

The association between physical environment and cycling to school among Turkish and Moroccan adolescents in Amsterdam

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Abstract

Objectives This study examined the effect of physical environment on cycling to and from school among boys and girls of Turkish and Moroccan origin living in Amsterdam.

Methods The LASER study ($n = 697$) was an interview study that included information on cycling to and from school and the perceived physical environment. Objective information on physical environment was gathered from Statistics Netherlands and the Department for Research and Statistics at the Municipality of Amsterdam. Structural equation modelling with latent variables was applied, taking into account age, gender, self-assessed health, education, country of origin, and distance to school.

Results For every unit increase in the latent variable scale for bicycle-friendly infrastructure, we observed a 21 % increase in the odds for cycling to and from school. The association was only borderline statistically significant and disappeared after controlling for distance to school. The enjoyable environment was not associated with cycling to and from school after controlling for all background factors.

Conclusions Bicycle-friendly infrastructure and an enjoyable environment were not important factors for cycling to and from school among those with no cultural cycling background.

Keywords Infrastructure · Environment · Commuting · LASER study · Ethnic

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Introduction

Worldwide, every second individual does not meet the recommendations for health-enhancing physical activity (WHO 2009). Based on global recommendations, all children and adolescents aged 5–17 years should be physically active for at least 60 min per day (WHO 2011). Childhood and adolescence are critical life-phases for adopting a physically active lifestyle (Mäkinen et al. 2009, 2010). As transport-related physical activity could be seen as an easy and ecological way to increase daily physical activity, we need reliable information on how to promote and sustain transport-related physical activity among adolescents. Environmental factors such as school and home neighbourhood could be important for the uptake or continuation of transport-related physical activity among adolescents (Abraham et al. 2010; Barnett et al. 2009; Hobin et al. 2012; Sallis et al. 1999).

The evidence on environmental determinants to cycling is contradictory (Foster et al. 2009; Fraser and Lock 2010; Nelson and Woods 2010; Panter et al. 2010; Prins et al. 2012; Wong et al. 2011). Cycling is positively associated with safe routes to school, green spaces, and clear separation of cycle paths from other traffic; it is negatively associated with traffic danger (Fraser and Lock 2010). In addition, land-use mix, street connectivity, biking facilities and safety structure are positively associated with cycling among youth (Ding et al. 2011). Other research has found no consistent associations between cycling for transportation and intersection density, land-use mix, and residential density (Wong et al. 2011). These studies have, however, focused on different age groups and different forms of cycling, which makes comparisons and extrapolations to other populations unreliable.

Studies on the environmental correlates of cycling among ethnic minority groups living in the Netherlands and the rest of Europe are scarce. In the Netherlands, Turkish and Moroccan adolescents are of special interest as they do not have a strong cultural background of cycling compared to the general Dutch population. Moreover, Turkish and Moroccan adolescents are less likely to be physically active, ride a bicycle and are more likely to be overweight compared to Dutch adolescents (Hosper et al. 2008, 2011; Nicolaou et al. 2008, 2012; Reijneveld et al. 2012; Singh et al. 2009). It would, therefore, be important to assess whether environmental determinants (for example pedestrian crossings, litter, traffic intensity, distance to school) affect the adoption of cycling behaviours among ethnic minority groups (Ding et al. 2011; Fraser and Lock 2010).

Inconsistencies in the research results might be explained by the focus on specific environmental factors. It may be that an overall favourable cycling environment would have more of an effect than specific environmental factors. Further, it has been suggested that both objective and perceived measures of the physical environment might be relevant for transport-related cycling (van Loon and Frank 2011). In this study, we combined several subjective and objective measures of the physical environment into two latent variables: “bicycle-friendly infrastructure” and “enjoyable environment”. The variable for a bicycle-friendly infrastructure included the existence of cycle paths in the neighbourhood, slow traffic, well-lit streets, pedestrian crossings, and low traffic intensity. An enjoyable environment has trees along the streets, attractive natural surroundings, a low amount of litter and sufficient green areas. Our aim was to examine the effect of a “bicycle-friendly infrastructure” and an “enjoyable environment” on cycling to and from school among Turkish and Moroccan boys and girls living in Amsterdam.

