the physical
298 activity intensity comparison, we used t-tests to compare the difference of each PA
299 intensity levels (percentage of total physical activity) between two transport
300 groups. All tests conducted were two-sided and significance was set at the 5% level
301 ($p < 0.05$).

302 **RESULTS**

303 **Subject recruitment**

304 A total of 700 children were enrolled at the three schools that participated during
305 the study period and 432 (47.5% girls, 52.5% boys) of these were consented into
306 the SLOSH project. Hence 62% of all the children living in the town were
307 involved in the project. For the purposes of this study, children`s data from

308 primary 6 (n=426) and primary 7 (n=427) were included. The flow of children
309 through the study is outlined in Figure 1.

310 **Characteristics of the sample**

311 An overview of the demographic characteristics of the pupils in the study is
312 presented in Table 1A (primary 6) and Table 1B (primary 7). The mean age was
313 10.59 ± 0.02 years in primary 6 and 11.64 ± 0.02 in primary 7. The mean BMI SDS
314 was 0.31 ± 1.2 kg/cm² in primary 6 and 0.33 ± 1.2 kg/cm² in primary 7. On
315 average their BMI was significantly higher than the UK average in 1990 (P6 t =
316 4.30 p < 0.001; P7 t = 4.71 p < 0.001). The systolic blood pressure was 115.9 ± 1.2
317 mm Hg and diastolic blood pressure was 67.8 ± 0.9 mm Hg in primary 6 while the
318 systolic blood pressure was 116.4 ± 1.4 mm Hg and diastolic blood pressure was
319 65.6 ± 1.0 mm Hg in primary 7. Both of the blood pressure measurements were
320 within the normal range (systolic blood pressure 102-120 mm Hg, diastolic blood
321 pressure 61-80 mm Hg). The %FEV1 was $85 \pm 1\%$ in primary 6 and $84 \pm 1\%$ in
322 primary 7. An %FEV1 of 80% predicted a normal spirometry, so children in our
323 study have normal airflow in both primary 6 and 7. These characteristics were not
324 significantly different between sexes or across schools (Supplementary
325 materials). The data were therefore pooled across sexes and schools. The average
326 distance travelled to school was 1.75 km.

327 **Factors influencing mode of transport**

328 Of the 217 children in primary 6 that provided both questionnaires and health data,
329 127 (58.5%) were categorised as active and 56 (25.8%) were categorised as passive
330 travellers. Seventy percent of actively commuting children used walking as the
331 main form of transport (see supplementary materials). In the binary logistic
332 regression analysis, children who lived further away from school had greater odds
333 of being passive travellers than the children who lived nearer to school (OR=2.67;
334 95% CI=1.71-4.18). Moreover, children from higher council tax band properties
335 (F-H) had a greater odds of being passive travellers than the children in the low
336 council tax bands (A-E) (OR=1.51; 95% CI=1.11-2.06) (Figure 2A). Hence,
337 children who lived further from school or from more affluent families were more
338 likely to use passive school transport in primary 6. For the 165 children in primary
339 7 that provided questionnaires, 104 (63.0%) were categorised as active and 47
340 (28.5%) were categorised as passive travellers. In P7 68% of actively commuting
341 children used walk as main form of transport (supplementary materials). In the
342 binary logistic analysis, only the distance to school significantly affected mode of
343 transport, with children who lived further from their school having a greater odds
344 ratio of being passive traveller than the children who lived nearer to school
345 (OR=1.91; 95% CI=1.27-2.87) (Figure 2B). In primary 7 council tax band of their
346 residence was not a significant factor (OR=1.31; 95% CI=0.93-1.83).

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

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

353 **Association of mode of transport and physical activity levels.**

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

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

364 All of the children started school around 9:00 am and finished by 15:15 pm and the
365 average distance from home to school was 1.75 km. Based on Willis' study, the
366 average walking speed for children under 15 years is 5.0 kph (24), so most of the
367 children would finish their commuting within half an hour. We restricted the first

368 comparative analysis to 8:30 - 9:00 am and 15:15 - 15:45 pm. For the morning
369 commuting time of primary 6 children, time of the day, ID (group) and group*time
370 interaction were the most significant factors ($F_{\text{time}}=6.17$, $p<0.001$; $F_{\text{ID (group)}} =$
371 18.26 , $p<0.001$, $F_{\text{group*time}} = 2.29$, $p<0.001$). There was also a significant group
372 effect ($F_{\text{group}}=4.97$, $p=0.029$). On average active travellers had 319 more activity
373 counts than passive travellers during this period and were therefore 35.8% more
374 active. Group, time of the day, ID (group) and group*time interaction explained
375 46.1% of the variation in primary 6 morning commuting PA. For primary 7
376 morning commuting, time of the day, ID (group) and group were the most
377 significant factors ($F_{\text{time}}=3.05$, $p<0.001$; $F_{\text{ID (group)}} = 13.96$, $p<0.001$, $F_{\text{group}}=17.28$,
378 $p<0.001$) but there was no significant effect of group*time interaction ($F_{\text{group*time}}$
379 $= 1.12$, $p=0.303$) (Figure 4A). In primary 7, 40.8% of the variation in activity levels
380 was explained by group, time of the day, ID (group) and group*time interaction.
381 On average active travellers had 527 more counts than passive travellers during
382 this period, and were hence 69.4% more active (Figure 4B).

