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Evidence of moderation effects in predicting active transport to school

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26 Abstract

27 Background: Distance from home to school is an important influence on the decision
28 to use active transport (AT); however, ecological perspectives would suggest this relationship
29 may be moderated by individual, interpersonal, and environmental factors. This study
30 investigates whether (i) gender, (ii) biological maturation, (iii) perceived family support for
31 physical activity (PA), and (iv) multiple deprivation moderate the relationship between
32 distance to school and AT.

33 Methods: 611 children (11-12 years old, 334 females) were recruited from schools in
34 Leicestershire, UK. Gender, family support for PA, and AT were self-reported. Home and
35 school postcodes were used to determine multiple deprivation and distance to school (km).
36 Predicted age at peak height velocity was used to indicate biological maturation.

37 Results: Logistic regressions revealed the main effects explained 40.2% of the
38 variance in AT; however; distance to school was the only significant predictor. Further
39 analyses revealed that distance to school had a greater negative impact on the use of AT in
40 late-maturing (OR: 3.60, CI: 1.45-8.96), less deprived (OR: 3.54, CI: 1.17-10.72), and
41 children with low family support of PA (OR: 0.26, CI: 0.11-0.61).

42 Conclusions: This study provides evidence that, although distance to school might be
43 the strongest predictor of AT, this relationship is complex.

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51 **Introduction**

52 Regular physical activity (PA) reduces risk of disease [1], improves mental health
53 [2] and extends life expectancy [3]. Incorporating PA into everyday life is imperative
54 especially for children to promote long-term active lifestyles lasting into adulthood [4] and
55 offset the general decline in PA that occurs at approximately 12 years old [5]. However, only
56 21% of boys and 16% of girls aged 5-15 in the United Kingdom (UK) are meeting guidelines
57 for recommended PA levels [6]. Actively commuting to school (i.e., primarily walking and
58 cycling for the purpose of functional, rather than leisure travel [7]) can provide a convenient
59 and meaningful contribution to increasing PA levels and energy expenditure [8, 9]. To
60 increase the number of children actively commuting, understanding the underlying reasons
61 for this behavioural choice are essential [10].

62 Distance from home to school is integral in the decision to actively commute to
63 school, specifically the likelihood of utilising inactive transport increases with distance [11,
64 12]. A longitudinal study exploring 31 mostly socio-cultural and environmental factors found
65 that distance to school (< 1km) was primarily associated with maintenance of active travel
66 over a one year period [13]. Very few UK 9-10 year old children were observed to actively
67 commute when the distance between home and school was over 2km [14], however, this
68 threshold has been suggested to be 8km in 11 year olds [15].

69 Despite the importance of distance to school, behaviour is guided by multiple levels
70 of influence [16, 17]; at the core of which is individual psycho-biological factors. For
71 example, boys are more likely than girls to actively commute to school [18]. Similarly,
72 biological maturation may also be important when predicting active transport. Adolescents of
73 the same chronological age can vary by up to five years in biological age [19]. The timing
74 and pace of this biological maturation has important consequences for physical,
75 psychological and behavioural development, some of which may impact involvement in PA

76 [20]. For instance, children's maturation status has been investigated with regards to self-
77 reported [21] and objectively measured PA with equivocal findings reported [22]. Biological
78 maturity has not been explored as a predictor of active school transport.

79 Interpersonal and socio-cultural influences must also be considered. The central
80 interpersonal guidance on children's mode of transport decision is their parents/guardians.
81 Children are more likely to actively commute if their parents did so when they were children
82 and if they currently actively commute to work [23]. Positive parental attitudes have been
83 shown to be particularly important for children who lived a short distance from school [24].
84 Despite active travel being a specific form of PA that may have distinct antecedents, children
85 are more likely to actively commute when their parents value the benefits of PA [25].
86 Another socio-cultural influence on the decision to actively commute to school is multiple
87 deprivation. A review of predominantly cross-sectional studies concluded that children from
88 low multiple deprivation areas were more likely to actively commute to school [26]; previous
89 explanations included less access to cars [27] and living in urban environments closer to
90 schools [28].