Methods

Data came from the LASER study, a cross-sectional survey conducted in 2003–2004 by the Department of Public Health at the Academic Medical Centre (AMC) at the University of Amsterdam. The study methods are described elsewhere (Hosper et al. 2007a, b). The LASER study selected a random sample of 1,556 persons of Turkish origin and 995 persons of Moroccan origin aged between 10 and 30 years living in Amsterdam, the Netherlands. In total, 768 persons of Turkish origin and 476 persons of Moroccan origin (total $n = 1,244$) participated in the study. People were defined as being of Turkish or Moroccan origin when they or their father was born in Turkey or Morocco. Information was collected through a home interview by trained interviewers of the same sex and ethnicity as the participant. For this study, the analyses were limited to Turkish and Moroccan adolescents aged between 10 and 18 years ($n = 697$) at the time of the LASER study. Those participants who were aged from 19 to 30 ($n = 547$) were excluded from the analyses.

The objective physical environment, which was measured using Geographical Information System (GIS) data, was linked to each individual through the geographical coordinates of their home. Further, additional data were gathered from the following registers: Statistics Netherlands (CBS) and the department for Research and Statistics of the Municipality of Amsterdam (departments of Physical Development, Spatial Development, and Sports and Recreation). For each individual from the Municipality of Amsterdam, the percentage of green area (e.g. neighbourhood parks) within a radius of 500 m around the residence was calculated (Graham 2008). The location of the participant’s school was derived from the survey data. Using the mailing list of all schools in Amsterdam provided by the Department of Research and Statistics of the Municipality of Amsterdam (O + S), geographical co-ordinates for the schools were calculated based on their physical addresses. The Euclidean distance (=as the crow flies) between school and home was determined using the co-ordinates of both locations.

The perceived physical environment was measured using data collected in the interview. The data included 19 self-reported physical environmental items concerning the individual’s neighbourhood. The environmental items were derived from the NEWS questionnaire (Saelens et al. 2003). The following cycling-related items were used in this study: “there are many attractive natural sights in my neighbourhood (e.g. landscape, views)”, “My neighbourhood is generally free of litter”, “it is safe to cycle in or near my neighbourhood”, “there are cycling paths in or near my neighbourhood”, and “there are many major intersections in my neighbourhood”. Responses for the

items were made on a four-point Likert scale: (1) strongly disagree, (2) disagree, (3) agree and (4) strongly agree.

Cycling was measured with the SQUASH questionnaire (Short Questionnaire to Assess Health-enhancing physical activity), which has been shown to have reasonable validity (Wendel-Vos et al. 2003). SQUASH assesses the weekly average amount of cycling to and from school with the following introduction: “think about an average week in the past few months. Please indicate how many days per week you performed the following activities, how much time on average you were engaged in this, and (if applicable) how strenuous this activity was for you”. Separate questions were asked regarding the frequency and duration of the activity: “How many days per week do you cycle?” and “How many minutes per day do you cycle (commuting activities)?” In addition, the self-reported intensity of physical activity was assessed with the categories “slow, medium or fast”. For the analyses, cycling was dichotomised to “yes” (individual had reported cycling on 1 day per week or more) and “no” (individual had reported cycling on 0 days per week).

Background and confounding variables such as age (continuous), sex (male/female), respondent’s own education and father’s country of origin (Dutch/Turkish/Moroccan) were also taken into account. Education was categorised into two categories: (1) lower secondary education (VMBO) and (2) higher secondary education (HAVO, VWO). The Euclidean distance to school (km) was also included as a possible confounder in the analyses. Self-assessed health was measured with the following question: “What is your usual health status?” with a scale of good, not so good, poor or very poor. For the analyses, self-assessed health status was dichotomised into good (combining good and not so good) and poor (combining poor and very poor).

