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# Environmental and Socio-demographic Factors Associated with 6–10-Year-Old Children's School Travel in Urban and Non-urban Settings

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**Abstract** Walking or bicycling to school is an important source of physical activity and may help prevent childhood obesity. However, active commuting has been declining in recent decades. The purposes of this study were to explore travel characteristics in children and examine factors associated with active commuting in children living in urban and non-urban setting. Participants were 834 parents and corresponding children aged 6–10 years, living in the district of Coimbra, Portugal. Data were collected during April–June of 2013 and 2014. Anthropometric measures (height, weight, waist circumference) were taken in children. Mode shift and child/family demographics were assessed by a parental questionnaire. School and home addresses were geocoded and the shortest route (meters) was taken in consideration. Although car is the most common way of travel to school, active transportation is significantly more prevalent in children living in the non-urban setting. Different determinants were found associated with active travel according to the level of urbanization. The adjusted logistic regression revealed that, independently of the urbanization, children whose mothers actively commute to work, whose parents reported their neighbor as safe to walk, and children living less than 2000 m from school were significantly more likely to walk to school. Present findings highlight the need to consider models with different levels, including individual, social, and environmental characteristics, when developing interventions and policies to promote active transport to school.

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## Introduction

Walking, bicycling, or using other modes of active travel to school provides an opportunity to incorporate regular physical activity (PA) into the lives of children [1]. Active transportation was shown to be associated with increased daily energy expenditure and increased cardiovascular fitness when compared to traveling by car [2, 3]. Also, children who walked to school had higher odds of a healthy waist circumference and better high-density lipoprotein cholesterol profiles than non-active commuters [4].

The proportion of children adopting an active way of travel to school varies considerably across countries [5] and even within the same country [6, 7]. Despite the potential health benefits of active commuting, declining rates of children walking or biking to school over the last decades have been reported in various countries, such as Switzerland [8], Australia [9], and Canada [10]. To the best of our knowledge, previous studies from Portugal regarding travel to school were conducted with older children and revealed a small prevalence of active transportation. For instance, a study from 2012 carried in 14–18-year-old children found that 44.8% engaged in active transportation [11] and results from 2014 indicated that 35.8% of children aged 13 and older were active commuters [12], with the prevalence decreasing over the past years [13] following the tendency observed in most developed countries.

Previous studies have highlighted multilevel, ecological barriers as the main reasons for the small prevalence of active transportation. The rise of build environments oriented for cars and less attention to pedestrian infrastructures together with parental safety concerns regarding children's independent mobility has limited active transportation [6, 14, 15]. However, even when most physical environmental conditions for active transport are fulfilled, such as sidewalks and bicycle lanes, many children still do not use active transportation [16, 17], indicating that creating a walkable environment is a necessary but not a sufficient condition to increase active school transportation. For instance, child and parent attitudes regarding the convenience of active transportation and their lack of motivation have been cited as barriers [18]. Parental modeling behaviors of active transportation has been associated with children's active school transportation [19], reinforcing that, during the first years of life, parental views and behaviors may be the key social environment influences on children's behaviors.

Understanding the barriers to active transportation to school in specific environments may provide an important contribution to design and implement relevant policies and effective programs to increase opportunities for active transportation. Therefore, the aims of this study were to observe the home-school travel characteristics in urban and non-urban settings and investigate possible determinants of active transportation in 6–10-year-old children, according to the level of urbanization of their place of residence.

## Materials and Methods

### Sample

The cross-sectional study was carried out among 6–10-year-old children studying in elementary schools in central Portugal, and their respective parents. The study is part of a larger project which examined the social, cultural, and physical factors that may contribute to physical activity and obesity rates in Portuguese children [20–22]. The project was approved by the Portuguese Commission for Data Protection which requires anonymity and no transmissibility of data, corroborated by the *Direcção Geral de Inovação e Desenvolvimento Curricular* (Portuguese General Directorate of the Ministry of Education). Assent was requested from schools and informed written consent was obtained from participants. Two areas were selected to participate in the study, the city of Coimbra and the village of Lousã. Three of the biggest primary schools situated in the center of those areas were included in the study and all the students from those schools were invited to participate. Parents were informed that they had 1 week to return the consent forms completely filled if they wanted to participate in the study. Apart from the geographical location, no pre-selection was applied but parents who reported that their child had a health condition that would hinder their participation in sport activities were not included in the study.

In total, 1369 questionnaires were delivered across schools and 834 were received completely filled and with the consent form (443 in the urban setting and 391 in the non-urban setting). From those 834 parents that participated in the study, a total of 793 children were included in the anthropometric measures (the difference was due to children being sick or not feeling well, children refused to participate or did not attend school during the days the investigators were collecting the measures). Data was collected from April to mid-June in 2013 and in 2014.

