URBAN ENVIRONMENT, TRANSPORT BEHAVIOURS, AND HEALTH

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To everyone who loves cities!

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ABSTRACT

Urban environments are very complex systems with a myriad of factors intricately related. Built environment, transport, physical activity and sedentary behaviours, air pollution, and social contacts and feelings of loneliness can have effects on urban population's health and well-being. Also, some of these determinants can be associated and can interact between them modifying their effects on health. According to the World Health Organisation (WHO), health is "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". Taking into account this comprehensive health definition, this thesis covered different layers of health: general, mental, and physical. With four different studies, the results of the present thesis suggest that it is possible to design urban environments that can increase physical activity levels, mainly through active transport, and that the crime-safety perceptions can have an important role in terms of reinforcing the effects of the built environment on physical activity and sedentary behaviours. Furthermore, active transport, mainly bicycle use, seems to be a source of good mental health and well-being, and a tool to boost social capital production. Increasing physical activity levels also seems to be a good way to improve cardiovascular health through blood pressure levels reduction.

The present thesis suggests that urban and transport planning have a great potential to promote healthy behaviours and ensure mental and physical health of city dwellers, mainly through active transport promotion. In order to improve the health promotion through urban environment, more research about aesthetics urban attributes, urban social capital production, effects on mental health and well-being, and effectiveness of urban interventions is needed.

RESUMEN

Los entornos urbanos son sistemas muy complejos con una miríada de factores intrincadamente relacionados. El entorno construido, el transporte, la actividad física y los comportamientos sedentarios, la contaminación del aire y los contactos sociales y los sentimientos de soledad pueden tener efectos en la salud y el bienestar de la población urbana. Además, algunos de estos determinantes se pueden asociar y pueden interactuar entre ellos modificando sus efectos sobre la salud. Según la Organización Mundial de la Salud (OMS), la salud es "un estado de completo bienestar físico, mental y social y no simplemente la ausencia de enfermedades o dolencias". Teniendo en cuenta esta definición integral de salud, esta tesis cubre diferentes niveles de salud: general, mental y física. Con cuatro estudios diferentes, los resultados de la presente tesis sugieren que es posible diseñar entornos urbanos que puedan aumentar los niveles de actividad física, principalmente a través del transporte activo, y que las percepciones de seguridad con respecto al crimen pueden tener un papel importante en términos de reforzar los efectos del entorno construido sobre la actividad física y los comportamientos sedentarios. Además, el transporte activo, principalmente el uso de bicicletas, parece ser una fuente de buena salud mental y bienestar, y una herramienta para impulsar la producción de capital social. El aumento de los niveles de actividad física también parece ser una buena forma de mejorar la salud cardiovascular a través de la reducción de los niveles de presión arterial.

La presente tesis sugiere que la planificación urbana y de transporte tienen un gran potencial para promover comportamientos saludables y garantizar la salud mental y física de los habitantes de las ciudades, principalmente a través de la promoción del transporte activo. Para ir mejorando la promoción de la salud a través del entorno urbano, se necesita más investigación sobre los atributos urbanos estéticos, la producción de capital social urbano, los efectos

sobre la salud mental y el bienestar, y la efectividad de las intervenciones urbanas.

RESUM

Els entorns urbans són sistemes molt complexos amb una miríada de factors relacionats de manera intricada. L'entorn construït, el transport, l'activitat física i els comportaments sedentaris, la contaminació de l'aire i els contactes socials i els sentiments de solitud poden tenir efectes en la salut i el benestar de la població urbana. A més, alguns d'aquests determinants es poden associar i poden interactuar entre ells modificant els seus efectes sobre la salut. Segons l'Organització Mundial de la Salut (OMS), la salut és "un estat de complet benestar físic, mental i social i no simplement l'absència de malalties o dolències". Tenint en compte aquesta definició integral de salut, aquesta tesi cobreix diferents nivells de salut: general, mental i física. Amb quatre estudis diferents, els resultats de la present tesi suggereixen que és possible dissenyar entorns urbans que puguin augmentar els nivells d'activitat física, principalment a través del transport actiu, i que les percepcions de seguretat pel que fa al crim poden tenir un paper important en termes de reforçar els efectes de l'entorn construït sobre l'activitat física i els comportaments sedentaris. A més, el transport actiu, principalment l'ús de bicicletes, sembla ser una font de bona salut mental i benestar, i una eina per impulsar la producció de capital social. L'augment dels nivells d'activitat física també sembla ser una bona forma de millorar la salut cardiovascular a través de la reducció dels nivells de pressió arterial.

La present tesi suggereix que la planificació urbana i de transport tenen un gran potencial per promoure comportaments saludables i garantir la salut mental i física dels habitants de les ciutats, principalment a través de la promoció del transport actiu. Per anar millorant la promoció de la salut a través de l'entorn urbà, es necessita més recerca sobre els atributs urbans estètics, la producció de capital social urbà, els efectes sobre la salut mental i el benestar, i l'efectivitat de les intervencions urbanes.

PREFACE

The PhD in which this thesis is framed was done at the Barcelona Institute for Global Health (ISGlobal), Barcelona, Spain between September 2014 and September 2018, and was supervised by Prof. Mark J Nieuwenhuijsen. The present thesis consists of a compilation of four scientific articles first-authored by the PhD candidate according to the procedures of the Biomedicine PhD programme of the Department of Experimental and Health Sciences of the Universitat Pompeu Fabra, Barcelona, Spain.

The present thesis contributed to: (1) understand the interaction effects between built environment and crime-safety perceptions on physical activity and sedentary behaviours; (2) understand the effects of transport mode use on self-perceived health, mental health, and social contact measures; (3) understand the effects of physical activity and black carbon on blood pressure; and (4) highlight the gaps in the urban health field and to provide recommendations for future research.

The PhD candidate had an active role in Physical Activity through Sustainable Transport Approaches (PASTA) project, which had partners in Antwerp, Barcelona, London, Örebro, Rome, Vienna and Zurich. PASTA was a EU funded multi-faceted, cross-disciplinary research project that studied the interrelationship between transport behaviours and health [1]. In the PASTA project the PhD candidate was primarily involved in Work-Package (WP) 3, which was the biggest WP of the project and included the Core module, Health add-on, and Tracking add-on studies [1,2]. Her main tasks in WP3 were: (1) to coordinate PASTA Survey (Core module) recruitment in Barcelona; (2) to coordinate PASTA Health add-on (sub-study focused on health effects of air pollution exposure in combination with transport mode using objective measurements) in Barcelona; (3) to coordinate PASTA Tracking add-on (sub-study to track participants with Moves app) in the seven PASTA case-study cities; and (4) to coordinate PASTA Final Questionnaire design. Within the PASTA project, the PhD candidate also contributed to WP2. In WP2, she helped to organize a Barcelona workshop with urban and transport planning stakeholders, and she helped to organize and completely transcript twelve individual interviews with Barcelona urban and transport experts.

The PhD candidate spent three months as a visiting graduate student in Active Living Research from University of California San Diego (USA), under the supervision of Professor James F Sallis. The result of this visit was the elaboration of Paper I of the present thesis. The visit was supported by the *Centro de Investigación Biomédica en Red de Epidemiología y Salud Pública* (CIBERESP) Mobility Grant 2016 and makes this thesis a candidate of the PhD International Mention.

The PhD candidate was responsible for all the statistical analyses, interpretation of findings, writing and submissions for publication of the original research papers included in the present thesis. She also co-authored fourteen further publications (four of them under review and one in preparation) related to PASTA project and health effects of urban and transport planning related exposures (Annex I).

Moreover, throughout the four PhD years, the candidate has participated in plenty of outreach activities focused in science translation (Annex II) and has given specialized courses about urban environment and health for urban and transport planners from Spanish public administrations (Annex III).

ABBREVIATIONS

AGAUR	Agència de Gestió d'ajuts Universitaris i de Recerca
BMI	Body Mass Index
BQ	Baseline Questionnaire
CIBERESP	Centro de Investigación Biomédica en Red de Epidemiología y Salud Pública
CO	Carbon monoxide
CREAL	Centre de Recerca en Epidemiologia AmbientaL (current ISGlobal)
DALYs	Disability-Adjusted Life-Years
ESCAPE	European Study of Cohorts on Air Pollution Effects
EU	European Union
FAR	Floor Area Ratio
FIN	Final questionnaire.
FL	Long Follow-up questionnaire;
FS	Short Follow-up questionnaire;
GIS	Geographical Information System
IC	Confidence Interval
IQR	InterQuartile Range
ISGlobal	Barcelona Institute for Global Health
METs	Metabolic Equivalent of Tasks
NEWS-Y	Neighborhood Environment Walkability Scale for Youth
NO	Nitrogen monoxide
NO_2	Nitrogen dioxide
O_3	Ozone

OR	Odds Ratio
PASTA	Physical Activity through Sustainable Transport Approaches
PM	Particulate Matter
PSS	Perceived Stress Scale
RR	Relative Risk
SD	Standard Deviation
SDGs	Sustainable Development Goals
SO_2	Sulphur dioxide
TAPAS	Transportation, Air pollution and Physical ActivitieS
TEAN	Teen Environment And Neighborhood
VOCs	Volatile Organic Compounds
WHO	World Health Organisation
YLDs	Years Lived with Disability

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1 INTRODUCTION

In human history, cities have been a source of innovation and wealth creation, but at the same time they have been also a source of crime, pollution, and disease [3]. In the 19th century, cities were designed as tools to tackle public health issues as infectious diseases through improving sanitation, housing, and land use distribution, being able to separate different uses that could be harmful, such as industrial activity from housing. The main 19th century urban design principles relied on the idea of moving environmental and societal hazards outside the city [4]. During the 20th century, urban planning started to adopt more rational patterns stimulating interventions like zoning and highway projects to be able to connect the rationally separated zones through motorized transport [4]. In that way, urban planning started to promote a more utilitarian use of urban space and designed cities for cars, consequently leading to reduced physical activity levels and to unhealthier lifestyles. In the 21st century new paradigms are emerging, emphasizing the main role of improving neighbourhood conditions in order to tackle public health concerns as lack of physical activity and non-communicable diseases, among others.

The globe is living a rapid urbanization due to the increasing percentage of world's population living in urban areas. In 1950, 30 per cent of the world's population was urban, in 2014 this percentage increased to 54% and by 2050, 66 per cent of the world's population is projected to be living in urban environments [5]. Most people move to cities for work, therefore, they need productive employment, safe housing, and access to services. This world picture presents cities as a source of challenges and opportunities.

This thesis begins by describing some of the key health determinants and health outcomes of urban environments, how some different conceptual frameworks present the relationship between them, and the actual thesis conceptual framework. It then presents four studies in which associations and interactions between some of the determinants and health outcomes are assessed, and ends with a discussion and suggestions for future research.

1.1 Urban determinants of health

1.1.1 Built environment

The urban development process, and more particularly the design and planning of settlements, reside in one sphere: the built environment [6]. The built environment is a concept that refers to all the built elements that shape the city design.