91 Despite the above knowledge, a key strength of ecological perspectives has generally
92 been overlooked. With a few exceptions [13, 25, 29] researchers haven't considered how the
93 multiple levels of influence interact with each other. It is currently unknown whether the
94 association between distance to school and active transport is moderated by the individual,
95 interpersonal, and socio-environmental variables described above. Although many factors
96 may influence the decision to active commute, the aim of the present study was to focus on
97 variables that might intuitively moderate the relationship between distance to school and
98 active travel. Prior to considering these moderating effects we expected boys; children who
99 are physically mature, with a supportive family for PA, living in socio-economically deprived
100 areas, and children living closer to school to be more likely to actively commute to school

101 (hypothesis 1). With regard to moderating effects, we proposed that as the distance from
102 school increases, the likelihood of boys actively commuting may decrease less rapidly,
103 compared to girls (e.g. because of decreased safety concerns of parents for boys compared to
104 girls [30]) (hypothesis 2). The same can be said for physically more mature children,
105 independent of gender and age in that they are allowed to actively commute to school, and
106 therefore distance to school is less impactful (hypothesis 3). Children whose parents
107 encourage PA to actively commute will be less influenced by the distance to school,
108 compared to those who don't receive parental support (hypothesis 4). Finally, distance to
109 school may be less of an important influence on the decision to actively commute in areas of
110 multiple socio-economic deprivation (hypothesis 5). This is because families in these
111 deprived areas are less likely to own motorised transport and the child has less choice but to
112 actively commute [27].

113 **Method**

114 *Participants*

115 Twenty-four secondary schools within Leicestershire (Midlands County in England)
116 were invited to participate. Seven schools across three local authorities (two independent
117 private schools, five state-funded schools) agreed to participate. Two schools were rural and
118 five schools urban [31]. Using the 2014 index of multiple deprivation (IMD) [32], which
119 ranks areas from 0 (most deprived) to 9 (least deprived), the sampled schools ranked 0 ($n=1$),
120 2 ($n=4$), 5 ($n=1$) and 7 ($n=1$). Within our sample (and across the UK), secondary school
121 pupils who live further than 4.8km away from their nearest school are eligible for free
122 transport [33].

123 Data were collected from 619 11-12 year old children (334 females; mean age = 12.35
124 years, $SD = 0.29$; ethnicity: White = 80.7%, Asian = 15.4%, Black = 2.7%, other = 1.3%).
125 The study was approved by a university ethics committee and written informed consent was

126 obtained from each schools head teacher, parent/guardians had an opportunity to withdraw
127 their child from the study, and children provided their written assent.

128 *Measures*

129 *Distance to school.* Six/seven digit postcodes of the child's home and school were
130 entered into Google Maps using the 'get directions' function and the walking distance
131 between the two points was recorded in kilometres. Using Google Maps as a GPS mapping
132 resource is a recommended method to measure walking and cycling routes for research [34].

133 *Biological maturity.* Two anthropometric measurements were taken at school for
134 stretch stature, sitting height, and body mass using a portable stadiometer and electronic
135 scales. From these measurements, a prediction of when age at peak height velocity (APHV)
136 was likely to occur was used to indicate biological maturity [35]. In brief, a gender-specific
137 multiple regression equation that included stature, body mass, sitting height, leg length,
138 chronological age, and their interactions was applied. This technique has been shown to
139 estimate maturity status to within an error of 1.18 years 95% of the time in boys and 1.14
140 years 95% of the time in girls [35]. To remove the confounding effect of gender (i.e., girls
141 mature earlier than boys) children's APHV was centred on the mean APHV for their
142 respective gender.

143 *Family Support for PA.* Questions about children's perceived family support of PA
144 were adapted from the Amherst Health and Activity study (student survey; [36]). The stem
145 'During a typical week how often has a member of your household (for example, your father,
146 mother, brother, sister, grandparent, or other relatives)' was followed by five items (e.g.
147 'Encouraged you to do physical activities or play sports?'). All items were responded to on a
148 5-point scale ranging from 1 (none) to 5 (daily). The survey was designed to be relevant to all
149 children aged 6 – 17 and all items have been shown to be reliable [36]. The Cronbach's
150 Alpha coefficient in the present study was .79.

151 *Multiple deprivation.* The IMD was calculated based on children’s home postcode.
152 This measure has been used previously in PA-based research [37] and is calculated from a
153 variety of data including average income, employment, health and disability, education, skills
154 and training, housing and services, crime and living environment. The scale ranges from 0
155 (most deprived) to 9 (least deprived).