### Anthropometry

Height (cm), weight (kg), and waist circumference (cm) were measured at school with participants dressed in lightweight clothing and without shoes. The body mass index (BMI, $kg/m^2$) was calculated. Children were classified into normal weight or overweight (including obesity), according to the age- and sex-specific BMI cut-offs of the International Obesity Task Force (IOTF) [23]. Abdominal obesity was defined using the cut-off value of $\geq 0.5$ [24] for waist-to-height ratio (WHtR), and children were classified as having no risk or having risk of abdominal obesity.

### Measures Collected by Parental Questionnaire

Details about the questionnaire used are described elsewhere [20]. Child measures included sex, age (6 and 7 years old; 8 or more years), and way of transport to school. Transport to/from school was assessed by the question "How does your child typically travels to/from school?" and trips were coded as walking, cycling, private motorized transport, or public transport. A binary variable was generated from these data (active versus passive transportation).

Parental variables considered for this study were parental education ((1) no parent has a university degree, (2) one parent has a university degree, and (3) both parents have a university degree); household income divided as low (< €1000 per month), middle (between €1000 and €1500), and high (> €1500 per month); and type of transport use by the parents to travel to work (passive vs. active). Parents were also asked which factors they perceived as barriers for their child participation in PA (e.g., time, transportation, facilities, safety, costs, weather, health, and child interest) and what type of recreational facilities they had close to home (closeness defined as a walking distance). Both items were asked as a multiple-choice question and parents could provide multiple responses. Their answers were categorized 0–1 facilities close to home, 2–3 facilities or 4–5 facilities; and none (0) barrier, 1–2 barriers or more than 2 barriers. Specifically for active commute, parents reported if it was possible, considering distance and neighborhood safety, for their children to active commute to school, and their answers were divided as safe or not safe.

Participants' home address was reported by parents and location of schools was obtained from the City Council website. The addresses were geocoded and the shortest route home-school (in meters) along the street network was used. Distance to school was classified into 0–1000, 1001–2000, 2001–3000, or greater than 3000 m from home. Place of residence for each individual was classified as urban or non-urban according to the criteria of the Portuguese Statistical System [25], in which urban areas are defined as a city with > 500 inhabitants/km$^2$ or > 50,000 inhabitants.

### Statistical Analysis

Sample was divided according to the place of residence (urban vs non-urban) and descriptive statistics were done for all the variables using chi-square tests to observe possible differences. A chi-square test was also used to investigate whether distributions of trip characteristics (walk, cycle, private motorized vehicle, and public transport) differed according to the level of urbanization. Next, a crude (bivariate) analysis was conducted for active transport to school (e.g., walk, cycle) and potential predictor factors. Factors with a $p$ value < 0.05 in the bivariate analyses were considered for the multivariate model. Children's sex and age were specified as fixed effects in the model and were included in the multivariate model irrespective of statistical significance in the bivariate analyses. Statistical significance was set at 0.05 and analyses were performed using the Statistical Package for the Social Sciences (SPSS v.23; SPSS an IBM Company, Chicago, IL).

## Results

Participants' characteristics are outlined in Table 1. Children were aged between 6 and 10 years (mean 8.05, SD = 1.21). The majority of children from the urban setting lived at more than 3000 m from school (56.5%), while the inverse was seen in children from the non-urban setting, in which 40.8% reported to live at less than 1 km (km) from the school. Most fathers (90.9%) and mothers (85.3%) reported a passive way of transport from home to work, particularly in the urban setting. Parents from the urban setting reported more safety concerns regarding children's active commute than parents living in the non-urban setting ($X^2 = 78.94$, $p < 0.001$).

Data on travel mode to school is presented in Table 2. A majority of trips were made by private motor vehicle (74.7%) while cycle trips were not reported by any parent. Walking to school was more common among children living in the non-urban setting (29.4%) than in children from the urban setting (11.5%) and the differences in the way of transport according to the level of urbanization were statistically significant ($p < 0.001$).

Table 3 shows the variables related with active transportation in children living in the urban setting. In the