Statistical analyses were performed with STATA 11.1 (Statacorp 1984–2007) and MPLUS 6 (Muthén and Muthén 2010). The characteristics of the study population by sex and country of origin were analysed. MPLUS was used to conduct the structural equation modelling (SEM). We applied the two-step approach in SEM (Kline 2005). In the first step, the confirmatory factor analysis was applied to construct two latent variables representing the bicycle-friendly infrastructure and the enjoyableness of the environment (the measurement part of the model). Compiling of the latent variables began with the following indicator variables: the *bicycle-friendly infrastructure* latent variable included the indicators “cycle paths in my neighbourhood”, “traffic is slow”, “streets are well lit” and “there are pedestrian crossings and traffic lights” as well as “the traffic intensity”, whereas the *enjoyable environment* variable included “trees along the streets”, “attractive natural surroundings”, “a low amount of litter” and “the percentage of green areas”.

The fit of the model when including the enjoyable environment and bicycle-friendly infrastructure variables was good for both boys and girls (data not shown). Model fit indexes for the final measurement model were $\chi^2 = 0.1257$, CFI = 0.99, TLI = 0.97, RMSEA = 0.03 and WRMR = 0.55. The correlation between enjoyable environment and bicycle-friendly infrastructure was 0.56. In compiling the latent variables, a highly positive correlation between the cycle lanes in the neighbourhood and many busy intersections was observed. Therefore, this correlation (two-way arrowhead) between these indicators was added to the model to obtain a better fit. Among both boys and girls, an enjoyable environment was associated with attractive natural surroundings, a clean environment and a high percentage of green areas, whereas a bicycle-friendly infrastructure was associated with safe cycling. As every latent variable must have a scale (Kline 2005), we set one of the indicator parameters to 1 to scale the latent variable. This indicator also acts as the reference variable within the latent variable. In the second step, the structural part of the model (i.e. the association of bicycle-friendly infrastructure and enjoyable environment with cycling and walking to and from school) was added to the model. The interpretation for regression coefficients in the SEM model is as follows (Muthén and Muthén 2010): $\log \text{ odds} = B_0 + B_1x$, and with x changes of one unit, the odds change to e^{B_1} .

Finally, we applied a sequential SEM model to identify the association of bicycle-friendly infrastructure and enjoyable environment with cycling to and from school (cycled to and from school vs. did not cycle to and from school). Our assumption was that boys and girls would have different associations between the determinants and cycling. However, as the associations were similar between boys and girls (presented in Fig. 1), boys and girls were analysed together in the final sequential SEM model. In each step, the measurement part of the estimated structural equation model remained the same and the model fit indexes were examined to evaluate whether the model fit was acceptable. Background (age and sex) and possible confounding factors (self-assessed health, education, country of origin and distance to school) were sequentially inserted into the model after the latent variables for bicycle-friendly infrastructure and enjoyable environment. Odds ratios and 95 % confidence intervals are given.

Results

The characteristics of the study population by sex and country of origin are presented in Table 1. The mean age of the respondents was approximately 14 years. There were clear educational differences among the respondents. Almost all the participants assessed their health to be good.