The majority of research done nowadays that looks at associations between built environment and health has been focused on physical activity outcomes. It has been suggested that the built environment attributes like residential density, intersection density, public transport density, and the number of parks have the potential to contribute to increase physical activity levels [7]. A built environment measure that has been used extensively and helps to understand physical activity behaviours in cities is the walkability index. The walkability index is a measure composed by: residential density, street connectivity, retail floor area ratio, and land use mix [8]. It is calculated using Geographical Information System (GIS) techniques and its utility remains in the integration of different built environment attributes in one indicator, as all the measures alone are very unlikely to encourage physical activity.

1.1.2 Transport

When rational city planning and zoning began in the early 20th century [4], the need appeared to connect all the different areas created. The combination of geographical expansion and urban population growth, led to motorized transport having a main role in city organisation through highway projects. Nowadays, different professionals in different agencies are responsible for the urban design and transport planning. Thus, to design cities able to provide health and well-being outcomes, transport planning should assume a major role and needs to work together with urban design [9].

Transport is associated with economic and social development, due to its functionality of moving goods and people from one place to another. But it can be also associated with different health risks and benefits depending on which transport mode is used [10]. Cars have been associated with many negative effects to urban systems, including congestion, use of physical space, noise, heat, emissions of greenhouse gases, air pollution exposure, and lack of physical activity of the urban population [11,12]. Public transport has often been associated with low travel satisfaction [13], but also with an increase of physical activity levels and a BMI reduction [14–16] due to its combination with walking from the origin/destination to the public transport stop. The main source of health benefits presented in the literature is active transport (i.e. walking and bicycling). Active transport has been associated with multiple health benefits including lower all-cause mortality [17,18], cardiovascular risk [18–21], body weight [20,22], diabetes risk [23], risk of being stressed [24], better physical and mental well-being [25,26], and health-related quality of life [27].

1.1.3 Physical activity and sedentary behaviours

Physical activity is defined as any bodily movement produced by contraction of skeletal muscle that substantially increases energy expenditure [28–30]. Physical activity has four dimensions: frequency, duration, intensity (measured by metabolic equivalent of task - MET) and type of activity [31]. It also occurs in different places (domains), which generally are classified as household or domestic, occupational/school, transport, and leisure time/recreational. Complementarily, the Sedentary Behaviour Research Network (SBRN) has defined sedentary behaviours using two components: energy expenditure (<=1.5 METs) and posture (lying, reclining, and sitting) [32].

Physical activity in adults has been associated with reduced rates of all-cause mortality, coronary heart disease, high blood pressure, stroke, diabetes, metabolic syndrome, type 2 diabetes, colon cancer, breast cancer, fallings, and depression [33]. Despite this knowledge, having low physical activity accounted for 1.4 million deaths and 24.3 million disability-adjusted life-years (DALYs) worldwide in 2016, and was classified as the 14th risk factor in terms of global DALYs [34]. Sedentary behaviours are increasingly associated with health risks as increased risk of obesity, diabetes, the metabolic syndrome, cardiovascular disease, and death [35]. This correlation with sedentary behaviour even extends to individuals who meet physical activity recommendations [36], which implies that sedentary behaviour may represent a distinct risk factor that is independent of the overall amount of physical activity [35].

1.1.4 Air pollution

Ambient air pollution is a complex mixture of particulate and gaseous components. These include airborne particulate matter (PM), which can be divided by size and includes soot, and gaseous pollutants such as ozone (O_3), nitrogen oxides (NO_2, NO), sulphur dioxide (SO_2), volatile organic compounds (VOCs) and carbon monoxide (CO) [37]. Air pollution sources can be anthropogenic or natural.

Air pollution is typically higher in urban areas than in the surrounding semi-urban or rural areas. In the European Study of Cohorts on Air Pollution Effects (ESCAPE), PM2.5 concentrations at traffic sites were on average 14% higher than at urban background sites [38]. This difference relies on the fact that cities concentrate a high amount of emission sources, with motorized transport being the main one. In that way, urban dwellers exposure to traffic-related air pollution is constant and proximal to their daily life activity places (home, work, and street).

Nowadays there is plenty of literature showing the adverse health effects of air pollution in many different body systems. Air pollution has been associated with dementia [39], neurodegenerative diseases [40], low birth weight [41], lung cancer [42], myocardial infarction [43], cardiovascular diseases [44], and diabetes [45], among others. In 2016, air pollution was classified the fifth leading risk factor for global burden of disease, with ambient particulate matter pollution as the most important cause of disease among environmental risk factors, leading to 4.0 million deaths and 105.7 million DALYs [34].

1.1.5 Crime

People who live in cities are likely to be more afraid of crime than people who live in the suburbs, smaller towns or rural areas [46]. The fear of crime is also higher in those sectors of society which are more likely to feel vulnerable like women, elderly, and groups with socio-economic disadvantages [46]. Gender has been suggested as the main predictor of fear of crime. It seems that women experience more fear of crime because of their greater physical and social vulnerability, with sexual assault being one of their biggest fears [46,47].

Fear of crime can have effects on people emotions and can be a source of anxiety, inducing feelings of isolation and vulnerability, and thus diminishing people's well-being and quality of life [46]. Fear of crime undermines individual and community quality of life increasing social division [46]. It also constrains people from doing activities outdoors being a potential source of lack of physical activity [48]. In population groups such as children and adolescents, their outdoors activities can also be constrained because of their parent safety concerns [49].

Three main determinants of fear of crime have been defined: (1) individual's sense of vulnerability, which may be related to factors such as gender, age, and socio-economical factors; (2) lack of social structure creating social isolation and lack of trust; and (3) individual's perceptions of the built environment. Incivilities (e.g. broken urban furniture, dirty streets, vacant and abandoned lots, etc.) can be symbols of social decontrol and disorder [46].

1.1.6 Social contacts and loneliness

Social relationships are suggested to have an important influence on people's health. A social network is defined as the web of social relationships that surrounds individuals. One of the most important functions of social networks is social support. Additionally, one of the results of social networks is the production of social capital, which can be defined as reciprocity norms and trust [50].

Loneliness is nowadays considered to be one of the main problems in Western society [51]. Loneliness is "the unpleasant experience that occurs when a person's network of social relations is deficient in some important way, either quantitatively or qualitatively" [52]. Feeling lonely is accompanied by feeling emptiness and rejection, and the opposite of loneliness is belongingness or social embeddedness [51]. Social isolation concerns the objective characteristics of a situation and refers to a small social network. There is a continuum running from social isolation on one end to social participation on the other [51]. More frequent social participation has been associated with better subjective general health [53]. Social support has protective effects against stress, more when a stressor becomes more intense or persistent [50,54].

It has been suggested that urban sprawl can decrease social capital. The geographical spread of social networks may reduce people's engagement in neighbourhoods and thereby lowering the sense of security and belonging. Also, car dependency due to the long distances have shown lower social participation and general trust among car commuters compared with active and public transport commuters [55].

1.2 Health outcomes

1.2.1 General health

The concept of health has evolved during human history. According to the World Health Organisation (WHO), health is “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” [56].

Nowadays health is conceived as the result of different determinants from individual ones (age, sex, hereditary factors), to behaviours (lifestyle), and to those related to anthropogenic and natural environments. A self-perception of general health has been well documented as a measure that provides a good summary of health status [57].

1.2.2 Mental Health

Mental health is defined as a “state of well-being in which every individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community” [58]. Mental health is a fundamental prerequisite for overall health. Countries around the world need to improve the priority and organisation of, and resources devoted to, mental health care [59].

Vigo 2016 [60] estimated that the global burden of mental illness accounts for 32.4% of years lived with disability (YLDs) and 13.0% of DALYs. Globally, it is estimated that 4.4% of the global population suffer from depressive disorder, and 3.6% from anxiety disorder [61]. Depressive disorders led to a global total of over 50 million Years Lived with Disability (YLD) in 2015. Globally, depressive disorders are ranked as the single largest contributor to non-fatal health loss (7.5% of all YLD). Similarly, anxiety disorders led to a global total of 24.6 million YLD in 2015, are ranked as the sixth largest contributor to non-fatal health loss globally, and appear in the top 10 causes of YLD in all WHO Regions [61].

Mental disorders are associated with risk factors for chronic disease such as smoking, reduced activity, poor diet, obesity, and hypertension; however, these lifestyle factors have not yet been shown to mediate associations with morbidity and mortality [62]. Emotional stability is an important predictor of subjective well-being [63]. Some literature suggests that environmental factors operating in the urban environment appears to be associated with mental health outcomes like psychiatric disorders, mood disorders, and anxiety disorders [64,65].

1.2.3 Perceived stress

Perceived stress presents a global and comprehensive stress construct that refers to the interaction between the individual and the environment when a stressor occurs [66]. The perception of an event as stressful can result in a range of physiological, behavioural, and psychological changes, such as cardiovascular disease, increased negative affect, lowered self-esteem, and lowered feelings of control. Hence, anxiety disorders and depression can be manifestations of chronic (perceived) stress [67]. It has been suggested that perceived stress is associated with the incidence of cardiovascular diseases [67].

Levels of stress have a lot to do with perceptions of control. In urban environments, transport can be a source of control perception, mainly in relation to time management. Travellers who are able to predict their trip length may experience less stress than travellers for whom the length of the trip is uncertain [68]. It has been suggested that modes of transport like car, motorbike or bicycle are associated with more perceived control than public transport [68]. Anyhow, it can be hypothesized that the results of this evidence relied on what was the mode of transport prioritized when the urban environment was designed.

1.2.4 Blood pressure

Blood pressure is a measurement of the force exerted against the walls of the arteries as the heart pumps blood throughout the human body. The Lancet Commission on hypertension defines individuals as having hypertension (or high blood pressure) when they persistently cross the blood pressure threshold above which there is robust scientific evidence that antihypertensive treatment will improve their prognosis. Generally this threshold will be the traditional cut-off values of 140 mm Hg systolic, 90 mm Hg diastolic, or both [69].

In 2016, high systolic blood pressure was classified as the third leading risk factor for global burden of disease, causing 10.4 million deaths and 212.1 million DALYs, being the second leading risk factor for men and the leading risk factor for women [34]. High blood pressure has been defined as the strongest modifiable risk factor for cardiovascular disease and related disability worldwide [69]. Evidence suggests that up to 80% of cardiovascular disease can be prevented through a healthy lifestyle (sufficient physical activity, avoidance of obesity, moderate alcohol intake, healthy diet, and no tobacco or drug use) [69].

Some studies have reported decreases in blood pressure and hypertension with built environment measures such as walkability [70,71]. Women living in compact communities have been found to have lower probability of experiencing a coronary heart disease event, myocardial infarction, or a cardiac death [72]. Moreover, a reduction in cardiovascular mortality has been associated with residential greenness exposure [73]. Long-term and short-term exposure to air pollution has been suggested as an important environmental risk factor associated with an increase in blood pressure levels [74,75], and also with other cardiovascular responses such as hypertension, heart failure hospitalisation and mortality, decreases in heart-rate variability, and progression in coronary calcification [76–83]. Additionally, active transport have been associated with lower likelihood of having hypertension [84], and shown robust protective effect for cardiovascular outcomes [18,85].