**Table 1** Participant characteristics ($n = 834$), central Portugal (2013–2014)

| | | Total % (n) | Urban % | Non-urban % |
|---|---|---|---|---|
| Sex | Girls | 50.8 (424) | 52.1 | 49.4 |
| | Boys | 49.2 (410) | 47.9 | 50.6 |
| Age | 6–7 years | 39.0 (325) | 37.7 | 40.4 |
| | 8–10 years | 61.0 (509) | 62.3 | 59.6 |
| Obesity | Normal weight | 78.1 (619) | 76.3 | 80.1 |
| | Overweight/obesity | 21.9 (174) | 23.7 | 19.9 |
| Abdominal obesity | No risk | 78.1 (541) | 79.1 | 76.4 |
| | Risk | 21.9 (152) | 20.9 | 23.6 |
| Recreational facilities close to home | 0–1 | 23.9 (199) | 24.6 | 23.1 |
| | 2–3 | 27.6 (230) | 36.6 | 17.5 |
| | 4–5 | 20.6 (171) | 19.4 | 21.9 |
| | 6 or more | 27.9 (232) | 19.4 | 37.5 |
| Parental perceived safety to active home-school transport* | Safe | 32.0 (266) | 18.5 | 47.3 |
| | Not safe | 67.9 (566) | 81.5 | 52.7 |
| Barriers | None | 21.5 (179) | 20.0 | 23.3 |
| | 1–2 | 65.6 (545) | 66.9 | 64.1 |
| | > 2 | 12.9 (107) | 13.2 | 12.6 |
| Household income* | Low | 29.7 (234) | 18.5 | 42.2 |
| | Medium | 26.1 (206) | 22.1 | 30.6 |
| | High | 44.2 (348) | 59.4 | 27.2 |
| Parental education* | 0 parents with high degree | 38.9 (304) | 24.9 | 55.3 |
| | 1 parent with high degree | 24.7 (193) | 20.7 | 29.4 |
| | 2 parents with high degree | 36.4 (284) | 54.4 | 15.3 |
| Distance to school* | 0–1000 m | 27.1 (222) | 15.1 | 40.8 |
| | 1001–2000 m | 23.1 (189) | 19.9 | 26.9 |
| | 2001–3000 m | 9.0 (74) | 8.5 | 9.7 |
| | > 3000 m | 40.8 (334) | 56.5 | 22.8 |
| Mother transportation* | Passive | 85.3 (614) | 93.3 | 75.2 |
| | Active | 14.7 (106) | 6.7 | 24.8 |
| Father transportation* | Passive | 90.9 (660) | 93.0 | 88.3 |
| | Active | 9.1 (66) | 7.0 | 11.7 |

*Note.* *Chi-square $p$ value $< 0.05$

**Table 2** Characteristics of the home-school-home trip of children aged 6–10 years living in central Portugal (2013–2014)

| | Walk % (*n*) | Cycle % (*n*) | Private motorized transport % (*n*) | Public transport % (*n*) | Total *n* |
|---|---|---|---|---|---|
| Total sample | 19.9% (166) | 0 | 74.7% (623) | 5.4% (45) | 834 |
| Urban | 11.5% (51) $^{a}$ | 0 | 86.5% (383) $^{a}$ | 2.0% [9] $^{a}$ | 443 |
| Non-urban | 29.4% (115) $^{b}$ | 0 | 61.4% (240) $^{b}$ | 9.2% [36] $^{b}$ | 391 |
| Statistics | $X^2 = 70.73$, $p < 0.001$ | | | | |

*Note.* $p$ value was calculated by chi-square test; $^{a, b}$ Each subscript letter denotes a statistical significant difference according to the level of urbanization

**Table 3** Results from the bivariate and the multivariate logistic regression of active transport to school with potential predictor variables for children living in the urban setting (central Portugal, 2013–2014)

| | Child active transport to school | | | |
|---|---|---|---|---|
| | Bivariate analyses | | Multivariate analyses | |
| | OR (95%CI) | *p* value | OR (95%CI) | *p* value |
| Sex* | | 0.36 | | 0.62 |
| Girls | 0.76 (0.42–1.37) | | 0.65 (0.17–2.44) | |
| Boys | Ref. | | Ref. | |
| Age* | | 0.57 | | 0.23 |
| 6–7 years | 0.84 (0.45–1.55) | | 0.64 (0.16–2.55) | |
| 8–10 years | Ref. | | Ref. | |
| Obesity | | 0.02 | | 0.33 |
| Normal weight | 3.01 (1.16–7.81) | | 0.31 (0.04–2.43) | |
| Overweight/obesity | Ref. | | Ref. | |
| Abdominal obesity | | 0.01 | | 0.20 |
| No risk | 4.53 (1.37–14.92) | | 5.88 (0.59–22.12) | |
| Risk | Ref. | | Ref. | |
| Perceived safety to act. commute | | < 0.001 | | < 0.001 |
| Safe | 94.04 (38.82–135.03) | | 18.88 (3.72–95.89) | |
| Not safe | Ref. | | Ref. | |
| Facilities close to home | | 0.04 | | 0.83 |
| 0–1 | 0.51 (0.21–1.25) | | 1.83 (0.15–13.75) | |
| 2–3 | 0.53 (0.24–1.19) | | 1.38 (0.20–7.61) | |
| 4–5 | 1.09 (0.48–2.48) | | 1.51 (0.34–16.71) | |
| 6 or more | Ref. | | Ref. | |
| Barriers | | 0.04 | | 0.88 |
| None | 3.47 (0.95–12.66) | | 2.54 (0.18–35.04) | |
| 1–2 | 2.23 (0.66–7.55) | | 7.77 (0.67–89.67) | |
| > 2 | Ref. | | Ref. | |
| Household income | | 0.53 | | – |
| Low | 1.36 (0.64–2.88) | | – | |
| Medium | 0.88 (0.40–1.96) | | – | |
| High | Ref. | | – | |
| Parental education | | 0.23 | | – |
| 0 parents with high degree | 0.70 (0.34–1.49) | | – | |
| 1 parent with high degree | 0.49 (0.20–1.23) | | – | |
| 2 parents with high degree | Ref. | | – | |
| Distance to school | | < 0.001 | | < 0.001 |
| 0–1000 m | 40.10 (25.09–66.10) | | 25.10 (2.82–55.62) | |
| 1001–2000 m | 19.70 (8.97–45.28) | | 20.33 (3.98–31.03) | |
| 2001–3000 m | 1.00 (0.23–10.54) | | 9.77 (0.79–14.09) | |
| > 3000 m | Ref. | | Ref. | |
| Mother transportation | | < 0.001 | | 0.01 |
| Passive | 0.11 (0.05–0.26) | | 0.15 (0.03–0.90) | |
| Active | Ref. | | Ref. | |
| Father transportation | | 0.02 | | 0.78 |
| Passive | 0.34 (0.14–0.85) | | 1.58 (0.26–9.78) | |
| Active | Ref. | | Ref. | |