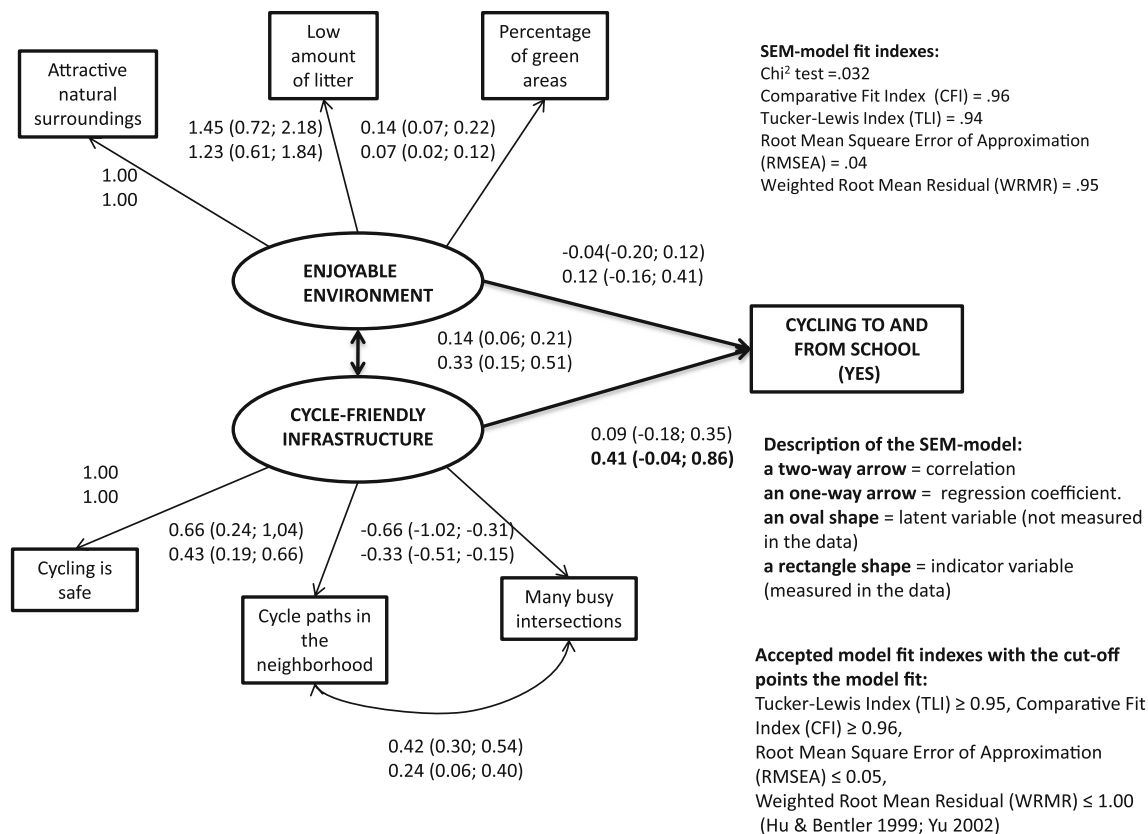


Fig. 1 Structural equation model for the association between an enjoyable environment, a bicycle-friendly infrastructure and cycling to and from school for boys (*upper*) and girls (*lower*). Unstandardised regression coefficients, correlations and 95 % confidence intervals.

The mean distance between home and school was 2.6 km. Participants of Turkish origin reported longer distances to school than participants of Moroccan. Less than one-fifth of all the participants cycled to and from school, whereas almost half of them walked to and from school. Turkish participants reported more cycling to and from school than Moroccan participants.

The unadjusted and non-standardised associations of the latent variables for bicycle-friendly infrastructure and enjoyable environment with cycling to and from school among youth of Turkish and Moroccan origin are presented in Fig. 1. In the SEM model, the coefficients between the latent variable (an oval shape in the figure) and the indicator variable (a rectangle shape in the figure) as well as the coefficients between the latent variable and the outcome variable (cycling to and from school) can be interpreted as regression coefficients. The enjoyable environment included attractive natural sights, a low amount of litter and the percentage of green areas. The more cycle lanes (boys $\beta = 0.66$; 95 % CI = 0.24, 1.04 and girls $\beta = 0.44$; 95 % CI = 0.19, 0.66) and fewer busy intersections (boys $\beta = -0.66$; 95 % CI = $-1.02, -0.31$ and girls $\beta = -0.33$; 95 % CI = $-0.51, -0.15$) there were in their neighbourhood, the

One of the indicator parameters is set to 1 to scale the model. LASER study on Turkish and Moroccan adolescents aged 10–18 years, 2003–2004, the Netherlands

more bicycle-friendly the infrastructure was. An enjoyable environment included attractive natural sights, a low amount of litter and a good percentage of green areas. The less litter (boys $\beta = 1.45$; 95 % CI = 0.72, -2.18 and girls $\beta = 1.23$; 95 % CI = 0.61, 1.84) and the more green areas (boys $\beta = 0.14$; 95 % CI = 0.07, 0.22 and girls $\beta = 0.07$; 95 % CI = $-0.02, 0.12$) in the neighbourhood, the more participants enjoyed their living environment. The enjoyable environment was positively correlated (boys $r = 0.14$; 95 % CI = 0.06, 0.21 and girls $r = 0.33$; 95 % CI = 0.15, 0.51) with the bicycle-friendly infrastructure. Thus, when there was less litter and greener areas in the participants' neighbourhood, boys and girls reported that the infrastructure was more bicycle-friendly.