156 *Active versus Inactive Travel.* Based on previous work [38], participants were asked
157 “How do you get to school?” followed by eight responses: (a) Walk all the way (b) Walk part
158 of the way (c) Public bus (d) School bus (e) Car/taxi (f) Bicycle (g) Train/metro (h)
159 Skateboard or scooter. Participants could mark as many responses as were appropriate to
160 them. Children were classified into two groups (i) active travellers (children who walked all
161 the way, or used a bicycle, skateboard, or scooter), (ii) inactive travellers (all other forms of
162 transport, including those who travelled part of the route actively). We adopted this
163 conservative classification as it is likely that the primary mode of transport for a child who
164 reports part-active travel would be inactive (e.g., walking to the bus stop) [39]. To further
165 justify this choice, we explored differences between part-active and inactive participants in
166 the study variables. MANOVA and follow up univariate test revealed no significant
167 differences across all the variables except from distance to school ($F(1, 333) = 9.682, p =$
168 $.002$; part active = 2.9 ± 2.3 km versus inactive = 4.0 ± 3.0 km).

169 *Statistical Analysis.* We used logistic regression using SPSS (IBM version 21) to test
170 our study hypotheses with active versus inactive travel as the binary coded outcome variable.
171 In the main effects model (hypothesis 1), predictor variables were unstandardised to assist in
172 interpreting odds ratios, however, they were standardised into *Z* scores (with the exception of
173 the binary coded gender variable) in subsequent models to facilitate interpretation of the
174 interaction terms.

175 **Results**

176 *Descriptive statistics*

177 Eight children failed to answer how they travelled to school and were removed from
178 the analysis. Of the remaining 611 participants, 45.3% were classed as inactive travellers,
179 36% used active transport to school and 18.7% travelled via a combination of active and
180 inactive travel methods (and were therefore classified as inactive). The majority (75.4%)
181 were classified as ‘normal’ according to Cole’s BMI cut points [40]; 39.2% lived within 2km,
182 59.0% lived within 4km, 76.9% lived within 6km and 82.9% lived within 8km. Descriptive
183 statistics of the sample can be seen in Table 1. Bivariate correlations among constructs are
184 presented in Table 2 for information only.

185 [INSERT TABLE 1 & 2 NEAR HERE]

186 *Primary analysis*

187 The first logistic regression model (hypothesis 1) included all main effects (distance
188 from school, gender, APHV, family support of PA, and multiple deprivation) as predictors of
189 active versus inactive travel to school. The results can be seen in Table 3 and the predictors
190 explained 40.2% of the variance in mode of transport, however, only distance to school was a
191 significant predictor of active transport, after adjusting for other variables. There were no
192 differences in relationships across gender (i.e., no gender \times predictor interactions).

193 [INSERT TABLE 3 NEAR HERE]

194 To test subsequent hypotheses, each proposed interaction was independently added to
195 the standardised version of the model described above. As shown in Table 3, the interaction
196 between gender and distance to school was not significant; however, APHV, family support
197 for PA, and multiple deprivation significantly moderated the relationship between distance to
198 school and mode of transport. Simple slopes analysis using data ± 1 standard deviation from
199 the standardised mean scores revealed that distance to school had a relatively greater negative
200 impact on the use of active travel in children who are biologically late-maturing (i.e., Girls

201 with APHV ≥ 13.43 years; Boys with APHV ≥ 14.26 years), from less deprived backgrounds
202 (i.e., 8.31 on a 0 – 9 index of multiple deprivation) and with low family support of PA (i.e.,
203 2.36 on a 1 – 5 self-report scale), compared to children who are biologically early-maturing
204 (i.e., Girls with APHV ≤ 11.65 years; Boys with APHV ≤ 12.30 years), from more deprived
205 backgrounds (i.e., 2.89 on a 0 – 9 index of multiple deprivation) and with high family support
206 of PA (i.e., 4.22 on a 1 – 5 self-report scale). See Figure 1 for graphical representation of
207 these moderation effects.

208 [INSERT FIGURE 1 NEAR HERE]

209 To account for potential school differences we ran the regression models again
210 adjusting for school differences in student catchment area (i.e., school average distance
211 travelled by students; coded as 0 = > 6 km, 1 = 5.9 - 3km, 2 = < 3 km). All significant
212 relationships remained with the exception of the interaction between distance and deprivation
213 (OR = 2.37, CI = .75 - 7.44, $p = .14$). No changes to our results were seen in further iterations
214 when we adjusted for the fact that two of the sampled schools were privately funded (versus
215 state schools) and that another two of the sampled schools were largely rural (versus urban).