*Note.* *Fixed effect in the multivariate model; variables that had a $p$ value < 0.05 entered in the multivariate model; *OR* odds ratio, *CI* confidence interval univariate model, children with normal weight (OR = 3.01, $p = 0.02$), with no abdominal obesity (OR = 4.53, $p = 0.01$), children that lived closer to school (OR = 13.92, $p < 0.001$), whose parents reported no barrier to children's PA (OR = 1.72, $p = 0.04$), and that it was safe for children to active commute (OR = 94.04, $p < 0.001$) had significantly higher odds to adopt an active way of transport to school. On the other side, children with less recreational facilities close to home (OR = 0.75, $p = 0.04$) and whose mother or father reported a passive way of travel to work (OR = 0.11, $p < 0.001$ and OR = 0.34, $p = 0.02$, respectively) had significantly less odds of traveling to school in an active way.

Table 4 presents the regression models regarding the association between active transport to school and a number of variables for children living in the non-urban setting. Children from lower income households (OR = 1.47, $p = 0.01$), whose parents had less education (OR = 1.53, $p = 0.01$), parents who reported safe neighborhood conditions to active commute (OR = 18.78, $p < 0.001$), and children who lived closer to the school (OR = 8.06, $p < 0.001$) had significantly higher odds to engage in active transportation than children whose parents reported higher incomes, higher education, and living further from school. Also, in the non-urban setting, parents that reported less recreational facilities close to home (OR = 0.56, $p < 0.001$) and parents who travel to work by passive modes of transport (mother OR = 0.17, $p < 0.001$ and father OR = 0.41, $p = 0.01$) had significantly less odds of their children to adopt active transportation to school.

In the final multivariate models, results were similar for children living in the urban and in the non-urban setting with shorter distance to school, mother's mode of transportation and perceived safety of the neighborhood remaining significantly associated with the likelihood of undertaking active transportation to school (Tables 3 and 4). Those living at less than 1000 m or between 1001 and 2000 m from school were significantly more likely to walk to school than those residing at more than 3000 m both in the urban (OR = 25.10, OR = 20.33, $p < 0.001$, respectively) and in the non-urban setting (OR = 32.10, OR = 25.09, $p < 0.001$, respectively). In both settings, parents who reported more perceived safety for their children to actively commute had significantly higher odds of their children walk to school compared with parents who reported more safety concerns (urban OR = 18.88, $p < 0.001$; non-urban OR = 10.08, $p < 0.001$). Finally, independently of the setting, children whose mother reported to travel in a passive way to work had significantly lower odds of undertaking active transportation to school than children with an active mother (OR = 0.11, $p = 0.01$ and OR = 0.21, $p = 0.00$ in the urban and non-urban setting, respectively).

## Discussion

From a public health perspective, for children of younger ages, active transport should be considered as a major key factor to increase PA levels and to reduce important negative health outcomes such as obesity [1, 26]; however, few studies have been carried in Portugal regarding this aspect; most of them were carried in older children, and the level of urbanization is not usually taken in consideration. The present study shows that most children travel to school by private motorized vehicle which is line with previous results found in Portuguese adolescents [11, 12, 27, 28].

In this study, 19.9% of children walked to school which is a lower prevalence of active transportation compared with 28.1% registered in a sample of Portuguese children with a mean age of 10.4 (SD = 0.3) [27], 35% found in a sample of 8th and 10th students [12], 45% reported for a sample of children with a mean age of 16.6 years (SD = 1.3) [11], and 52.6% found in a sample of girls from the 7th to 12th grades [29]. Differences in the prevalence of active transportation may be due to sample characteristics and the different environments but also due to children's age, since longitudinal analyses indicated that as children grew older, the likelihood of using active transportation to school increased, particularly after the age of 10 years to decrease at the beginning of the secondary school years [30, 31]. Also, in line with previous studies, few Portuguese children cycled to school [4, 27].