1.3 Conceptual frameworks

Urban environments are very complex systems with a myriad of factors intricately related, which can be important determinants of urban population's health as described above in the two previous sections (1.1 Urban determinants of health, 1.2 Health outcomes). Different conceptual frameworks can be used to try to explain this complex reality. The following sections will explain three conceptual frameworks that already exist and are used widely in the literature, and will present the conceptual framework created to explain the different associations and interactions studied in this thesis.

1.3.1 The map of the determinants of health

Barton and Grant [6] re-defined the map of the determinants of health, re-dimensioning the health determinants into the size of a neighbourhood (Figure 1). Using a layers concept such as an "onion", this health map suggests that all layers can interact and are connected between them. The main idea of this map is to show that health is not only the result of intrinsic characteristics of the individual, it also depends on many other layers that come from outside the human body boundaries.

Figure 1. The map of the determinants of health [6].

1.3.2 Ecological models of health behaviours

Ecological models of health behaviours mainly focus on behavioural change. Those models also follow a layered or “onion” structure to represent the multiple levels of influence on a specific behaviour. One of the core principles of these models is that influences interact across levels. Figure 2 shows an ecological model focused on physical activity behaviours. The model synthesized findings and concepts from the fields of health, behavioural science, transport and city planning, policy studies and economics, and leisure sciences. This model is organized around four domains of physical activity (active recreation, active transport, household activities, occupational activities), and it shows that social and cultural environments operate at multiple levels.

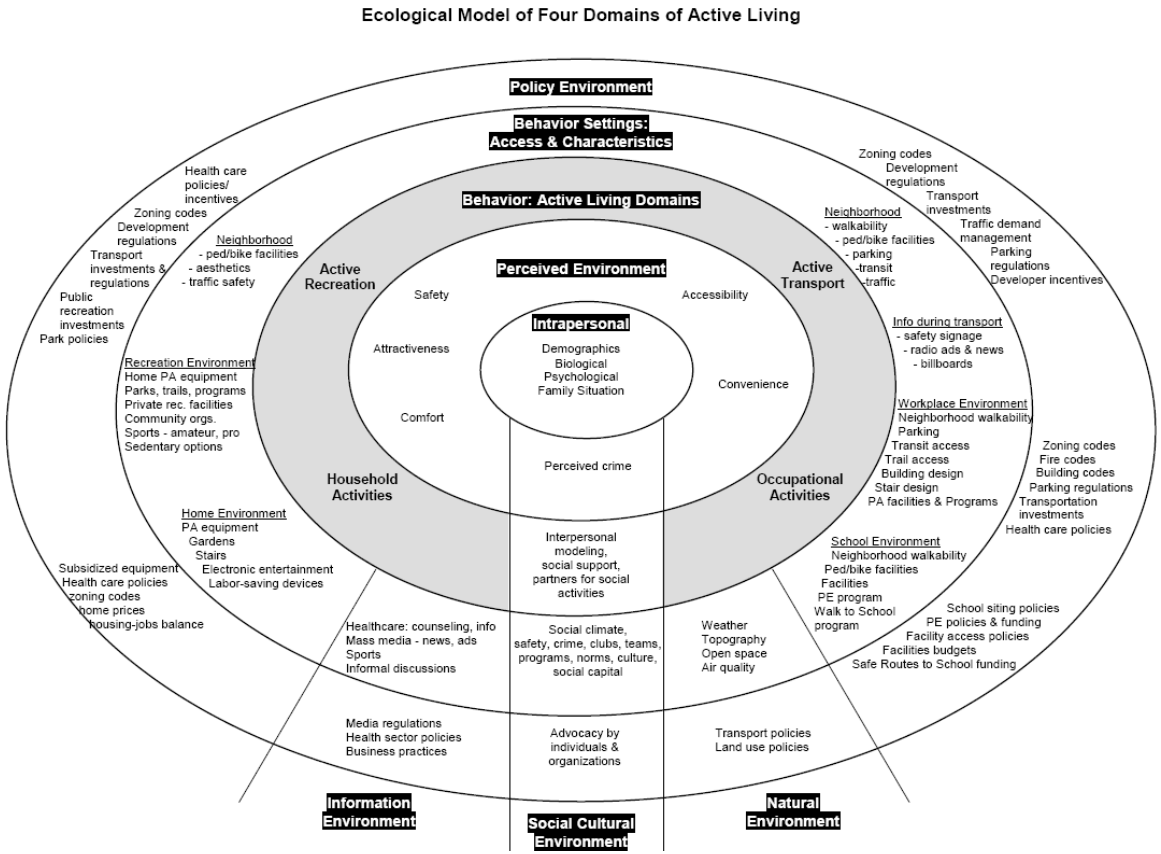


Figure 2. Ecological models of health behaviours focused in active living domains [86].

1.3.3 The urban and transport planning, environmental exposures and health conceptual framework

The urban and transport planning, environmental exposures and health conceptual framework put together different determinants of health that are in the urban environments. This model follows a linear design which makes easier to draw causal inference from left to right, from a very exposure-outcome conceptual definition. It is a very attractive conceptual framework for epidemiologists due to its easiness with which an exposure (left) and outcome (right) can be defined. The framework aims to provide a narrative towards new insights and possible solutions for the current environmental and health challenges in cities. It focuses on the links between built environment, environmental exposure, and health and identifies new concepts, methods and tools to inform science and policies [87].

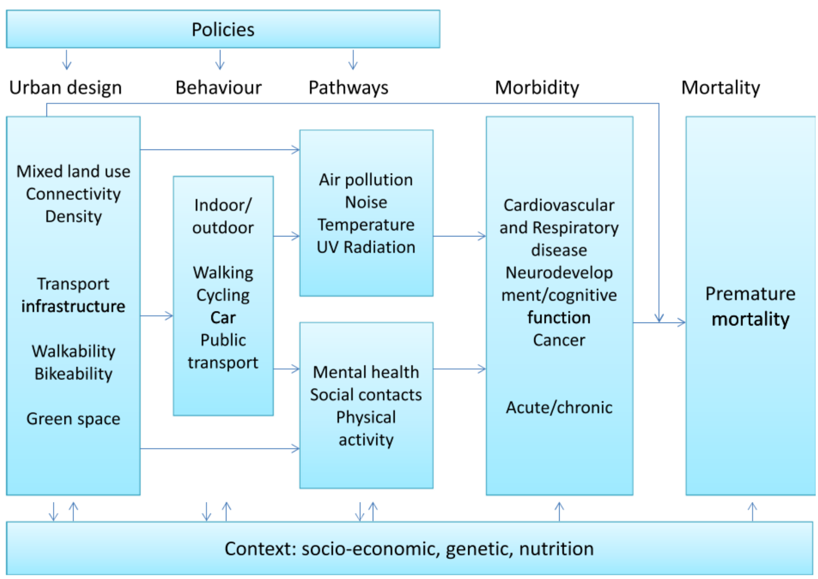


Figure 3. Conceptual framework for the relation between urban and transport planning, environment exposures and health [87].

1.3.4 Thesis conceptual framework

Due to the different urban determinants of health and health outcomes studied in this thesis, a particular conceptual framework was developed. It has been inspired by all the previously presented conceptual frameworks, in particular by “The urban and transport planning, environmental exposures and health conceptual framework”. This is mainly because of the model’s simplicity to represent the exposure-outcome approach used in the present work.

In Figure 4, all the urban determinants of health and health outcomes studied in the present thesis are represented. The specific measures of built environment, perceived crime, and transport mode use are specified. More details about these measures and the rest can be found in Results section in the specific Papers.

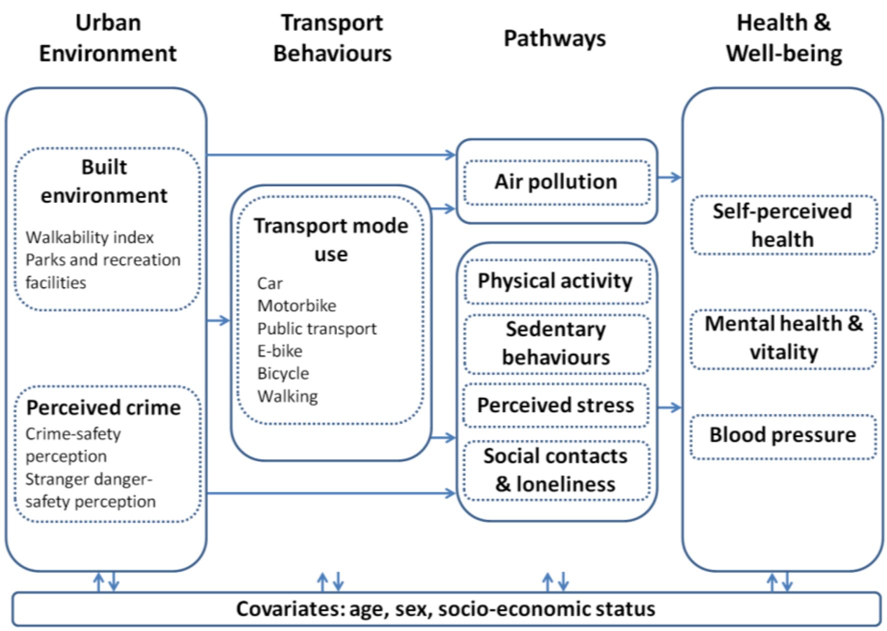


Figure 4. Thesis conceptual framework.

2 RATIONALE

The ongoing worldwide urbanization process makes cities affront major challenges. Urban environments present many factors that can be important determinants of health. A comprehensive understanding of urban health determinants interrelations and their effect on many different health outcomes is needed. More precisely, the gaps identified in the literature are described below.

The potential moderation effect of perceived crime on the relationship between the built environment and physical activity and sedentary behaviours remains unclear. This moderation effect has been assessed before in younger and older adults, but mixed results were found. Only a few studies differentiated their results by gender, even though it seems that women report higher prevalence of insecurity about crime and safety than men [88]. Therefore, there is a need to further explore this potential moderation effect, mainly in population subgroups who can present particular behavioural patterns, such as adolescents.

The evidence about the association between transport mode use and several perceived health and social contact measures is scarce. Several studies have examined the relationship between active commuting and commuting stress (stress directly related with the act of commuting) [68,89–91], but none of them have studied the relationship between solely bicycle commuting and perceived stress (global and comprehensive stress construct) in adults, nor taken into account urban environment determinants. Furthermore, few studies have evaluated associations between transport and social capital indicators [55,92], but none have evaluated associations between transport and loneliness, although loneliness is currently considered to be a major problem in Western society [51]. In addition, until now, studies have assessed associations between a single transport mode and health outcomes or made comparisons across transport modes when evaluating associations with health outcomes. A multiple transport modes approach is needed, as it may be a more realistic description of transport behaviour for many people nowadays. Moreover, most studies in transport and health are conducted in one country, and mainly in North America or Northwest Europe. Consequently, international studies or at least studies located in Mediterranean/Southern European urban environments which are particularly dense are needed to represent variability in transport behaviour.