216 **Discussion**

217 *Main finding of this study*

218 In accordance with previous research [12-15], the closer to school participants lived;
219 the more likely they were to actively commute. None of the remaining study variables
220 (Gender, APHV, family support of PA, and multiple deprivation) were associated with active
221 transport, when other variables were held constant. However, many of these constructs
222 helped in providing new information demonstrating that the relationship between distance
223 and active transport is moderated by a number of factors. In particular, distance had a greater
224 negative impact on the use of AT in a) late-maturing children, b) less socio-economically
225 deprived children and c) children with low family support of PA.

226 *What is already known on this topic?*

227 Distance to school is arguably the most important influence on children's decision to
228 use active transport [41, 42]. Other studies have suggested that gender [18], family support
229 for PA [25], and multiple deprivation [26] are also contributing factors. The majority of prior
230 research has failed to adopt an ecological perspective, however, which suggests that
231 behavioural choices are complex decisions based on the interplay between multiple levels of
232 influence.

233 *What this study adds*

234 Biological maturity of children was not associated with active transport in our main
235 effects model; however, our results demonstrated that the influence of distance to school on
236 active travel was stronger in late maturing children. Graph C in Figure 1 illustrates the
237 likelihood of actively commuting decreases considerably as distance to school increases for a
238 later maturing child, to such an extent that a late maturing child (1 *SD* above the APHV
239 mean) who lives relatively far away (1 *SD* further than the mean distance) has a probability of
240 near zero of actively commuting to school. In contrast, the likelihood of actively commuting
241 decreases to a much lesser extent in an earlier maturing child. No previous research has
242 examined the association between biological maturity and active transport. The reasons why
243 this moderation effect occurs is unclear, however, parents of physically mature children may
244 be less concerned with safety and allow more independence to actively travel relatively long
245 distances, compared to parents of physically immature children. Future research may wish to
246 explore these potential mechanisms.

247 In contrast to previous research [26], multiple deprivation did not predict active
248 transport. This is likely due to our focus on models adjusted for other variables, as the
249 bivariate correlation between multiple deprivation and active travel was statistically
250 significant and of moderate magnitude. Nonetheless, our results do suggest that in deprived

251 areas the influence of distance to school has little impact upon the decision to walk to school,
252 whereas the influence becomes much stronger in less deprived areas. This may be explained
253 by the limited options available to those living in deprived areas, including less access to cars
254 for commuting to school [26] and living in urban environments which are closer to schools
255 [43]. Increased options of active transport for less socially deprived children means the
256 likelihood of active travel decreases markedly as distance increases. When accounting for
257 school differences in catchment areas the interaction between distance and deprivation was
258 no longer significant. This may be because of the similarity and shared variance between
259 catchment area and deprivation (i.e., urban, deprived areas tend to have schools with smaller
260 catchment areas).

261 Despite literature evidencing a relationship [25, 27], our adjusted main effects model
262 suggests that when distance to school is included as a predictor of active travel, family
263 support for PA offers no additional explanatory utility. However, we did find support for our
264 proposed interaction between distance to school and family support of PA. Specifically,
265 distance to school was a less meaningful influence on the decision to actively commute when
266 family support for PA was present. This means that, unlike findings reported by Panter et al
267 [24], the likelihood of active travel when living near school (i.e., -1 *SD* below the
268 standardised mean distance from school) was similar whether positive attitudes were
269 conveyed or not. However, the chances of active travel decline much more rapidly as distance
270 increases if positive attitudes are not conveyed. It should be noted, however, that the attitudes
271 measured by Panter et al. [24] differed to those in the present study (attitudes towards active
272 travel versus PA).

273 Finally, in contrast to previous research [18, 20, 26], our results displayed no
274 significant main or interaction effects of gender. It is unlikely that this was attributable to the
275 inclusion of other variables in our regression models as the bivariate correlation between

276 gender and active travel was also non-significant. However, it should be noted that within our
277 sample girls lived a mean distance of 5.31km from school whereas boys lived, on average,
278 3.55km from school. It is unknown why our sample and findings should differ from many
279 others, although studies reviewed by Davison et al. [26] were based in countries other than
280 the UK. School systems differ between countries, for example, in the UK children tend to
281 transition to their next school aged 11 years old, often located further afield compared to their
282 previous school. It is also worth investigating whether the UK perspective on active travel for
283 boys and girls may differ when compared to other countries.