Active travel to school was significantly more prevalent in children living in the non-urban setting than in their urban counterparts. Previous studies are not consensual regarding this matter. Sirard et al. [32] found no association between walking or cycling to school and levels of urbanization while, in contrast, Ewing and colleagues found that a high local population density was associated with an increase likelihood of active commuting in children [33]. Bruijin and colleagues [34] found that Dutch adolescents attending schools in less urbanized cities (with less than 50,000 inhabitants) were more likely to engage in active travels than those

**Table 4** Results from the bivariate and the multivariate logistic regression of active transport to school with potential predictor variables for children living in the non-urban setting (central Portugal, 2013–2014)

| | Child active transport to school | | | |
|---|---|---|---|---|
| | Bivariate analyses | | Multivariate analyses | |
| | OR (95%CI) | *p* value | OR (95%CI) | *p* value |
| Sex* | | 0.20 | | 0.52 |
| Girls | 1.33 (0.86–2.05) | | 0.78 (0.34–1.80) | |
| Boys | Ref. | | Ref. | |
| Age* | | 0.48 | | 0.99 |
| 6–7 years | 1.17 (0.75–1.82) | | 0.91 (0.38–2.16) | |
| 8–10 years | Ref. | | Ref. | |
| Obesity | | 0.84 | | – |
| Normal weight | 1.06 (0.61–1.85) | | – | |
| Overweight/obesity | Ref. | | – | |
| Abdominal obesity | | 0.67 | | – |
| No risk | 1.15 (0.60–2.22) | | – | |
| Risk | Ref. | | – | |
| Perceived safety to act. commute | | < 0.001 | | < 0.001 |
| Safe | 18.78 (9.98–35.36) | | 10.08 (3.41–29.77) | |
| Not safe | Ref. | | Ref. | |
| Facilities close to home | | < 0.001 | | 0.49 |
| 0–1 | 0.12 (0.05–0.29) | | 0.96 (0.18–4.93) | |
| 2–3 | 0.45 (0.24–0.87) | | 0.57 (0.18–1.79) | |
| 4–5 | 0.94 (0.54–1.62) | | 1.28 (0.45–3.61) | |
| 6 or more | Ref. | | Ref. | |
| Barriers | | 0.08 | | – |
| None | 2.30 (0.99–5.34) | | – | |
| 1–2 | 1.94 (0.90–4.20) | | – | |
| > 2 | Ref. | | – | |
| Household income | | 0.01 | | 0.50 |
| Low | 2.25 (1.25–4.04) | | 1.19 (0.35–4.04) | |
| Medium | 1.72 (0.91–3.24) | | 1.09 (0.39–2.99) | |
| High | Ref. | | Ref. | |
| Parental education | | 0.01 | | 0.29 |
| 0 parents with high degree | 2.34 (1.11–4.92) | | 1.81 (0.46–7.05) | |
| 1 parent with high degree | 1.54 (0.68–3.47) | | 1.12 (0.28–4.43) | |
| 2 parents with high degree | Ref. | | Ref. | |
| Distance to school | | < 0.001 | | < 0.001 |
| 0–1000 m | 39.03 (18.85–75.65) | | 13.98 (2.45–50.11) | |
| 1001–2000 m | 13.52 (1.74–25.08) | | 1.31 (0.21–8.38) | |
| 2001–3000 m | 2.47 (0.15–14.64) | | 1.06 (0.77–14.68) | |
| > 3000 m | Ref. | | Ref. | |
| Mother transportation | | < 0.001 | | 0.00 |
| Passive | 0.17 (0.10–0.30) | | 0.22 (0.09–0.58) | |
| Active | Ref. | | Ref. | |
| Father transportation | | 0.01 | | 0.22 |
| Passive | 0.41 (0.20–0.81) | | 0.54 (0.17–1.69) | |
| Active | Ref. | | Ref. | |

*Note.* *Fixed effect in the multivariate model; variables that had a *p* value < 0.05 entered in the multivariate model; *OR* odds ratio, *CI* confidence interval living in more urbanized areas which is consistent with present findings. The majority of children from the non-urban setting lived closer to school in contrast with children from the urban area, which may in part explain the results found. Also, additional factors related to the physical environment can play an important role. For instance, urbanized towns usually tend to have greater traffic volume and speed, which is often referred as a barrier for active commuting to school [35].