There is a need to disentangle the main effects and interaction effects of air pollution and physical activity on blood pressure levels using personal objective and continuous measurements. Some epidemiological studies have investigated the effects of air pollution on blood pressure [76,77,93], but none of them has assessed air pollution and physical activity data continuously to measures personal exposure. Also, none of the studies was done in different cities simultaneously.

3 OBJECTIVES

General objective

To evaluate associations and interactions between different urban determinants of health and different health outcomes.

Specific objectives

(1) To evaluate the modifying effects of parental and adolescents’ perceptions of neighbourhood crime-related safety (crime rate and stranger danger) in the associations between objective built environment and multiple indicators of adolescents' physical activity and sedentary behaviours (Paper I).

(2) To evaluate the association between bicycle commuting and perceived stress among working or studying adults in a dense urban setting (Paper II).

(3) To evaluate the association between different transport modes use and several health and social contact measures in adult populations in seven European cities (Paper III).

(4) To assess the main and interaction effects, of black carbon and physical activity on systolic and diastolic blood pressure, in a healthy adult population from three European cities using objective personal measurements over short-term (hours and days) and long-term exposure (Paper IV).

4 METHODS

4.1 TEAN study

The TEAN (Teen Environment And Neighborhood) study was funded by the National Heart, Lung, and Blood Institute (2007-2011) of the National Institutes of Health to improve understanding of the environmental correlates of physical activity, sedentary, behaviour, and dietary behaviours among adolescents. TEAN was based on an ecological model conceptual framework [86]. The purpose of the study was to advance knowledge about multiple levels of correlates of physical activity, sedentary behaviour, dietary patterns, and weight status in adolescents aged 12 to 16 years, with an emphasis on neighbourhood environments.

To accomplish the specific objective 1 (Paper I) of this thesis, TEAN data was analysed. The sample was of 928 adolescents and their parents, who answered a survey regarding to their neighbourhood environment perception and their physical activity levels, and the adolescents wore an accelerometer for one week. Geographical Information System data was used to assess objectively the neighbourhood built environment. Built environment measures used were walkability index and number of parks and recreation facilities, both in a 1km buffer from participants' home. The measures used about perceived crime came from the validated scale Neighborhood Environment Walkability Scale for Youth (NEWS-Y) [94]. Those measures were elaborated following recommendations from previous literature, which recommended to measure fear of crime including items that: (1) refer explicitly to "fear" rather than worry or concern about crime; (2) specifically mention crime; and (3) are not hypothetical [88]. Two scales were obtained (crime perception, stranger danger perception) and both were reversed to become safety scales (crime-safety perception, stranger danger-safety perception). Physical activity and sedentary behaviours were measured using accelerometer and questionnaire data. The modifying effects were evaluated by mixed-effects models adjusted for all potential confounders.

4.2 TAPAS Travel Survey

TAPAS (Transportation, Air pollution and Physical Activities) was a health risk assessment program, which addressed climate change, physical activity and urban policies (http://www.tapas-program.org/) funded by the Coca Cola Foundation, AGAUR (Agència de Gestió d'ajuts Universitaris i de Recerca), and CREAL (current ISGlobal) internal funding. As part of the project, TAPAS Travel Survey was conducted to investigate the risks and benefits of active commuting. The subjects who fulfilled the inclusion criteria were recruited between June 2011 and May 2012 across forty sampling random points of Barcelona city. The sample framework was a convenience sampling of cycling commuters (2 days or more per week) and commuters who do not cycle or cycle less than 2 days a week. Pedestrians were excluded from the non-cyclist commuters as the main interest was in the contrast of motorized modes (private and public transportation) and the bicycle.

To accomplish the specific objective 2 (Paper II) of this thesis, the data from 788 adults who commuted to work or study places in Barcelona was analysed. They responded to a comprehensive telephone survey concerning their travel behaviour. Participants were categorised in: bicyclist commuters and non-bicyclist commuters. The perceived stress was assessed with the short version of the Perceived Stress Scale (PSS-4) [66] and categorised as stressed and non-stressed. The association was evaluated by multivariate logistic regression models adjusted for all potential confounders.

4.3 PASTA project

PASTA (Physical Activity through Sustainable Transport Approaches) project was a European Union (EU) funded project carried out from 2013 to 2017 (http://www.pastaproject.eu/home/). PASTA pursued the following four main aims: (1) to investigate correlates and inter-relationship between active mobility (i.e. walking and cycling, in combination with public transport use), physical activity, air pollution, and crash risk; (2) to evaluate the effectiveness of selected interventions and measures to promote active mobility so as to increase both active mobility and physical activity; (3) to improve the comprehensive Health Impact Assessment (HIA) of active mobility; and (4) to foster the exchange between the disciplines of public health and transport planning, as well as between research and practice [1].

To accomplish PASTA aims 1 and 2, the project combined a "Core module" with several "Add-on modules". The data used in the present thesis was from the "Core module" and the "Health add-on" [1,2].

4.3.1 Core module

The "Core module" was a longitudinal study with approximately 10,000 adults from 7 European cities (Barcelona, Antwerp, London, Örebro, Rome, Vienna, and Zurich) (Figure 4). Participants answered several on-line questionnaires (baseline, short follow-ups, long follow-ups, and final) from November 2014 to January 2017 concerning their transport behaviours, physical activity levels, and several health outcomes. Figure 5 represents PASTA "Core module" study design.

To accomplish the specific objective 3 (Paper III) of this thesis, data from the baseline and the final questionnaires was analysed. Self-perceived health was the main outcome, three mental health measures were used (perceived stress [66], mental health [57], and vitality [57]), and social contact measures (loneliness [95] and contact with friends and/or family). Associations between transport mode use and health/social contact measures were estimated using mixed-effects logistic regression models, linear regression models, and logistic regression models according to the data available. All the associations were assessed with single and multiple transport mode models. All models were adjusted for potential confounders.

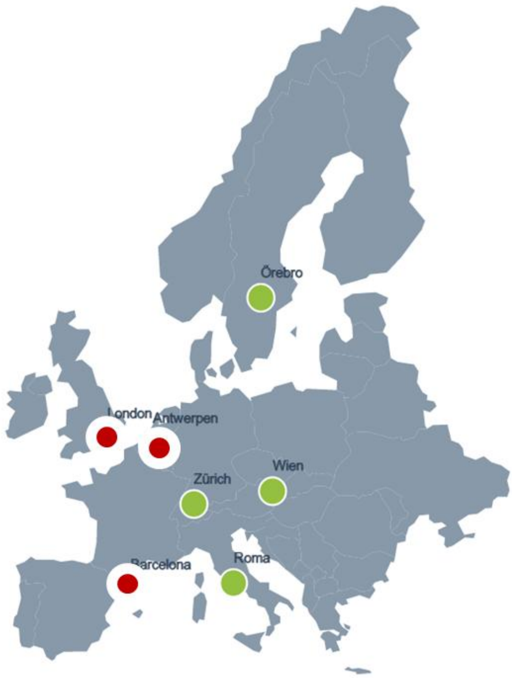


Figure 4. The seven European cities involved in PASTA project. Cities in green were only involved in the "Core module". Cities in red were involved in the "Core module" and the "Health add-on". Image adapted from PASTA visual guidelines.

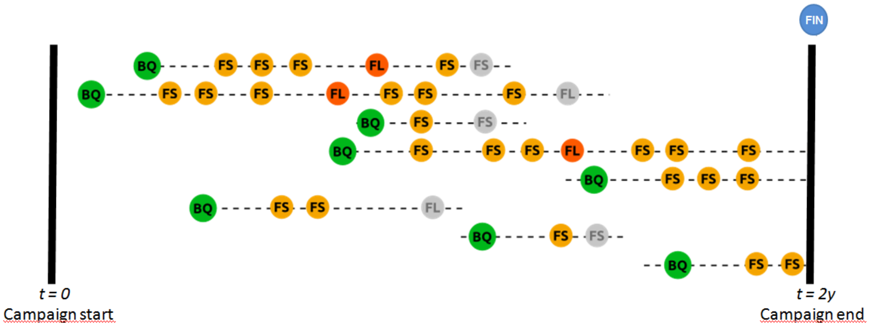


Figure 5. PASTA "Core module" study design. BQ: Baseline Questionnaire; FS: Short Follow-up questionnaire; FL: Long Follow-up questionnaire; FIN: Final questionnaire. Image adapted from PASTA visual guidelines.

4.3.2 Health add-on

The "Health add-on" was a panel study conducted in three cities (Antwerp, London, and Barcelona) between March 2015 and March 2016 (Figure 4). The study participants were 122 adults (40 per city approximately) who were participating in PASTA "Core module" and have fulfilled the "Health add-on" inclusion criteria. For one week, participants wore sensors to measure their exposure to black carbon, physical activity levels, and geolocation continuously. The first and the last day of the week (days 0 and 7), a battery of non-invasive measurements was done: heart rate variability, blood pressure, retinal vessel diameters, FeNO, and lung function. Extra measurements were done for heart rate variability (days 1, 4, and 6) and blood pressure (day 4). Participants also answered a questionnaire to assess short-term exposures (last 24 hours), personal characteristics, self-perceived health, and physical activity and transport behaviours in days 0, 4, and 7. The measurement week was repeated in three different seasons (winter, summer, and mid-season). Figure 6 represents PASTA "Health add-on" study design.

To accomplish the specific objective 4 (Papers IV) of this thesis, data related to black carbon, physical activity, and blood pressure was analysed. The associations and modifying effects were evaluated by mixed-effects models adjusted for all potential confounders.

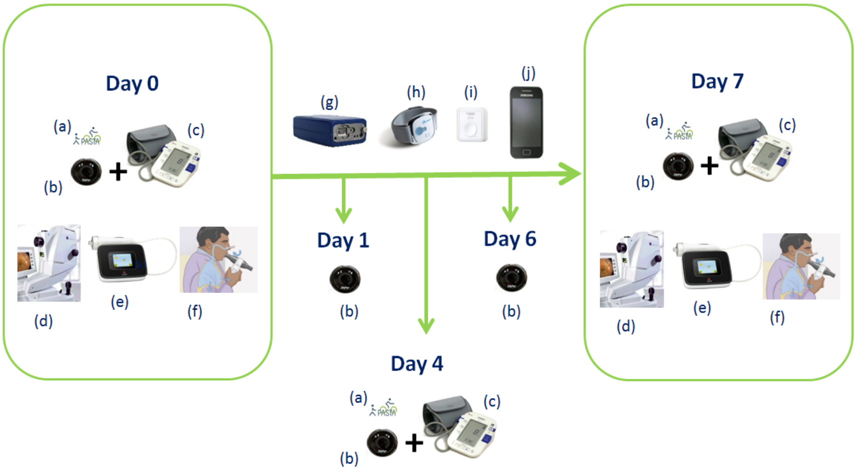


Figure 6. PASTA "Health module" study design. (a) Questionnaire; (b) Zephyr Bio-Harness to measure heart rate variability; (c) Omron model M10-IT to measure blood pressure; (d) Retina pictures camera; (e) NIOX VERO device to measure FeNO; (f) Spirometry tests to measure lung function; (g) microAeth to measure black carbon; (h) SenseWear to measure physical activity levels; (i) GPS to measure geolocation; (j) smartphone with an app to measure geolocation and physical activity levels.