284 The schools used within this study represent a range of multiple deprivation, included
285 both urban and rural schools, and have a transport policy consistent with the rest of the UK.
286 The results, therefore, have generalisable implications for increasing PA behaviour in
287 schoolchildren. For example, children (and their parents) from less deprived areas may be
288 more likely to choose sedentary travel options, when the distance from school is relatively
289 far. Therefore, enhanced cycling and walking routes from affluent areas not near schools
290 could be the target of environmental intervention. Instead of free bus provision, could
291 supervised cycling, scooting or walking groups be an effective alternative? Finally, parents
292 who do not value and support physical activity may be the focus of educational interventions,
293 especially those who do not live near their child's school. Future work exploring later
294 maturing children and active travel should also be undertaken.

295 *Limitations of this study*

296 This study did not objectively measure active travel and the sample is taken from a
297 narrow age range, therefore, the findings do not reflect younger or older children whose
298 active travel may be influenced by different variables. Many other factors have been shown
299 to influence active travel that we did not measure, such as weather conditions, neighbourhood
300 characteristics and parental mode of travel to work [10, 44-47]. We chose to identify specific

301 moderators of the distance to school and active travel relationship, rather than maximise the
302 amount of explained variance in the decision to actively travel to school. The IMD score is a
303 comprehensive indicator of social deprivation; however, it is a normative ranking system
304 used to compare areas, not a true measure of actual deprivation [48]. In addition, using the
305 IMD to make inferences about individual participants may introduce ecological fallacy and
306 potential circularity, whereby the deprivation score is partly based on lack of access to
307 facilities (for example), yet this deprivation leads to a lack of access to facilities [49; 50].
308 Also assessing biological maturation through predicted APHV with cross-sectional data is
309 likely less accurate than when observed in a longitudinal study [51]. Finally, we did not
310 explicitly investigate mechanisms which may explain some of our findings, including the
311 underlying reasons why socially-deprived and late maturing children are less influenced by
312 distance to school. We have offered speculation on these topics, such as less inactive options
313 available and less safety concerns, however, these should be explicitly tested.

314 **Conclusion**

315 The present study provides evidence that distance to school is the strongest predictor
316 of active transport. However, the study also displayed that this relationship is complex. Late-
317 maturing children, those from socio-economically less deprived backgrounds, and children
318 with low family support of PA should be targeted to help increase active transport uptake,
319 particularly when living relatively far from school. The characteristics of the sampled schools
320 (e.g., state and privately funded, urban and rural) and participants (distance to school,
321 ethnicity, degree of social deprivation, overweight/obese rates) suggest that our sample may
322 reflect UK school children in general.