Bicycle-friendly infrastructure was positively ($\beta = 0.41$; 95 % CI = $-0.04, 0.86$) associated with cycling to and from school among girls (in figure). Among girls, for every increase in the bicycle-friendly infrastructure, there was a 51 % increase ($e^{\text{regression coefficient}} = e^{0.41} = 1.51$) in the odds for cycling to and from school. This association was, however, only borderline statistically significant. An enjoyable environment was not associated with cycling to and from school among boys and girls.

Table 1 Characteristics of the study population by sex and country of origin

	Boys	Girls	Turkish	Moroccan
Age (M years)	14.4	14.5	14.5	14.4
Total (n)	353	344	399	285
Education (%)				
Low	66	49	65	65
High	34	50	35	35
Total (n)	344	336	393	274
Father's country of origin (%)				
Turkish	61	55	–	–
Morocco	39	45	–	–
Total (n)	347	337	–	–
Distance to school (M km)	2.6	2.6	2.7	2.3
Total (n)	243	220	279	178
Self-assessed health (%)				
Good	89	87	88	87
Bad	11	13	11	13
Total (n)	380	344	399	684
Cycling to and from school (%)				
Yes	20	11	18	12
No	80	89	82	88
Total (n)	351	343	398	283
Walking to and from school (%)				
Yes	48	56	50	55
No	62	44	50	45
Total (n)	353	344	296	227
Cycling during leisure-time (%)				
Yes	61	42	43	39
No	39	58	57	61
Total (n)	283	249	399	285
Enjoyable environment				
Attractive natural surroundings (%)				
Strongly disagree	9	9	10	8
Disagree	42	45	45	42
Agree	44	40	39	46
Strongly agree	5	5	6	4
Total (n)	350	343	398	282
Low amount of litter in nature (%)				
Strongly disagree	3	6	5	5
Disagree	35	30	38	26
Agree	55	58	51	65
Strongly agree	7	6	7	5
Total (n)	350	343	398	282
Percentage of green areas (Me)				
1 quartile	27	23	27	23
2 quartile	25	30	27	28
3 quartile	25	26	25	25
4 quartile	22	21	21	24
Total (n)	353	344	399	285

Table 1 continued

	Boys	Girls	Turkish	Moroccan
Bicycle-friendly infrastructure				
Cycling is safe (%)				
Strongly disagree	2	3	3	3
Disagree	20	23	25	16
Agree	69	65	63	73
Strongly agree	9	9	9	8
Total (n)	349	340	397	279
Cycle paths in the neighbourhood (%)				
Strongly disagree	3	4	4	3
Disagree	25	25	24	25
Agree	67	63	65	65
Strongly agree	6	8	7	6
Total (n)	351	342	398	282
Many busy intersections (%)				
Strongly disagree	5	9	6	9
Disagree	44	51	50	44
Agree	47	35	41	41
Strongly agree	4	5	3	6
Total (n)	352	344	399	284

Proportion of respondents (n), prevalence (%), means (M) and median (Me). The LASER study, 2003–2004, The Netherlands