383 However, for the primary 6 afternoon commuting time, there was a significant
384 difference for time of the day, ID (group) and time*group interaction ($F_{\text{time}}=6.68$,
385 $p<0.001$; $F_{\text{ID (group)}} = 16.85$, $p<0.001$, $F_{\text{group*time}}=2.36$, $p<0.001$). Together these
386 factors explained 43.4% of the variation in PA. On average active travellers had
387 169 more counts than passive travellers during this period and were therefore
388 17.7% more active. (Figure 4C). For the afternoon commuting of primary 7, the

389 most significant factors were time of the day, ID (group) and time*group
390 interaction ($F_{\text{time}}=14.94$, $p<0.001$; $F_{\text{ID (group)}} = 13.92$, $p<0.001$, $F_{\text{group*time}}=3.01$,
391 $p<0.001$), and there was also a significant difference between the two groups ($F_{\text{group}}=5.83$, $p=0.018$) (Figure 4D). On average active travellers had 289 more counts
392 than passive travellers during this period and were therefore 30.3% more active.
393 Hence, during both the morning and afternoon commuting periods in both primary
394 6 and 7 we detected that children who were active commuters were more physically
395 active than passive commuters.
396

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

398 We calculated the counts for every 15 mins over the whole 6 days period of
399 measurement of each child, divided into weekdays and weekends. The patterns of
400 average 15 mins physical activity measurement are illustrated in (Figure 3A).
401 During the weekdays, all three schools started at around 9:00 am and finished by
402 15:15 pm. Also they all had a morning break at around (10:30-11:05 am) and lunch
403 time around (12:15-1:30 pm). These breaks corresponded to peaks in physical
404 activity across the day. We analysed the data collected between 7:00 am-22:00 pm
405 for weekdays and 8:25 am – 21:45 pm for weekends. In Primary 6 weekdays, time
406 of the day and individual ID were the most significant factors influencing PA levels
407 ($F_{\text{time}}=15.57$, $p<0.001$; $Z_{\text{ID (group)}}=5.79$, $p<0.001$) and the group*time interaction
408 was also significant ($F=1.51$, $p=0.007$) but there were no significant effects of
409 travel group ($F_{\text{group}}=0.01$, $p=0.911$) (Figure 3A). The result was similar for

410 weekend primary 6 activities with time and ID being the most significant factors
411 ($F_{\text{time}}=3.80$, $p<0.001$; $Z_{\text{ID (group)}} = 5.49$, $p<0.001$) but there were no significant
412 effects of group and group*time interaction ($F_{\text{group}}=0.63$, $p=0.429$; $F_{\text{group*time}} =$
413 0.81 , $p=0.829$) (Figure 3C). The results were similar for children in primary 7,
414 during the weekdays time and ID were also the most significant factors ($F_{\text{time}}=11.18$, $p<0.001$; $Z_{\text{ID (group)}} = 5.24$, $p<0.001$), and the group* time interaction
415 was also significant ($F_{\text{group*time}} = 1.64$, $p=0.001$). But there were no significant
416 effects of group ($F_{\text{group}}=2.96$, $p=0.089$) (Figure 3B). During the weekend, time of
417 the day and ID were the most significant factors ($F_{\text{time}}=4.77$, $p<0.001$; $Z_{\text{ID (group)}} =$
418 5.36 , $p<0.001$) but there were no significant effects of group and group*time
419 interaction ($F_{\text{group}}=0.06$, $p=0.805$; $F_{\text{group*time}} = 1.02$, $p=0.442$) (Figure 3D). The
420 group factor was not significant in both primary 6 and primary 7 during both
421 weekdays and weekends ($p>0.05$).

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

424 Using the data set for children which met the criteria for active or passive travellers,
425 independent t-tests showed that there was no significant differences in the
426 proportion of total time spent on sedentary, light, moderate vigorous or very
427 vigorous activity between passive or active travellers for both primary 6 and 7
428 when data was combined for the whole wear time over school days and weekends
429 (Independent t-test for primary 6 Sedentary $t = 1.17$, $p = 0.25$; Light $t = -2.08$, $p =$
430 0.043 ; Moderate $t = -0.49$, $p = 0.63$, Vigorous $t = -0.44$, $p = 0.66$, very vigorous

431 $t=0.28$ $p=0.78$; Independent t-test for primary 7 Sedentary $t = -1.33$, $p = 0.195$;
432 Light $t = 0.55$, $p = 0.590$; Moderate $t=1.54$, $p=0.136$, Vigorous $t = 2.69$, $p = 0.009$,
433 very vigorous $t=-0.87$ $p=0.395$) (Figure 5).