5 RESULTS

5.1 Paper I

Perceived crime-safety interactions with objective built environment to explain physical activity, active transport, and sedentary behaviors

5.2 Paper II

The relationship between bicycle commuting and perceived stress: a cross-sectional study

5.3 Paper III

The effects of transport mode use on self-perceived health, mental health, and social contact measures: a cross-sectional and longitudinal study

5.4 Paper IV

Effects of physical activity and air pollution on blood pressure

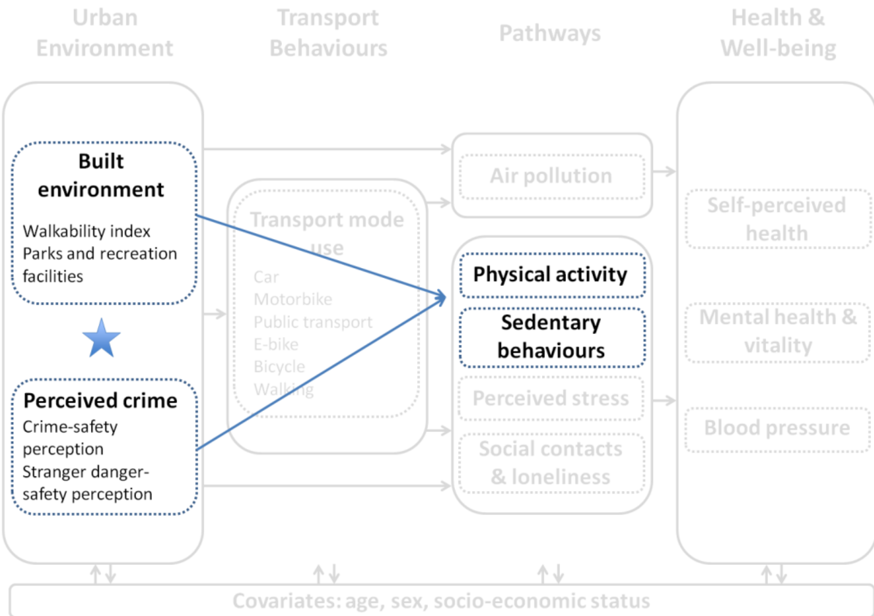
5.1 Paper I

Avila-Palencia, I., Conway, T.L., Cain, K.L., Frank, L.D., Glanz, K., Saelens, B.E., Sallis, J.F.

Perceived crime-safety interactions with objective built environment to explain physical activity, active transport, and sedentary behaviors

In preparation

Urban determinants of health, health outcomes, and relationship between them evaluated in Paper I.



Perceived crime-safety interactions with objective built environment to explain physical activity, active transport, and sedentary behaviors

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Abstract

Background: The inconsistent associations of crime and physical activity raise the possibility that perceived crime interacts with other variables, such as built environment constructs, rather than having simple main effects on physical activity. Our main aim was to evaluate effect modifications of parents' and adolescents' perceptions of neighborhood crime-related safety (crime rate and stranger danger) in associations between objective built environment and multiple indicators of adolescents' physical activity and sedentary behaviors.

Methods: This cross-sectional study was based on data from the TEAN (Teen Environment And Neighborhood) study. Adolescents between the ages of 12 and 16 were the targeted participants, along with one parent/caregiver per household. Adolescents and parents answered a questionnaire, and adolescents wore an accelerometer for 7 days. Mixed-effects models were used to evaluate the modifying effect of perceived crime-safety measures in the association between built environment measures and physical activity and sedentary behaviors measures.

Results: Interaction effects were found in both genders, but mainly in girls. Girls who had higher crime-safety perception and parents with higher stranger danger-safety perception of their neighborhood were more encouraged to actively travel to/from school if they had higher walkability index in a 1km buffer around their home. Girls with parents who had low safety perceptions encouraged more car/bus use if there was higher walkability index and more parks and recreation facilities in a 1km buffer around their home. More time spent in front of a screen was associated with more parks and recreation facilities in a 1km buffer around their home. Regarding boys, parents who had lower crime-safety perception of their neighborhood may reinforce the positive effect of having parks and recreational facilities in a 1km buffer around their home on active transport to/from other places than school in adolescents. Adolescents who had lower crime-safety perception of their neighborhood may reinforce the positive effect of having parks and recreational facilities in a 1km buffer on their leisure time physical activity.

Conclusions: Several results indicated that perceived crime and built environments may work together to explain adolescent physical activity.

Keywords: Walkability, parks, crime, active transport, sedentary lifestyle, adolescent, survey

Introduction

Children and adolescents are recommended to accumulate at least 60 minutes of moderate-to-vigorous intensity physical activity daily [1]. Health benefits in children and adolescents of achieving those recommendations include increased physical fitness (both cardio-respiratory fitness and muscular strength), reduced body fatness, favorable cardiovascular and metabolic disease risk profiles, enhanced bone health and reduced symptoms of depression [1]. Individuals can achieve the recommendations, but they could also be sedentary most of their waking hours. In children and adolescents, evidence has found a relationship between time spent in sedentary behavior and obesity, blood pressure, total cholesterol, low self-esteem, social behavior problems, physical fitness, and low academic achievement [2]. Although high levels of moderate intensity physical activity seem to eliminate the increased risk of death associated with high sitting time in adults, it does not eliminate the increased risk associated with high TV-viewing time [3].

Built and social environments have been suggested to have an influence in physical activity levels [4]. On one hand, built environment attributes like residential density, intersection density, public transport density, and number of parks have the potential to contribute to physical activity [5]. Specifically for adolescents, distance to school, street connectivity, pedestrian safety, residential density, and walkability of the neighborhood have been associated positively to active modes of transport to school [6, 7]. On the other hand, social factors like crime might constrain adults, and their children's, social and physical activities to avoid places or situations that are perceived to be unsafe [8]. Previous literature has found that parent crime-safety and stranger danger-safety perception was associated with adolescent physical activity levels, especially for active transport behaviors [9].

The moderation of the association between built environment and physical activity by perceived crime has been assessed before in younger and older adults, but unclear results were found with a negative interaction between walkability and crime-safety related to total moderate-to-vigorous physical activity [10]. Only a few studies differentiated their results by gender, even though it seems that women present higher prevalence of insecurity about crime and safety than men [11].

The main aim of the present study was to evaluate effect modifications of parental and adolescents' perceptions of neighborhood crime-related safety (crime rate and stranger danger) in the associations between objective built environment measures and multiple indicators of adolescents' physical activity and sedentary behaviors.

Material and methods

Study design and population

This cross-sectional study was based on data from the TEAN (Teen Environment And Neighborhood) study. The purpose of TEAN was to advance knowledge about multiple levels of correlates of physical activity, sedentary behavior, dietary patterns, and weight status in adolescents aged 12 to 16 years, with an emphasis on neighborhood environments. The study was conducted between 2009 and 2011 in two regions: (1) Baltimore (Maryland-Washington, DC) and (2) Seattle-King County (Washington). Participants were recruited from four neighborhood types (termed quadrants) formed by low versus high levels of neighborhood walkability and low versus high neighborhood income, an indicator of socioeconomic status (SES). US Census block groups (year 2000) were used as the areal unit of analysis for both walkability and income characteristics, as it has been done in previous studies [12–14]. Households with adolescents within the study neighborhoods were randomly selected using address and demographics data purchased from the marketing company CAS Inc. Households received a letter introducing the study and were subsequently contacted by phone to assess eligibility and interest. Adolescents between the ages of 12 and 16 were the targeted participants, along with one parent/caregiver per household. Approximately equal adolescent-parent pairs were recruited in the high/low walkability-by-income quadrants in both regions. Recruitment was conducted simultaneously in all quadrants to avoid seasonal bias and was conducted only during the school year. Based on parent reports, adolescents' exclusion criteria were: (a) having any psychological or medical condition that would preclude full participation, (b) having any disability or illness that would preclude the adolescent from engaging in at least moderate-intensity physical activity, and (c) having any eating disturbance indicative of significant eating disorder psychopathology (e.g., self-induced vomiting) or a medically prescribed dietary regimen. Inclusion criteria included the following: (a) child and parent had to be English-speaking, but not necessarily as a first language (i.e., able to complete surveys written in English), and (b) adolescent must attend middle or high school or be home-schooled.

An accelerometer was sent to the participants with instructions for wearing and mailing it back. Adolescents were asked to wear the accelerometer for seven consecutive days during all waking hours (except when swimming or bathing) on a belt at their left iliac crest. They were instructed to start the data recording at midnight on the first day of expected wearing, complete logs for dates and times of wearing, and note device removals during the wearing days. Adolescents were instructed to wear the accelerometer for one or more extra days at the end of the week if they had any incomplete wearing days. Participants were also asked to complete surveys (both parent and adolescent versions) online or by mail.

The TEAN study was approved by the Institutional Review Boards at San Diego State University and Seattle Children's Research Institute following the ethical standards recognized by the Declaration of Helsinki (reviewed in Seoul, Republic of Korea, in October 2008), and written informed consent was obtained from all participants.

Built environment measures

We used two measures for built environment: (1) walkability index and (2) parks and recreation facilities. Walkability index was calculated using net residential density, intersection density, retail floor area ratio (FAR), and land use mix for the 1km street network buffer around each participant's residence. Data from the county-level tax assessor, regional land use at the parcel level (data from 2002 in King County and 2003 in Baltimore–Washington, DC, region), and street networks (data from 2001 for King County and 2000 in Baltimore–Washington, DC, region) were integrated into a Geographic Information System (GIS). Net residential density was calculated based on the number of residential units relative to the amount of residential land within the buffer. Land use mix examined the evenness of distribution of the square area or floor space dedicated to residential, entertainment (including restaurants), and retail mixed land uses. Intersection density was calculated based on the number of intersections per land area. Retail FAR was calculated as the square footage of retail/commercial relative to the total land area dedicated to retail/commercial within the buffer. This latter measure serves as a proxy for site design and captures the degree to which retail uses are set toward the curb or behind parking [15].

A sum of public parks and private recreation facilities was created for the 1km street network buffer around each participant's residence as a proxy of recreational environment around home. First, a comprehensive list of parks was compiled each for King County and the 5-county region in Maryland based on existing GIS layers, municipality and county databases and websites, and review of the area's Thomas Brothers street guide. Lists included parks, open spaces, and trails along with any information regarding their address, amenities, and acreage. Internet searches were used to obtain addresses or cross-streets when this information was not available through other sources. Second, a list of private recreation establishments was compiled for each region based on electronic yellow pages from Databases Unlimited, Switchboard.com and Mapquest.com. Establishments that were not primarily for recreation (i.e. social services, churches) were removed from the list. Finally, the number of public parks and recreation facilities within or intersected by the 1km street network buffer around each participant's residence were summed [16].