Finally, we adjusted for several background or potential confounding variables for cycling to and from school, utilising sequential SEM modelling (in Table 2). The boys and girls were analysed together because the gender-specific analyses (in Fig. 1) showed no marked gender differences in the associations between physical environment and cycling to and from school. This also provided more statistical power to the sequential SEM modelling. In the age-adjusted model (in Model 1), the bicycle-friendly infrastructure was positively but borderline associated with cycling to and from school ($\beta = 0.19$; 95 % CI = $-0.08, 0.46$). In SEM, this is a medium-sized effect. The association between the bicycle-friendly infrastructure and cycling to and from school remained the same after adjusting for sex ($\beta = 0.20$; 95 % CI = $-0.08, 0.47$) and self-assessed health ($\beta = 0.21$; 95 % CI = $-0.08, 0.49$) as well as for education ($\beta = 0.21$; 95 % CI = $-0.10, 0.51$). Therefore, for every unit of increase in the bicycle-friendly infrastructure, there was a 21 % increase ($e^{0.21} = 1.21$) in the odds for cycling to and from school. The distance to school (in Model 6), however, explained the association between bicycle-friendly infrastructure and cycling to and from school ($\beta = 0.03$; 95 % CI = $-0.25, 0.32$). The association between the enjoyable environment and cycling to and from school was not statistically significant after several adjustments ($\beta = -0.12$; 95 % CI = $-0.69, 0.44$).

Table 2 The association of enjoyable environment and bicycle-friendly infrastructure to cycling to and from school

Scale	Model 1: adjusting for age		Model 2: model 2 + gender		Model 3: model 2 + self-assessed health		Model 4: model 3 + education		Model 5: model 4 + country of origin		Model 6: model 5 + distance to school								
	β	95 % CI	β	95 % CI	β	95 % CI	β	95 % CI	β	95 % CI	β	95 % CI							
Enjoyable environment	Continuous	-0.12	-0.68	0.43	-0.12	-0.69	0.44	-0.14	-0.70	0.43	-0.19	-0.77	0.40	-0.15	-0.74	0.44	0.12	-0.42	0.65
Bicycle-friendly infrastructure	Continuous	0.19	-0.08	0.46	0.20	-0.08	0.47	0.21	-0.08	0.49	0.20	-0.10	0.50	0.21	-0.10	0.51	0.03	-0.25	0.32
Age (10–12/13–18 years)	0 vs. 1	-0.05	-0.30	0.20	-0.05	-0.30	0.21	-0.05	-0.30	0.21	-0.10	-0.39	0.18	-0.12	-0.41	0.17	0.16	-0.22	0.54
Gender (boys/girls)	0 vs. 1		-0.39	-0.62	-0.16	-0.39	-0.62	-0.16	-0.39	-0.62	-0.39	-0.62	-0.15	-0.40	-0.64	-0.15	-0.44	-0.75	-0.13
Self-assessed health (good/bad)	0 vs. 1						0.003	-0.36	0.36		0.04	-0.41	0.33	0.02	-0.39	0.35	-0.05	-0.55	0.45
Education (low/high)	0 vs. 1									0.10	-0.17	0.37	0.11	-0.16	0.38	0.11	-0.16	-0.43	0.06
Country of origin (Turkish/Morocco)	0 vs. 1																		
Distance to school (km)	Continuous																		
Distance to school (km, quadratic)	Continuous																		

Adjusting for age, gender, education, country of origin, distance to school, walking to and from school, and cycling during leisure-time. Sequential structural equation modelling with latent variables, standardised regression coefficients (β) and 95 % confidence intervals (95 % CI). The scale of the independent variable is also presented (scale). The LASER study, 2003–2004, the Netherlands

Accepted model fit index cut-off point in the model: Weighted Root Mean Residual (WRMR) = 0.55 (≤ 1.00). (Hu and Bentler 1999; Yu 2002)

Discussion

The aim of this study was to examine how physical environments, as measured with two latent variables (bicycle-friendly infrastructure and enjoyable environment) combining objective and subjective characteristics, acted as a barrier to or a motivation for cycling to and from school among boys and girls of Turkish or Moroccan origin. A bicycle-friendly infrastructure is of importance to girls, although we did not find any association between either of the latent variables for bicycle-friendly infrastructure and enjoyable environment and cycling to and from school after having controlled for distance to the school.