Results revealed that child sex and age were not significantly associated with walking to school. Curiously, the univariate models revealed that active transportation to school may be associated with different factors, depending of the level of urbanization. In the urban setting but not in the non-urban, children's obesity and parental perceived barriers was associated with active transportation, while household income and parental education were associated with active transportation to school in the non-urban setting but not among children living in the urban area. Previous studies had reported an association between active transportation to school and children's healthier body composition [4, 27], parental perceived barriers including personal, social and physical environmental characteristics [35], lower socioeconomic status and lower parental education [29, 30, 36, 37], which is in line with present findings. In common for both settings, less recreational facilities close to home, parental passive transportation to work and longer distances between house and school were negatively associated with active transportation. A neighborhood with less recreational facilities may also lack other infrastructures like sidewalks and crossroads, or it may be situated in isolated zones outside good residential areas with good public services which are physical environments commonly associated with active traveling to school [12].

The multivariate model studied the effects of multiple variables and recognized the strongest determinants of active transportation, namely mother transportation, parental perceived neighborhood safety to active commute, and distance to school, which were independently of the urbanization level. As expected, parental perceived neighborhood safety was a strong predictor of children's active commute both in the urban and in the non-urban setting. Perceived safety can be in terms of road safety (e.g., traffic- or pedestrian related concerns) as well as personal safety (e.g., crime- or predator-related concerns) and both items have been found to be associated with walking to school [2, 38, 39].

Parental modeling behavior of active transportation has been associated with children's active school transportation [2, 19, 40] reinforcing the importance of parental modeling for children's PA behaviors and suggesting that targeting parents and youth may increase intervention success. Previous data suggest that children are typically escorted by mothers to school [41] which explains why only mother's transportation to work remained relevant to children's active transportation to school. In this study, distance to school was the strongest correlate of active school transportation in all the analyses which is in line with most other studies [7, 19, 42]. Results indicate that 2000 m seems to be the maximum distance for walking between home and school, in both the urban and the non-urban setting. City councils may take in consideration the location of residential developments and other community facilities and pay special attention to the needs of pedestrians and cyclists (e.g., low traffic speed, sidewalks, crossroads, lights, landscape) at least within a radius of 2 km around schools. Also, school boards may create zones for parents to drop off and pick up children placed at 1 km from schools, which could stimulate active transportation in children living further away from schools. School policy may be a practical target for interventions since students and parents' perception of teacher and school support for active commuting may help to contradict the strong effect of parental safety concerns observed in this study.

This work had a number of strengths and limitations. A strong point of the study was the representative study sample of children and parents, distributed over two different settings. In addition, the distance of the shortest route from home to school for each individual was objectively calculated and a multivariate analysis gave us the opportunity to study the effects of multiple variables and find the strongest factors associated with active traveling to school. A weakness of this study was having no information of the number of days on which children used active school transportation, the number of cars per household, and that the way of travel itself was self-reported by parents. Future studies should have those variables in consideration and include them as potential factors influencing children's active commute. In addition, this is a cross-sectional study, which only allows to study associations rather than predictors of active school transportation, and the results may represent the specific conditions of the physical environments observed in this study.

In conclusion, active transportation to school is not very common in Portuguese children but seems to be significantly more prevalent in children living in less urbanized settings. Some factors associated with active transportation to school varied according to the level of urbanization; however, in the final model, mother transportation to work, parental perceived neighborhood safety, and home-school distance remained the strongest factors significantly associated with active transportation, independently of the settings. This indicates that future interventions and policies to promote active travels to/from school should target different levels of ecological models such as social and environmental factors.