Perceived crime-safety measures

We used two neighborhood perceived crime-safety measures: crime-safety and stranger danger-safety. Both measures were assessed using the Neighborhood Environment Walkability Scale for Youth (NEWS-Y) [17], and these sections were completed by both parents and adolescents. The idea behind measuring safety perceptions from both parent and adolescent is because an earlier study of NEWS-Y showed poor agreement between adolescent and parent reports, especially on these crime-related scales [17]. The instructions were to: "Please circle the answer that best applies to you and your local neighborhood, which means within a 10-15 minute walk from your home". For crime-safety the item was: "There is a high crime rate". For the stranger danger the items were: “There is a fear of being taken or hurt by (a) a stranger in a local park; (b) a stranger on local streets; (c) a stranger in my yard, driveway, or apartment common area; (d) a known “bad” person in my neighborhood”. Response options ranged from 1=strongly disagree to 4=strongly agree. The crime-safety score was from the single item. The stranger danger-safety score was a mean of four items. Both scales were reversed to become safety scales.

Physical activity measures

Six physical activity behaviors were measured: overall, transport, and recreation physical activity. For overall physical activity we used “non-school moderate-to-vigorous physical activity”, which was measured using an accelerometer (Actigraph models 7164, GT1M & GT3X, Pensacola, FL). Using MeterPlus v.4.3 (www.meterplussoftware.com), data were converted to moderate-to-vigorous intensity physical activity using age-specific cutpoints indicating ≥3 Metabolic Equivalent of Tasks (METs) [18]. Non-school moderate-to-vigorous physical activity was calculated because environments around home were not expected to be related to physical activity during school hours. Due to the skewed distribution of data, non-school moderate-to-vigorous physical activity was log-transformed for analyses.

We used three self-report measures for active transport: active transport to/from school, active transport to other places, and total active transport. Active transport to/from school was assessed in the adolescent questionnaire by asking: “In an average school week, on how many days do you use the following modes of transportation to get to and from school?” Possible transport modes were: Walk, Bicycle, Skateboard, Bus, Car. The response scale for each transport mode ranged from “0 days” to “5 days”. To create this variable we summed answers from Walk, Bicycle, and Skateboard options. Because of the preponderance of zeros, we dichotomized the variable: no (0 days) and yes (1-5 days). Active transport to other places was assessed in the adolescents’ questionnaire by asking: “How often do you usually walk or bike to/from the following?”: Indoor recreation or exercise facility, Friend’s or relative’s house, Outdoor recreation place, Food store or restaurant/café, Other retail stores, Non-school social or educational activities, Public transportation stop, Work, and Other. An additional question was: “How often do you skateboard to go places?”. Response options for both questions ranged from 0 to 5 (0=never; 1=once a month or less; 2=once every other week; 3 =once a week; 4=two or three times per week; and 5=four or more times per week). All items were used to compute a mean score (range =0 to 5). A total active transport index was created by computing a sum of z scores of active transport to/from school scale and active transport to other places.

We used two measures for recreation physical activity: leisure time physical activity in the neighborhood and leisure time physical activity in other places. Leisure time physical activity in the neighborhood was assessed in the adolescents’ questionnaire by asking: “How often are you physically active in/at the following places?”: At a neighbor’s house, yard or driveway; On a local street, sidewalk or vacant lot; In a nearby cul-de-sac or dead-end street; and In a nearby park or open space. Leisure time physical activity in other places was assessed in the adolescents' questionnaire by asking: "How often are you physically active in/at the following locations?" Adolescent responsed to 14 possible recreational places outside the neighborhood, such as "Indoor recreation or exercise facility (public or private; YMCA/Boys & Girls Club, dance, martial arts)", "Beach, lake, river or creek", "School grounds (during non-school hours)", or "Public park" among others. For both questions, response options were 0=never; 1=once a month or less; 2=once every other week; 3 =once a week; 4=two or three times per week; and 5=four or more times per week. For each question, means were calculated (range = 0 to 5).

Sedentary behavior measures

We used four measures to assess sedentary behaviors overall and in the transport and recreation domains: non-school sedentary time, riding in a car/bus, screen time, and TV time. Non-school sedentary time was measured using an accelerometer (Actigraph models 7164, GT1M & GT3X, Pensacola, FL). Data were converted to minutes engaged in sedentary behavior defined by < 100 counts per minute [19,20] which has been shown to have excellent classification accuracy [21]. Riding in a car/bus was assessed with one Item in the adolescents' questionnaire by asking adolescents how much time on a typical school day they ride in a car, bus, etc. Screen time was assessed calculating the mean of three items from the adolescents' questionnaire: how much time on a typical school day they (1) watch television/videos/DVD's, (2) play sedentary computer or video games (like Nintendo or Xbox), and (3) use the internet, email or other electronic media for leisure. TV time was assessed with one item in the adolescents' questionnaire that asked how much time on a typical school day they watch television/videos/DVD's. For each item, response options were: 0=none; 15=15 min per day; 30=30 min per day; 60 =1 hour per day; 120=2 hours per day; and 180=3 hours per day; 240=4 or more hours per day. These variables were treated as continuous variables.

Covariate measures

Adolescents´ characteristics used as potential confounders were: self-reported age, gender, race/ethnicity (recoded as white/non-Hispanic or non-white/Hispanic), having a driving license (yes/no), work outside home (volunteer or paid job/no work outside the home), and home schooled (yes/no). Household characteristics used as potential confounders were: parent-reported number of children under 18 years old in the household, number of adults in the household, number of motor vehicles per licensed driver, parent married/living with partner, and parent education university/more.

Statistical analyses

Descriptive univariate analyses were conducted for all study variables, calculating frequencies and percentages for categorical variables and mean, standard deviation (SD), median, and interquartile range (IQR) for continuous variables. Descriptive bivariate analyses were conducted using Chi square and U Mann Whitney tests to assess the statistical differences between boys and girls.

Mixed-effects models were used to evaluate the modifying effect of perceived crime-safety measures in the association of built environment measures with physical activity and sedentary behavior. Mixed-effects linear regression models were fitted for all outcomes that were continuous (with or without transformation) and mixed-effects logistic regression models were run for the outcome active transport to/from school. All regression models were run adjusted for the potential confounders and stratified by gender. The potential confounders included were those used in previous literature and that showed a $p<0.05$ with the exposures, moderators, and/or outcomes. The same confounders were used in all the models. As different models of accelerometers were used in the study, "accelerometer model" variable was added in the models with accelerometer outcomes. All models used census block group ID as a random effect and were conducted with a complete case analysis. All predictors included in the models were mean-centered. In all contrasts a significance value of $p<0.05$ was considered for main effects and a $p<0.10$ for interactions. All the statistically significant interaction effects were graphed using Jeremy Dawson's website (http://www.jeremydawson.co.uk/slopes.htm). All analyses were conducted in Stata version SE 14 (StataCorp LP, Texas USA).

Results

A total of 928 adolescent-parent pairs answered the surveys. The sociodemographic characteristics of the study population, prevalence of the built environment measures, perceived crime-safety measures, and physical activity and sedentary behaviors measures are presented in Table 1.

Physical activity behaviors

Physical activity behaviors have presented several statistically significant results. Regarding to built environment measures, in boys sample we can mainly see the effect of both built environment measures in active transport measures (Table 2). Boys having higher levels of walkability index and more parks and recreational facilities in 1km buffer from their residential address had statistically significant higher odds of going walking, cycling, and/or skating to/from school and higher levels of active transport in other places and in total. We can also see an effect of parks and recreation facilities in leisure time physical activity in other places, resulting having more parks and recreational facilities in 1km buffer in an increase in levels of leisure time physical activity in other places. In girls sample, we can see an effect of walkability index and parks and recreational facilities in non-school moderate-to-vigorous physical activity levels (Table 3). For a one-unit increase in walkability index and parks and recreation facilities, we expect to see about a 3-4% and a 1-2% increase in non-school moderate-to-vigorous physical activity respectively. We also can see an effect of walkability in all active transport measures and parks and recreation facilities with active transport in other places and the total active transport index. Higher levels of walkability and more parks and recreation facilities are associated with higher levels of active transport. In general, we can see that the effect of walkability index is much higher than the effect of parks and recreational facilities, mainly in active transport measures.

Regarding to crime-safety perception measures, we did not find any statistically significant effect in boys sample. Otherwise, in girls sample we found statistically significant results with safety measures related to parent's perception. For a one-unit increase in parent crime-safety perception scale we expect to see about a 9-10% increase in non-school moderate-to-vigorous physical activity (Table 3), and higher levels of active transport in other places, total active transport, and leisure time physical activity in other places. Parent stranger danger-safety perception was statistically significantly associated with moderate-to-vigorous physical activity and active transport in other places. For a one-unit increase in parent stranger danger-safety perception scale we expect to see about a 10-11% increase in non-school moderate-to-vigorous physical activity (Tables 3) and higher levels of active transport in other places. The effect of parent stranger danger-safety perception is slightly higher than the effect of parent crime-safety perception. Also, we can see that the effect of the statistically significant safety perception variables tend to be higher than the effect of the built environment measures.

Regarding to interaction effects, in boys sample we found statistically significant negative interaction effects in active transport in other places from parks and recreation facilities with parent crime-safety perception (coef (CI 95%) = -0.02 (-0.04, -0.00); p-value= 0.047). Parents who have lower crime-safety perception of their neighborhood may reinforce the positive effect of having parks and recreational facilities in a 1km buffer on active transport to/from other places than school in adolescents (Figure 1). We also found statistically significant negative interaction effects in leisure time physical activity in the neighborhood and in other places from parks and recreation facilities with adolescent crime-safety perception (neighborhood: coef (CI 95%) = -0.02 (-0.05, 0.00), p-value= 0.077; other places: coef (CI 95%) = -0.01 (-0.03, 0.00), p-value= 0.077). Adolescents who have lower crime-safety perception of their neighborhood may reinforce the positive effect of having parks and recreational facilities in a 1km buffer on leisure time physical activity in adolescents (Figures 2 and 3). In girls sample, we found statistically significant interaction effects in active transport to/from school from walkability index with adolescent crime-safety perception (OR(CI 95%) = 1.09 (1.00, 1.19), p-value= 0.057) and parent stranger danger-safety perception (OR(CI 95%) = 1.12 (1.00, 1.26), p-value= 0.052). Adolescents who have high crime-safety perception and parents who have high stranger danger-safety perception of their neighborhood may reinforce the positive effect of having high walkability index in a 1km buffer on travelling walking, cycling, and/or skating to/from school (Figures 4 and 5).

Sedentary behaviors

Sedentary behaviors have presented a few statistically significant results. Regarding to built environment measures, in boys sample we did not find any statistically significant result (Table 4). In girls sample, though, we found that parks and recreation facilities were associated with less time spent watching TV (Table 5).

Regarding to crime-safety perception measures, in boys sample we only found statistically significant association between parent stranger danger-safety perception with screen time and TV time. Higher parent stranger danger-safety perception of the neighborhood was associated with adolescent's less time spent in front of a screen and the TV. In girls sample, we found statistically significant positive association between adolescent stranger danger-safety perception with sedentary time, but negative association with screen time and TV time. Also, higher adolescent stranger danger-safety perception of their neighborhood was associated with more time spent in non-school sedentary behaviors, but less time in front of a screen and the TV.