The previous literature has provided mixed and inconsistent results on associations between characteristics of the physical environment and cycling among adolescents (Ding et al. 2011; Foster et al. 2009; Fraser and Lock 2010; Nelson and Woods 2010; Panter et al. 2010; Prins et al. 2012; Wong et al. 2011). This is in line with our finding that a bicycle-friendly infrastructure and an enjoyable environment were not associated with cycling to and from school among adolescents of Turkish and Moroccan origin living in Amsterdam after the distance to school was taken into account. The inconsistency in the results of this and previous research could be due to variation in the definition and measurement of the physical environment. We were able to examine both subjective and objective characteristics of the physical environment, whereas previous studies have often used only separate measures of either objective or subjective physical environment. Another reason might be the differences in interconnectivity between public parks and cycle paths, or the density of primary and secondary schools in neighbourhoods. The infrastructure and the green areas in Amsterdam typically supports cycling among all population groups and that differences in local physical environments are small.

Based on our study, a bicycle-friendly infrastructure was important for cycling to and from school among girls. To our knowledge, only a few studies have examined the contribution of the physical environment to cycling among children and adolescents in the Netherlands (de Bruijn et al. 2006; de Vries et al. 2007; Prins et al. 2009). Although these studies did not quite examine same age groups as we did, they are in line with our result. Bicycle-friendly infrastructure such as safety, low traffic, and the existence of cycle paths in the neighbourhood is associated positively with cycling to and from school among adolescents. Moreover, our strength was that we utilised two latent variables of enjoyable environment and cycle-friendly infrastructure, which measured both the objective and subjective environmental exposure more efficiently than only single environmental measures that were used in previous studies. We should, however, further investigate

whether the latent variables of enjoyable environment and cycle-friendly infrastructure are different among ethnic minority background than among Dutch adolescents.

The distance from home to school was an important factor for cycling to and from school among adolescents with ethnic background. The studies on ethnic minority groups have mainly been conducted in the United States (McDonald 2008; Mendoza et al. 2010), but have reported similar results: residential density and safety issues as well as the distance between home and school were associated with cycling to and from school among adolescents with ethnic minority background. This information is important when we want to promote cycling among adolescents with ethnic minority background, who are less likely ride a bicycle and are more likely to be overweight compared to Dutch adolescents (Hosper et al. 2008, 2011; Nicolaou et al. 2008, 2012; Singh et al. 2009). However, the different environmental exposure and its influence on commuting physical activity behaviours should be investigated more among those adolescents living close and far away from the school.

Several limitations should be kept in mind when interpreting our results. Self-reported physical activity is prone to measurement error. The SQUASH questionnaire used to measure physical activity was originally validated among the ethnic Dutch population (Wendel-Vos et al. 2003), although good reliability has been demonstrated among Turkish people (Hosper et al. 2007a). Although some misclassifications may occur, it is unlikely to be associated with the physical environment variable we examined in this study. Our measurement of environmental variables may not be optimal. The percentage of green areas is not the best measure of green areas, as one should also look at the quality and usability of green areas. In Amsterdam, many individuals have a limited amount of green areas within 500 m, but have some park areas near them. This does not, however, take into account all the possible cycle routes that boys and girls (or their parents) might consider when planning a cycle route to and from school. Besides, older children might attend schools outside the local neighbourhood more often, which was not captured by our definition of environmental variables, which may have an influence on our results. Unfortunately, we did not have information on factors such as the quality and usability of cycle lanes, or the financial means or priority to acquire and maintain a bicycle, which would influence whether an individual would use a bicycle for transportation or not.

To conclude, the evidence on the association of the physical environment on cycling behaviours is inconsistent (de Vet et al. 2010; Ding et al. 2011; van Loon and Frank 2011; Wong et al. 2011). Our study did not find any association between a bicycle-friendly infrastructure and an enjoyable environment with cycling to and from school

after controlling for distance to the school. This suggests that the distance to school is currently the most relevant factor in adopting cycling behaviours among youth from cultures where cycling is not traditional. From a more general perspective, our results suggest that when individuals from a non-cycling culture are exposed to a bicycle-friendly infrastructure or an enjoyable environment, these physical environments are not alone sufficient to promote commuting as a physical activity.

Future prospective studies should confirm the causal order between the physical environment and commuting as a physical activity. Moreover, the effect of the physical environment as a whole on commuting as a physical activity should be examined in more detail, particularly among ethnic groups, while taking into account the quality and usability of the green space and cycle routes.

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