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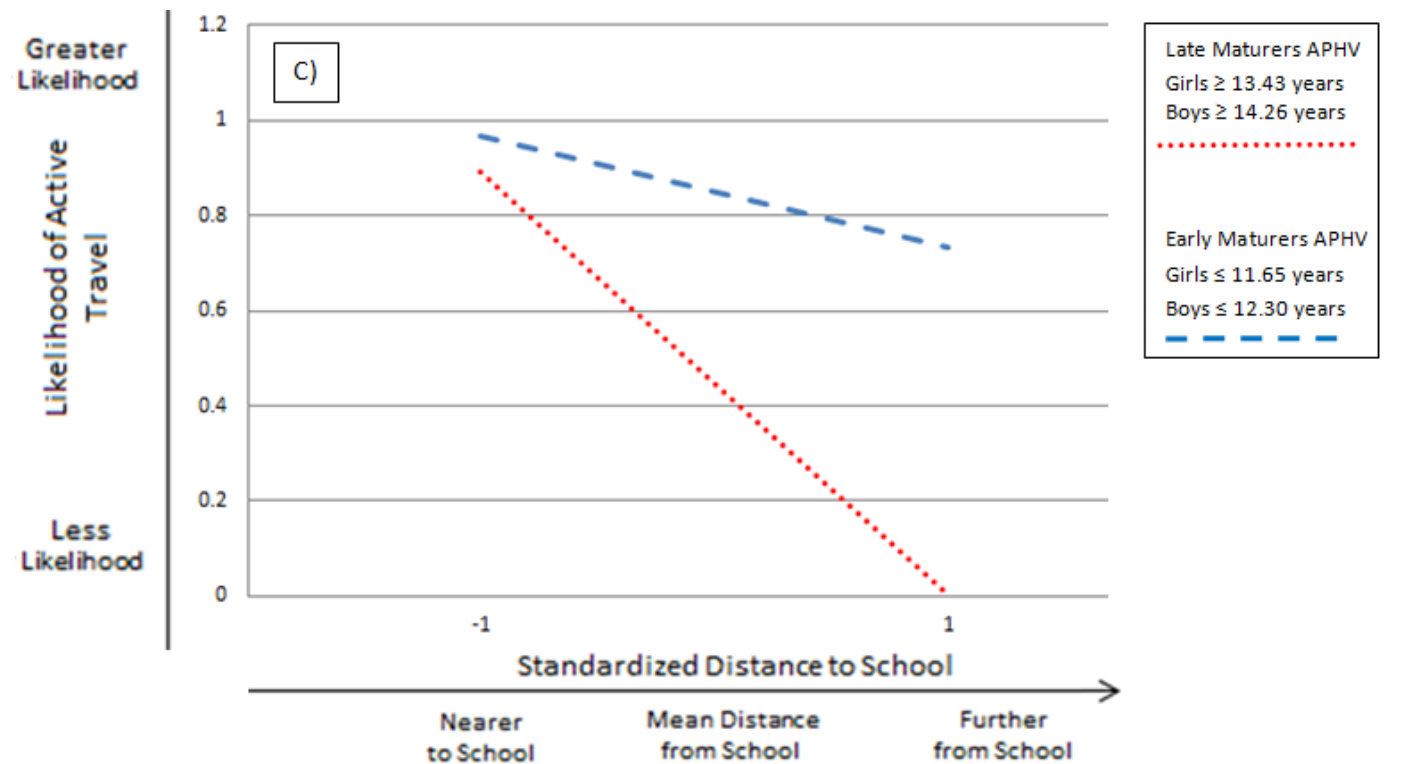