Regarding interaction effects, we did not find statistically significant interaction effects in boys sample. In girls sample, we found statistically significant negative interaction effects in riding car/bus from walkability index with parent stranger danger-safety perception (coef (CI 95%) = -2.05 (-4.19, 0.1), p-value=0.061). Parents who have low stranger danger-safety perception of their neighborhood may would have the opposite effect compared to those having a high safety perception having the neighborhood a high walkability index encouraging riding car/bus (Figure 6). We can see the same trend in Figures 7 and 8. Parents with low safety perception of their neighborhood would get an opposite effect of having parks and recreation facilities increasing then the use of car/bus and the amount of time spent in front of a screen of their adolescent girls.

Discussion

Summary of results

We found that boys and girls with higher walkability index and more parks and recreation facilities around their home are more prone to travel actively. Boys also have more leisure time physical activity in other places than the neighborhood due to have more parks and recreation facilities in a 1km buffer from their home. Girls have more non-school moderate-to-vigorous physical activity because of having higher walkability index and more parks and recreation facilities around their home. Regarding to the effects of safety perceptions, only girls have higher physical activity levels (non-school moderate-to-vigorous physical activity, active transport, and leisure time physical activity specifically) if their parents' have higher safety perception of the neighborhood where they live. On the other hand, boys and girls spent less time in front of a screen and the TV due to higher stranger danger-safety perception, from parents in the case of boys and from the adolescent in the case of girls. Also we saw that girls spent more time in overall non-school sedentary behaviors due to higher adolescent stranger danger-safety perception of the neighborhood.

Interaction effects were found in both genders, but mainly in girls. Girls who have higher crime-safety perception and parents with higher stranger danger-safety perception of their neighborhood are more encouraged to actively travel to/from school if they have higher walkability index in a 1km buffer from their home. Although, for sedentary behaviors it goes in the opposite direction. Girls with parents who have low safety perceptions are more likely to ride car/bus if there is higher walkability index and more parks and recreation facilities in a 1km buffer, and more likely to spent more time in front of a screen having more parks and recreation facilities around their home. Regarding to boys' sample, parents who have lower crime-safety perception of their neighborhood may reinforce the positive effect of having parks and recreational facilities in a 1km buffer on active transport to/from other places than school in adolescents. Adolescents who have lower crime-safety perception of their neighborhood may reinforce the positive effect of having parks and recreational facilities in a 1km buffer on their leisure time physical activity.

Comparison with previous studies

Physical activity behaviors

Regarding to built environment effects, the physical activity domain that presented more statistically significant results in both genders was transport. We found that higher walkability and more parks and recreation facilities were associated to higher levels of adolescents' active transport. These findings are consistent with previous literature from adults [22–25] and youth population [26]. In general, we can see that the effect of walkability is much higher than the effect of parks and recreational facilities. Conceptually, walkability results were more expected than parks and recreation facilities in terms of active transport. The association of recreation environments with adolescent active transport could be explained by two reasons: (1) recreation environments being common destinations of adolescents [27], and (2) parks and recreation facilities were among the destinations included in the active transport in other places measure definition. Our results are also consistent with other studies that used the same population [6,7]. Carlson 2014 [6] found that adolescents who had greater residential density (one of the walkability variables) around the home and school were more likely to engage in active travel to/from school. Carlson 2015 [7] also found that neighborhood walkability was positively associated with walking and bicycling time measured using a GPS.

Regarding to crime-safety perceptions effects, statistically significant results were found only in girls' sample. Safety perceptions affected all the girls' different physical activity domains (overall, transport, recreation). The statistically significant results were for parents' perceptions, which go in line with results presented in a previous study done with the same study population [9]. Esteban-Cornejo 2016 [9] found that parent crime-safety perception was associated with higher levels of physical activity in parks and in active transport, and stranger danger only in active transport. Although Esteban-Cornejo 2016 [9] did not find a sex interaction with crime/stranger danger perceptions, our stratified results showed a clear gender effect in safety perceptions, being only girls who present main effects statistically significant results. In general, we can see that the effect of parent stranger danger-safety perception is much higher than the effect of parent crime-safety perception, which goes in line with the idea that women tend to feel more physically vulnerable [11], ergo feel more fear of victimization.

Regarding interaction effects, the majority of statistically significant results were found in girls' sample. Girls with high safety perceptions (adolescent crime and parent stranger danger) may reinforce the walkability effect on their active travel behaviors. Those results go in line with the ones found by a study done with the same population [28]. Wang 2017 [28] found that the built environment seems to have stronger facilitating effects on active transport among adolescents who had lower perceived neighborhood barriers, which included being afraid because of crime. The interaction effects found in boys were in the opposite direction as expected. In all statistically significant results of interaction effects in boys, lower safety perceptions reinforced the effect of having parks and recreation facilities in 1km buffer from home of increasing physical activity in transport and recreation domains. Though unexpected, our results go in line with previous literature [10]. Bracy 2014 [10] examined interactions between different perceived safety measures (including crime-safety) and walkability and parks and recreational facilities in explaining physical activity from NQLS and SNQLS studies, which were younger and elder adults from the same settings as TEAN study. They found a negative interaction between walkability and crime-safety in explaining total moderate-to-vigorous physical activity in younger adults. As those results did not support the original hypothesis of being perceived safety a positive modifier of the relation between built environment and physical activity, Bracy 2014 [10] did not interpret the nature of the interaction.

Sedentary behaviors

Sedentary behaviors were mainly associated with crime-safety perceptions in both genders. The sedentary behaviors that showed more statistically significant results were the recreational ones (screen time and TV time). We also found that adolescent girls with higher stranger danger-safety perception of their neighborhood spent more time in non-school sedentary behaviors. This could mean that sedentary behaviors like screen and TV time are reduced, but maybe not others which could be related to reading, doing homework, or spend time outside with friends, etc.

Regarding to interaction effects, statistically significant results were found only in girls' sample. We found that those girls who have parents with low safety perception of their neighborhood (crime and stranger danger) tend to ride more a car/bus and spent more time in front of a screen if they have high walkability index and more parks and recreation facilities. There is the idea that increasing walkability and street lighting, increase the number of pedestrians in the street, then increase surveillance. Anyhow, social composition can be more influential to vandalism levels than surveillance [11]. It has been suggested that walkable and accessible streets can provide increased opportunities for crime, particularly if they are located in low density suburbs, where 'eyes on the street' are reduced [29]. Those reasoning could explain why we see that the population with parents with high safety perception have the expected effect from the built environment measures (a decrease of the sedentary behaviors), but those with low safety perception have the opposite effect, having an increase of the sedentary behaviors with higher levels of the built environment measures.

Limitations and strengths

Our study had some limitations. First, the parents of our study population were highly educated, being not representative of general population. Second, most of the outcome measures were self-reported, which may be imprecise and can be prone to recall bias. Finally, we cannot infer causality due to the cross-sectional design.

This study had several strengths too. First, participants were recruited from two regions of the United States that differed in demographic composition, climate, geography, and era of development. This made the results generalized across the two regions. Second, the exclusion criteria were designed to maximize environmental variability and help maximize internal validity while eliminating factors that might interfere with the ability to test our hypotheses. Third, we used objective measures to assess built environment (GIS), and physical activity and sedentary behaviors (accelerometers). Fourth, we had a good conceptualization and measurement of safety, using the validated NEWS-Y scale. Finally, neighborhood SES could influence perceived crime. In our study this variable was taken into account during recruitment, ensuring we have got population from different neighborhood SES.

Conclusions

Our results indicated that perceived crime and built environments may work together to explain adolescents' physical activity. Our findings provided support for the ecological principle of interactions cross-levels of influence [4]. The most conclusive interactions were the ones referring to transport behaviors (active and sedentary) in girls sample. Interaction effects in boys sample were not clear.

Our results may contribute to better understanding of the effects of perceived crime in the association of neighborhood built environment use for physical activity in adolescents. The results should be considered by decision makers to define better policies combining urban planning transformations with crime reduction interventions in neighborhoods.

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Declaration of interests

None.

Tables

Table 1. Main characteristics of the population

Variables	All (n=928) mean(SD)/n(%)	Adolescents' gender: Boys (n=460) mean(SD)/n(%)	Girls (n=468) mean(SD)/n(%)	p-value**
Outcomes				
Physical activity behaviors				
Non-school Moderate-to-Vigorous Physical Activity (min/day - accel)*	17.07 (15.61)	20.63 (17.82)	14.25 (12.48)	<0.001
Active transport to/from school (yes)	336 (36.2%)	176 (38.3%)	160 (34.2%)	0.395
Active Transport in other places (scale 0-5)*	1.11 (1.33)	1.25 (1.46)	1 (1.22)	<0.001
Total Active Transport (z-score scale)*	-0.32 (2.14)	-0.14 (2.29)	-0.56 (1.99)	<0.001
Leisure Time Physical Activity in the neighborhood (scale 0-5)*	1.4 (2)	1.8 (2)	1 (1.6)	<0.001
Leisure Time Physical Activity in other places (scale 0-5)*	1.2 (1)	1.27 (1.07)	1.07 (0.93)	<0.001
Sedentary behaviors				
Non-school sedentary time (min/day - accel)	496.12 (117.91)	493.47 (116.88)	498.77 (118.99)	0.448
Riding car, bus (min/day)	48.68 (44.36)	44.84 (43.13)	52.45 (45.27)	0.001
Screen time (min/day)*	180 (210)	195 (210)	150 (195)	<0.001
TV time (min/day)	85.74 (73.82)	92.12 (74.2)	79.46 (72.99)	0.003
Exposures				
Walkability Index (scale in 1 km buffer - GIS)*	-0.53 (3.89)	-0.64 (4)	-0.36 (3.86)	0.146
Parks and Recreation Facilities (count in 1 km buffer - GIS)*	3 (5)	3 (4.5)	3 (5)	0.300
Moderators				
Parent crime-safety perception (scale 1-4)*	3 (1)	3 (1)	3 (1)	0.111
Adolescent crime-safety perception (scale 1-4)*	3 (1)	4 (1)	3 (1)	0.007
Parent stranger danger-safety perception (scale 1-4)*	3 (1)	3.25 (1)	3 (1)	<0.001
Adolescent stranger danger-safety perception (scale 1-4)*	3.5 (1)	3.88 (0.75)	3.5 (1.25)	<0.001
Adolescents' characteristics				
Age*	14 (2)	14 (2)	14 (2)	0.168
Ethnicity (White-Non Hispanic)	611 (65.8%)	302 (65.7%)	309 (66%)	0.162
BMI*	0.47 (1.26)	0.54 (1.42)	0.42 (1.14)	0.156
Obese	106 (11.4%)	64 (13.9%)	42 (9%)	0.057
Having driving license	54 (5.8%)	27 (5.9%)	27 (5.8%)	0.911
Having a job	287 (30.9%)	131 (28.5%)	156 (33.3%)	0.278
Home schooled	39 (4.2%)	19 (4.1%)	20 (4.3%)	0.914
Household characteristics				
Children at household*	2 (1)	2 (1)	2 (2)	0.655
Adults at household*	2 (1)	2 (1)	2 (0)	0.071
Vehicle per driving license*	1 (0.25)	1 (0)	1 (0.33)	0.165
Parent marital status (married/live with partner)	774 (83.4%)	391 (85%)	383 (81.8%)	0.367
Parent college degree or more	695 (74.9%)	340 (73.9%)	355 (75.9%)	0.528
Household income (>$100,000)	399 (43%)	192 (41.7%)	207 (44.2%)	0.743
Accelerometer characteristics				
Accelerometer wearing time (hours/day)	6.48 (1.17)	6.59 (1.15)	6.38 (1.18)	0.003
Accelerometer models				0.686
7164	791 (85.2%)	397 (86.3%)	394 (84.2%)	
GT1M	69 (7.4%)	34 (7.4%)	35 (7.5%)	
GT3X	27 (2.9%)	12 (2.6%)	15 (3.2%)	