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## References

1. Tudor-Locke C, Ainsworth BE, Popkin BM. Active commuting to school: an overlooked source of childrens' physical activity? *Sports Med*. 2001;31(5):309–13. http://www.ncbi.nlm.nih.gov/pubmed/11347681. Accessed 8 July 2016.
2. Davison KK, Werder JL, Lawson CT. Children's active commuting to school: current knowledge and future directions. *Prev Chronic Dis*. 2008;5(3):A100. http://www.ncbi.nlm.nih.gov/pubmed/18558018. Accessed 3 Nov 2016.
3. van Sluijs EMF, Fearne VA, Mattocks C, Riddoch C, Griffin SJ, Ness A. The contribution of active travel to children's physical activity levels: cross-sectional results from the ALSPAC study. *Prev Med*. 2009;48(6):519–24. https://doi.org/10.1016/j.ypmed.2009.03.002.
4. Pizarro AN, Ribeiro JC, Marques EA, Mota J, Santos MP. Is walking to school associated with improved metabolic health? *Int J Behav Nutr Phys Act*. 2013;10(1):12. https://doi.org/10.1186/1479-5868-10-12.
5. Sirard JR, Slater ME. Walking and bicycling to school: a review. *Am J Lifestyle Med*. 2008;2:372–96. https://doi.org/10.1177/1559827608320127.
6. Oliver M, Badland H, Mavoa S, Witten K, Kearns R, Ellaway A, et al. Environmental and socio-demographic associates of children's active transport to school: a cross-sectional investigation from the URBAN study. *Int J Behav Nutr Phys Act*. 2014;11:70–82. https://doi.org/10.1186/1479-5868-11-70.
7. Mammen G, Stone MR, Buliung R, Faulkner G. School travel planning in Canada: identifying child, family, and school-level characteristics associated with travel mode shift from driving to active school travel. *J Transp Health*. 2014;1(4):288–94. https://doi.org/10.1016/j.jth.2014.09.004.
8. Grize L, Bringolf-Isler B, Martin E, Braun-Fahrländer C. Trend in active transportation to school among Swiss school children and its associated factors: three cross-sectional surveys 1994, 2000 and 2005. *Int J Behav Nutr Phys Act*. 2010;7:28. https://doi.org/10.1186/1479-5868-7-28.
9. Salmon J, Timperio A, Cleland V, Venn A. Trends in children's physical activity and weight status in high and low socio-economic status areas of Melbourne, Victoria, 1985-2001. *Aust N Z J Public Health*. 2005;29(4):337–42. http://www.ncbi.nlm.nih.gov/pubmed/16222931. Accessed 4 Jan 2018.
10. Buliung RN, Mitra R, Faulkner G. Active school transportation in the Greater Toronto Area, Canada: an exploration of trends in space and time (1986-2006). *Prev Med*. 2009;48(6):507–12. https://doi.org/10.1016/j.ypmed.2009.03.001.
11. Pizarro AN, Santos MP, Ribeiro JC, Mota J. Physical activity and active transport are predicted by adolescents' different built environment perceptions. *Aust J Public Health*. 2012;20(1):5–10. https://doi.org/10.1007/s10389-011-0432-4.
12. Loureiro N, de Matos MG. Why don't they walk or cycle? Reflections on active home–school transportation among Portuguese adolescents: the role of environmental perceptions. *Urban Plan Transp Res*. 2014;2(1):265–273. https://doi.org/10.1080/21650020.2014.922896.
13. INE. Censos 2011. Instituto Nacional de Estatística. http://censos.ine.pt/xportal/xmain?xpgid=censos2011_apresentacao&xpid=CENSOS. Published 2011. Accessed 20 Apr 2016.
14. Carver A, Timperio A, Hesketh K, Crawford D. Are children and adolescents less active if parents restrict their physical activity and active transport due to perceived risk? *Soc Sci Med*. 2010;70(11):1799–805. https://doi.org/10.1016/j.socscimed.2010.02.010.
15. Panter J, Corder K, Griffin SJ, Jones AP, van Sluijs EM. Individual, socio-cultural and environmental predictors of uptake and maintenance of active commuting in children: longitudinal results from the SPEEDY study. *Int J Behav Nutr Phys Act*. 2013;10:83. https://doi.org/10.1186/1479-5868-10-83.
16. Van Kann DHH, Kremers SPJ, Gubbels JS, et al. The association between the physical environment of primary schools and active school transport. *Environ Behav*. 2015;47(4):418–35. https://doi.org/10.1177/0013916513519644.
17. Napier MA, Brown BB, Werner CM, Gallimore J. Walking to school: community design and child and parent barriers. *J Environ Psychol*. 2011;31:45–51.
18. Loitz CC, Spencer-Cavaliere N. Exploring the barriers and facilitators to children's active transportation to and from school from the perspectives of practitioners. *J Phys Act Health*. 2013;10(8):1128–35. https://doi.org/10.1123/jpah.10.8.1128.
19. Van KDHH, Kremers SPJ, De Vries SI, De Vries NK, Jansen MWJ. Parental active transportation routines (PATRns) as a moderator of the association between neighborhood characteristics and parental influences and active school transportation. *Environ Behav*. 2016;48(7):946–65. https://doi.org/10.1177/0013916515574548.
20. Rodrigues D, Padez C, Machado-Rodrigues AM. Active parents, active children: the importance of parental organized physical activity in children's extracurricular sport participation. *J Child Health Care*. 2017;22:1–12. https://doi.org/10.1177/1367493517741686.