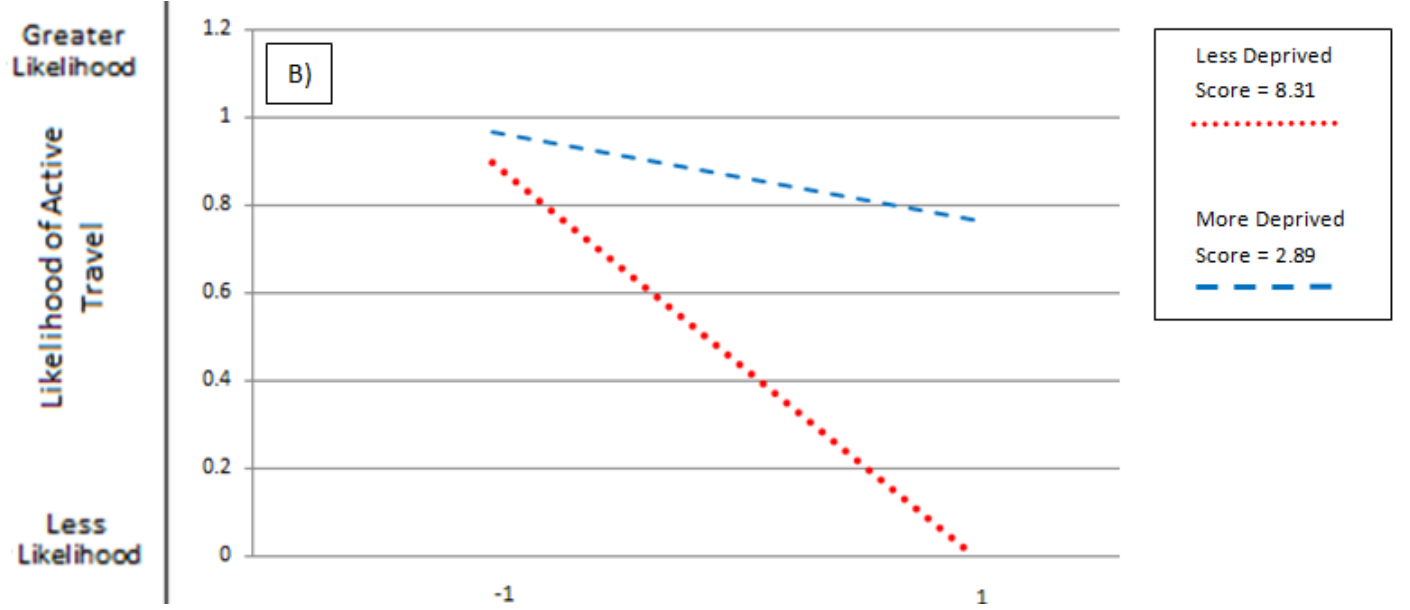
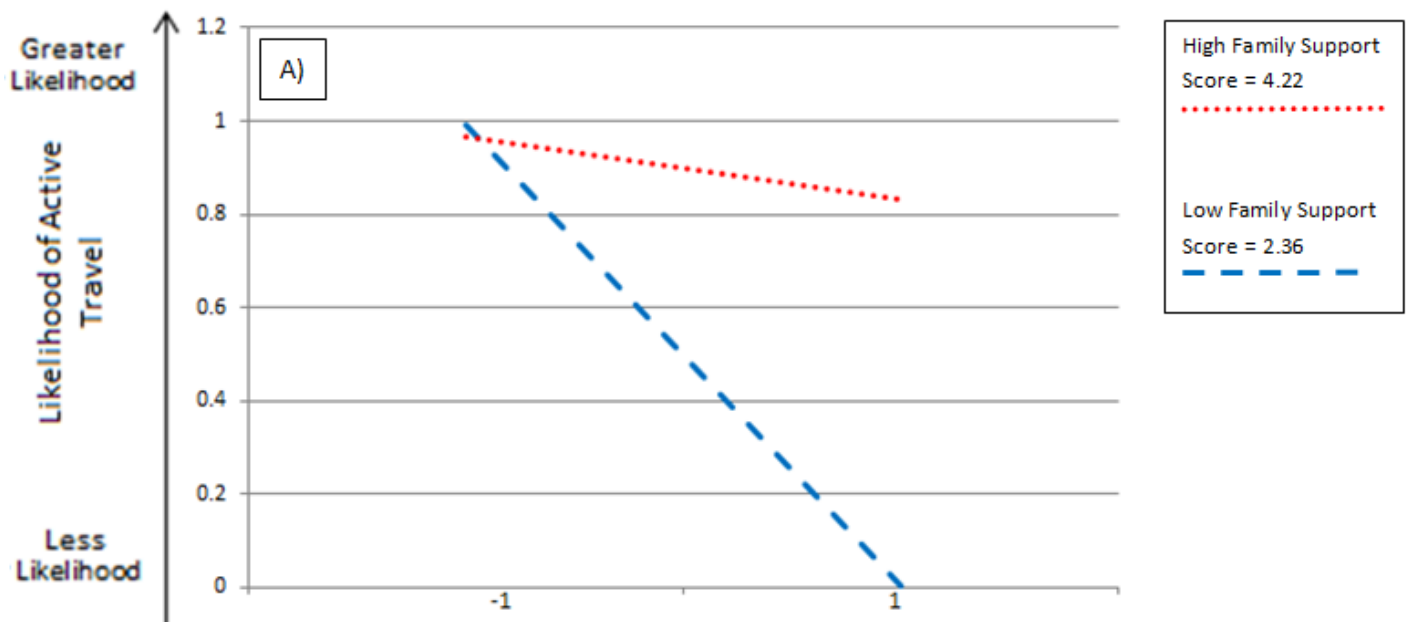