434 **DISCUSSION**

435 **Commuting time physical activity but not the total daily physical activity** 436 **differed between active and passive travellers**

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

451 was more than adequate potential for the children to increase their activity at other
452 points in the day.

453 Other studies in the UK have also failed to detect any impact of travel mode on
454 daily activity levels (25, 26), but these data contradict several other studies that
455 have indicated that active transport does affect overall activity (8, 15, 20, 27-32).

456 A study in Edinburgh in 2004, for example, suggested that walking to school
457 resulted in 25.9 additional minutes spent in moderate to vigorous activity on
458 weekdays compared to travelling by car or bus (27). Their study sample was
459 slightly older than the one recruited in this project (13-14 years). Age is a
460 particularly important factor as modes of school transport are thought to have a
461 larger impact on activity levels as children grow older, due to their declining
462 overall activity (27). Several other studies also included teenagers in their sample
463 which may account for the different results (28, 29). Notably those previous studies
464 which did not detect any significant difference between active and passive groups
465 both included children in the early years of primary school (25, 26). Other studies
466 found differences in one sex but not overall differences across the whole sample
467 (29-31). Additionally two of the studies used pedometers to measure physical
468 activity, which may make the results of these studies difficult to compare to those
469 obtained in this study (32-34). Although pedometers measure the total number of
470 steps during the time it is worn, they are unable to detect the intensity of the activity
471 undertaken (12).

472 **Factors that influenced how children travelled to school**

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

485 In the current study, in concordance with other studies, a shorter distance between
486 home and school was the strongest predictor of active travel mode choices (35-37).
487 Two Australian studies reported that children were more likely to walk or cycle to
488 school at least once a week, if they lived within 800 metres of their school (38, 39).
489 As the distance from home to school increases, the proportion of children using
490 active transport drops sharply. Those who lived within one mile of school were
491 more likely to walk compared to those that live one to 1.5 miles or further away.
492 Lower rates of active travel to school has also been shown associated with

493 increasing household income and increased car ownership in another study (37),
494 and those students from higher social economic status households were more likely
495 to travel to school by car than to walk (40, 41). However in our study, affluence
496 was a factor only for children in primary 6.

497

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

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

505 Unlike the present study, a study in Colombia suggested that active school
506 transport had the potential to reduce an individual's risk of becoming overweight
507 (OR=0.5, 95% CI=0.3-0.8, $p<0.05$). However, the age range of 11-18 years in the
508 Colombian study means that it is not directly comparable with the sample we
509 studied (42). A systematic review found only one study reporting an association
510 between active school transport and decreased body weight, which emphasises the
511 fragility of the evidence directly implicating modes of transport in obesity
512 development (10). The one exception was a Danish study which suggested that
513 children who cycled to school had significant improvements in their

514 cholesterol/HDL ratio, glucose metabolism, and a lower composite CVD risk
515 factor score compared to children using other means of transport (14).

516 **Strengths and weaknesses**

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

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

534 providing both usable accelerometry data, and returned questionnaires on
535 transport mode, was relatively small.

536

537 **Explanations and policy implications**

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

545 **CONCLUSION**

546 In both primary 6 and 7 (aged 10-12), children who lived further away from school,
547 or who lived in more expensive properties were more likely to travel passively to
548 school. Active commuting children had significantly higher activity levels than
549 passive commuters during the commuting time that encompassed their journey to
550 school. However, there were no significant differences between active and passive
551 school travellers in total daily physical activity (during weekdays or weekends).
552 There was no evidence that active school transport had a significant influence on
553 obesity, blood pressure or lung function in these children. These data suggest that
554 public health interventions promoting active travel to school at ages 10-12 may

555 have limited success, and that parents should not feel guilty for passively
556 transporting their children to and from school in this age range. Clearly randomised
557 controlled trials comparing active to passive transport are needed to provide
558 stronger evidence about the efficacy of ‘walk to school’ schemes to promote
559 activity and improve health outcomes.

560 **Acknowledgement:** We are extremely grateful to the parents and their children for
561 taking part in the SLOSH project. We are also grateful to the regional authority
562 and the local head teachers for permission to work in the schools, and to the
563 individual teachers who tolerated our disruption of their classes to measure the
564 children.

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

575 **Funding:** JRS was supported by a Wolfson merit award.

576 **Ethical approval:** The SLOSH project was granted ethical approval in November
577 2006 by the Grampian Local Research Ethics Committee 2 (06/S00802/118)

578 **Transparency statement:** The guarantors affirm that the manuscript is an honest,
579 accurate, and transparent account of the study being reported; that no important
580 aspects of the study have been omitted; and that any discrepancies from the study
581 as originally planned (and, if relevant, registered) have been explained.

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

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