21. Rodrigues D, Padez C, Machado-Rodrigues AM. Prevalence of abdominal obesity and excess weight among Portuguese children and why abdominal obesity should be included in clinical practice. *Acta Medica Port*. 2018;31(3): 159–64. https://doi.org/10.20344/amp.9000.
22. Rodrigues D, Padez C, Machado-rodrigues AM. Perceived psychological, cultural, and environmental barriers to sport in children living in urban and non-urban settings in the Midlands, Portugal. *Sport Sci Health*. 2017;13(3):565–571. https://doi.org/10.1007/s11332-017-0382-5.
23. Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. *Pediatr Obes*. 2012;7(4):284–94. https://doi.org/10.1111/j.2047-6310.2012.00064.x.
24. McCarthy HD, Ashwell M. A study of central fatness using waist-to-height ratios in UK children and adolescents over two decades supports the simple message—"keep your waist circumference to less than half your height.". *Int J Obes*. 2006;30:988–92.
25. Monteiro JL. Caracterização dos Espaços Urbanos na RLVT : O contributo da análise discriminante. *Rev Estud Reg - Inst Nac Estatística*. 2000;2° semestr(1):21–46.
26. Rosenberg DE, Sallis JF, Conway TL, Cain KL, Mckenzie TL. Active transportation to school over 2 years in relation to weight status and physical activity. *Obesity*. 2006;14(10): 1771–6. http://www.sparkpe.org/resultsRosenberg.pdf. Accessed 7 Apr 2017
27. Sarmiento OL, Lemoine P, Gonzalez SA, et al. Relationships between active school transport and adiposity indicators in school age children from low-, middle- and high-income countries. *Int J Obes*. 2015;5(2):S107–14. https://doi.org/10.1038/ijosup.2015.27.
28. Silva KS, Pizarro AN, Garcia LMT, Mota J, Santos MP. Which social support and psychological factors are associated to active commuting to school? *Prev Med*. 2014;63:20–3. https://doi.org/10.1016/j.ypmed.2014.02.019.
29. Mota J, Gomes H, Almeida M, Ribeiro JC, Carvalho J, Santos MP. Active versus passive transportation to school–differences in screen time, socio-economic position and perceived environmental characteristics in adolescent girls. *Ann Hum Biol*. 2007;34(3):273–82. https://doi.org/10.1080/03014460701308615.
30. Pabayo R, Gauvin L, Barnett TA. Longitudinal changes in active transportation to school in Canadian youth aged 6 through 16 years. *Pediatrics*. 2011;128(2):e404–13. https://doi.org/10.1542/peds.2010-1612.
31. Duncan S, White K, Mavoa S, Stewart T, Hinckson E, Schofield G. Active transport, physical activity, and distance between home and school in children and adolescents. *J Phys Act Health*. 2016;13(4):447–53. https://doi.org/10.1123/jpah.2015-0054.
32. Sirard JR, Ainsworth BE, McIver KL, Pate RR. Prevalence of active commuting at urban and suburban elementary schools in Columbia, SC. *Am J Public Health*. 2005;95(2): 236–7. https://doi.org/10.2105/AJPH.2003.034355.
33. Ewing R, Schroeer W, Greene W. School location and student travel analysis of factors affecting mode choice. *Transp Res Board*. 2004;1895:55–63.
34. Debruijn G, Kremers S, Schaalma H, Vanmechelen W, Brug J. Determinants of adolescent bicycle use for transportation and snacking behavior. *Prev Med*. 2005;40(6):658–67. https://doi.org/10.1016/j.ypmed.2004.09.003.
35. Lu W, McKyer ELJ, Lee C, Goodson P, Ory MG, Wang S. Perceived barriers to children's active commuting to school: a systematic review of empirical, methodological and theoretical evidence. *Int J Behav Nutr Phys Act*. 2014;11(1):140. https://doi.org/10.1186/s12966-014-0140-x.
36. DiGuiseppi C, Roberts I, Li L, Allen D. Determinants of car travel on daily journeys to school: cross sectional survey of primary school children. *BMJ*. 1998;316(7142):1426–8. http://www.ncbi.nlm.nih.gov/pubmed/9572753. Accessed 5 Jan 2017
37. Braza M, Shoemaker W, Seeley A. Neighborhood design and rates of walking and biking to elementary school in 34 California communities. *Am J Health Promot*. 2004;19(2): 128–36. http://www.ncbi.nlm.nih.gov/pubmed/15559713. Accessed 5 Jan 2017.
38. Oluyomi AO, Lee C, Nehme E, Dowdy D, Ory MG, Hoelscher DM. Parental safety concerns and active school commute: correlates across multiple domains in the home-to-school journey. *Int J Behav Nutr Phys Act*. 2014;11:32.
39. Pont K, Ziviani J, Wadley D, Bennett S, Abbott R. Environmental correlates of children's active transportation: a systematic literature review. *Health Place*. 2009;15(3): 827–40. https://doi.org/10.1016/j.healthplace.2009.02.002.
40. Carlson JA, Sallis JF, Kerr J, Conway TL, Cain K, Frank LD, et al. Built environment characteristics and parent active transportation are associated with active travel to school in youth age 12-15. *Br J Sports Med*. 2014;48(22):1634–9. https://doi.org/10.1136/bjsports-2013-093101.
41. McMillan T, Day K, Boarnet M, Alfonzo M, Anderson C. Johnny walks to school- do es Jane? Sex differences in children's active travel to school. *Child Youth Environ*. 2006;16(1):75–89. https://www.jstor.org/stable/10.7721/chilyoutenvi.16.1.0075.
42. Pizarro AN, Schipperijn J, Andersen HB, Ribeiro JC, Mota J, Santos MP. Active commuting to school in Portuguese adolescents: using PALMS to detect trips. *J Transp Health*. 2016;3(3):297–304. https://doi.org/10.1016/j.jth.2016.02.004.