Figure 1. Simple slopes graphs to show interactions between distance to school and family support of PA (A); multiple deprivation (B); and biological maturation (C).

Note: Gender was binary coded as girls = 0 and boys = 1, therefore, the regression equations reflect relationships between predictor variables and active travel in girls. However there was no statistical difference between boys and girls.

Note: The simple slopes analysis used data +/-1 standard deviation from the standardised mean scores to represent 'nearer' and 'further'.

APHV = Age at Peak Height Velocity

Table 1. *Descriptive statistics of study variables and relevant child characteristics*

| | All Children | | Females | | Males | |
|---|------------------|-----------|------------------|-----------|------------------|-----------|
| | <i>(n = 611)</i> | | <i>(n = 334)</i> | | <i>(n = 277)</i> | |
| | <i>M</i> | <i>SD</i> | <i>M</i> | <i>SD</i> | <i>M</i> | <i>SD</i> |
| Age (years) | 12.35 | .29 | 12.35 | .29 | 12.36 | .30 |
| Height (cm) | 152.12 | 7.80 | 152.95 | 7.83 | 151.13 | 7.66 |
| Weight (kg) | 45.69 | 11.07 | 46.87 | 11.57 | 44.29 | 10.30 |
| BMI (kg/m ²) | 19.63 | 3.77 | 19.92 | 3.97 | 19.28 | 3.51 |
| % Overweight/Obese* | - | 24.6% | - | 25.8% | - | 23.3% |
| Family support for physical activity | 3.29 | .93 | 3.21 | .91 | 3.38 | .95 |
| Multiple deprivation | 5.60 | 2.71 | 5.88 | 2.73 | 5.27 | 2.67 |
| Years from age at peak height velocity | -.53 | 1.02 | -.19 | .91 | -.92 | 1.00 |
| Predicted age at peak height velocity (years) | 12.87 | 1.00 | 12.54 | .89 | 13.28 | .98 |
| Distance from school (km) | 4.51 | 5.01 | 5.31 | 6.06 | 3.55 | 3.13 |

Note. *Values are percentages rather than mean (*SD*).

Table 2. *Pearson Correlations between Variables*

| | 1 | 2 | 3 | 4 | 5 |
|---|--------|--------|--------|--------|-------|
| 1 Gender | – | – | – | – | – |
| 2 Age at peak height velocity | .37** | – | – | – | – |
| 3 Multiple deprivation | -.12** | -.13** | – | – | – |
| 4 Walking distance from home to school (km) | -.17** | .07 | .31** | – | – |
| 5 Family support of physical activity | .09* | .03 | .11* | -.02 | – |
| 6 Active travel vs inactive travel | .07 | .03 | -.32** | -.47** | -.09* |

Note. * $p < .05$, ** $p < .01$

Table 3. Logistic regression model including main effects predicting active travel (hypothesis 1) and interaction terms (hypothesis 2 - 5)

| Predictor Variable | Hypothesis 1 | | Hypothesis 2 | | Hypothesis 3 | | Hypothesis 4 | | Hypothesis 5 | |
|--|--------------|----------------|--------------|----------------|--------------|----------------|--------------|----------------|--------------|----------------|
| | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| | | Lower - Higher | | Lower - Higher | | Lower - Higher | | Lower - Higher | | Lower - Higher |
| Constant | 1.03 | - | .09 | - | .06 | - | .07 | - | .06 | - |
| Gender | .99 | .66 - 1.92 | .69 | .22 - 2.10 | 1.13 | .67 - 1.93 | 1.02 | .60 - 1.74 | 1.02 | .60 - 1.73 |
| Multiple Deprivation | .35* | .90 - 1.08 | .94 | .73 - 1.21 | .92 | .71 - 1.19 | .93 | .71 - 1.20 | 1.94 | .97 - 3.86 |
| Distance (km) | .94 | .29* - .43* | .004* | .001* - .02* | .004* | .002* - .01* | .004* | .001* - .01* | .004* | 0.001* - .01* |
| Family Support of PA | 1.10 | .71 - 1.24 | .92 | .70 - 1.20 | .92 | .70 - 1.19 | .46 | .28 - .76 | .92 | .70 - 1.20 |
| Age at PHV | 4.78 | .81 - 1.39 | 1.03 | .80 - 1.33 | 2.05 | 1.19 - 3.51 | 1.07 | .83 - 1.38 | 1.04 | .80 - 1.35 |
| Gender × Distance from Home to School (km) | | | 2.26 | .32 - 16.06 | - | - | - | - | - | - |
| Age at PHV × Distance from Home to School (km) | | | | | 3.60* | 1.45 - 8.96* | - | - | - | - |
| Family Support of PA × Distance from Home to School (km) | | | | | - | - | .26* | .11 - .61* | - | - |
| Multiple Deprivation Index × Distance from Home to School (km) | | | | | - | - | - | - | 3.54* | 1.17 - 10.72* |

Note. PA = Physical activity; PHV = Peak height velocity; OR = Odds Ratio; CI = Confidence Interval; * $p < .05$. Predictor variables were unstandardised in the model testing hypothesis 1, and standardised in subsequent mode.