*median(IQR); **Chi square test, U Mann Whitney test. Missing data: Non-school Moderate-to-Vigorous Physical Activity [48 (5.17%)]; Active transport to/from school [11 (1.19%)]; Active Transport in other places [2 (0.22%)]; Total Active Transport [2 (0.22%)]; Leisure Time Physical Activity in the neighborhood [2 (0.22%)]; Leisure Time Physical Activity in other places [2 (0.22%)]; Non-school sedentary time [48 (5.17%)]; Riding car, bus [2 (0.22%)]; Screen time [2 (0.22%)]; TV time [2 (0.22%)]; Parent crime-safety perception [2 (0.22%)]; Parent stranger danger-safety perception [2 (0.22%)]; Ethnicity [7 (0.75%)]; BMI [5 (0.54%)]; Obese [5 (0.54%)]; Adolescent Having driving license [5 (0.54%)]; Adolescent Having a job [2 (0.22%)]; Children at household [4 (0.43%)]; Adults at household [4 (0.43%)]; Vehicle per driving license [8 (0.86%)]; Parent marital status [6 (0.65%)]; Parent college degree or more [6 (0.65%)]; Household income [41 (4.42%)]; Accelerometer models [41 (4.42%)]; accelerometer wearing time [48 (5.17%)].

Table 2. Regression models assessing interaction effects of built environment and perceived crime-safety measures to physical activity behaviors in boys sample.

	Non-school Moderate to Vigorous Physical Activity (log;accel)[a]	Active Transport to/from school[b]	Active Transport in other places[a]	Total Active Transport[a]	Leisure Time Physical Activity in the neighborhood[a]	Leisure Time Physical Activity in other places[a]
Boys sample	**coef (CI 95%)**	**OR (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**
Walkability Index (1 km buffer)						
Model 1						
Walkability Index	1.01 (0.99, 1.04)	1.18 (1.08, 1.28)**	0.06 (0.03, 0.10)**	0.13 (0.07, 0.19)**	0.00 (-0.05, 0.05)	0.02 (-0.01, 0.05)
Parent crime-safety perception	1.02 (0.95, 1.10)	0.97 (0.76, 1.24)	0.02 (-0.07, 0.12)	-0.02 (-0.19, 0.16)	-0.03 (-0.17, 0.11)	0.03 (-0.06, 0.11)
Walkability Index#Parent crime-safety perception	1.00 (0.98, 1.02)	1.05 (0.97, 1.13)	-0.01 (-0.04, 0.02)	-0.02 (-0.08, 0.03)	0.01 (-0.04, 0.05)	0.01 (-0.02, 0.03)
Model 2						
Walkability Index (1 km buffer)	1.01 (0.99, 1.03)	1.17 (1.08, 1.27)**	0.06 (0.03, 0.09)**	0.13 (0.07, 0.19)**	0.00 (-0.04, 0.05)	0.02 (-0.01, 0.04)
Adolescent crime-safety perception	0.99 (0.92, 1.06)	1.01 (0.78, 1.29)	-0.05 (-0.16, 0.05)	-0.06 (-0.24, 0.12)	0.07 (-0.07, 0.22)	0.02 (-0.07, 0.10)
Walkability Index#Adolescent crime-safety perception	1.00 (0.97, 1.02)	1.00 (0.92, 1.09)	-0.01 (-0.05, 0.02)	-0.04 (-0.10, 0.02)	-0.02 (-0.07, 0.03)	-0.01 (-0.04, 0.02)
Model 3						
Walkability Index (1 km buffer)	1.01 (0.99, 1.04)	1.17 (1.08, 1.27)**	0.07 (0.03, 0.10)**	0.14 (0.08, 0.20)**	0.00 (-0.05, 0.05)	0.02 (-0.01, 0.04)
Parent stranger danger-safety perception	1.05 (0.96, 1.14)	1.11 (0.83, 1.50)	0.09 (-0.03, 0.21)	0.16 (-0.05, 0.38)	0.07 (-0.10, 0.24)	0.06 (-0.05, 0.16)
Walkability Index#Parent stranger danger-safety perception	1.01 (0.99, 1.04)	1.01 (0.92, 1.11)	0.03 (-0.01, 0.06)	0.01 (-0.06, 0.08)	0.02 (-0.03, 0.08)	0.02 (-0.02, 0.05)
Model 4						
Walkability Index (1 km buffer)	1.01 (0.99, 1.03)	1.17 (1.07, 1.27)**	0.06 (0.03, 0.10)**	0.13 (0.07, 0.20)**	0.00 (-0.04, 0.05)	0.02 (-0.01, 0.04)
Adolescent stranger danger-safety perception	1.01 (0.91, 1.11)	0.88 (0.62, 1.24)	0.02 (-0.12, 0.16)	-0.08 (-0.33, 0.16)	0.19 (-0.01, 0.38)	0.06 (-0.06, 0.18)
Walkability Index#Adolescent stranger danger-safety perception	0.99 (0.96, 1.03)	1.04 (0.92, 1.18)	-0.02 (-0.07, 0.03)	-0.00 (-0.09, 0.09)	-0.01 (-0.08, 0.07)	-0.02 (-0.06, 0.03)
Parks and Recreation Facilities (1 km buffer)						
Model 1						
Parks and Recreation Facilities	1.01 (0.99, 1.02)	1.08 (1.03, 1.13)**	0.04 (0.02, 0.05)**	0.08 (0.04, 0.11)**	0.01 (-0.02, 0.03)	0.02 (0.00, 0.04)**
Parent crime-safety perception	1.03 (0.96, 1.10)	0.95 (0.74, 1.22)	0.02 (-0.08, 0.12)	-0.02 (-0.20, 0.15)	-0.01 (-0.15, 0.13)	0.04 (-0.04, 0.12)
Parks and Recreation Facilities#Parent crime-safety perception	0.99 (0.98, 1.01)	1.02 (0.97, 1.07)	-0.02 (-0.04, -0.00)**	-0.02 (-0.06, 0.01)	-0.02 (-0.05, 0.00)	-0.01 (-0.02, 0.01)
Model 2						
Parks and Recreation Facilities	1.01 (0.99, 1.02)	1.08 (1.03, 1.13)**	0.04 (0.02, 0.06)**	0.08 (0.05, 0.11)**	0.01 (-0.01, 0.04)	0.02 (0.01, 0.04)**
Adolescent crime-safety perception	0.99 (0.92, 1.06)	0.94 (0.73, 1.20)	-0.07 (-0.17, 0.03)	-0.11 (-0.29, 0.07)	0.08 (-0.06, 0.22)	0.02 (-0.07, 0.10)
Parks and Recreation Facilities#Adolescent crime-safety perception	0.99 (0.98, 1.00)	1.02 (0.98, 1.07)	-0.01 (-0.03, 0.01)	-0.01 (-0.04, 0.02)	-0.02 (-0.05, 0.00)*	-0.01 (-0.03, 0.00)*
Model 3						
Parks and Recreation Facilities	1.01 (0.99, 1.02)	1.08 (1.03, 1.13)**	0.04 (0.02, 0.06)**	0.08 (0.05, 0.11)**	0.01 (-0.01, 0.04)	0.02 (0.00, 0.03)**
Parent stranger danger-safety perception	1.05 (0.96, 1.14)	1.09 (0.81, 1.47)	0.09 (-0.03, 0.21)	0.14 (-0.07, 0.36)	0.07 (-0.10, 0.24)	0.05 (-0.05, 0.16)
Parks and Recreation Facilities#Parent stranger danger-safety perception	1.00 (0.98, 1.02)	1.01 (0.94, 1.07)	-0.00 (-0.03, 0.02)	0.00 (-0.05, 0.05)	0.00 (-0.03, 0.04)	0.00 (-0.02, 0.02)
Model 4						
Parks and Recreation Facilities	1.01 (0.99, 1.02)	1.08 (1.03, 1.13)**	0.04 (0.02, 0.06)**	0.08 (0.05, 0.11)**	0.01 (-0.01, 0.04)	0.02 (0.01, 0.04)**
Adolescent stranger danger-safety perception	1.00 (0.91, 1.10)	0.87 (0.62, 1.23)	-0.00 (-0.13, 0.13)	-0.10 (-0.34, 0.14)	0.19 (-0.01, 0.38)	0.05 (-0.07, 0.17)
Parks and Recreation Facilities#Adolescent stranger danger-safety perception	0.99 (0.97, 1.01)	0.99 (0.92, 1.07)	-0.02 (-0.05, 0.01)	-0.02 (-0.07, 0.03)	-0.03 (-0.07, 0.01)	-0.01 (-0.03, 0.02)

[a]Mixed-effects linear regression models. [b]Mixed-effects logistic regression models. *p-value<0.10, only for interactions. **p-value<0.05. All models were adjusted by site, adolescent age, adolescent gender, adolescent ethnicity, adolescent working status, adolescent driving license, parent educational level, parent marital status, adults at household, vehicle per driving license at household. Non-school Moderate-to-vigorous physical activity models were also adjusted by accelerometer model, accelerometer wearing time. Sample sizes: Non-school Moderate-to-vigorous physical activity (n=437), Active Transport to/from school (n=452); Active Transport in other places (n=457), Total Active Transport (n=457), Leisure Time Physical Activity in the neighborhood (n=457), Leisure Time Physical Activity in other places (n=457).

Table 3. Regression models assessing interaction effects of built environment and perceived crime-safety measures to physical activity behaviors in girls sample.

	Non-school Moderate to Vigorous Physical Activity (log;accel)[a]	Active Transport to/from school[b]	Active Transport in other places[a]	Total Active Transport[a]	Leisure Time Physical Activity in the neighborhood[a]	Leisure Time Physical Activity in other places[a]
Girls sample	**coef (CI 95%)**	**OR (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**
Walkability Index (1 km buffer)						
Model 1						
Walkability Index	1.04 (1.02, 1.06)**	1.11 (1.02, 1.20)**	0.09 (0.07, 0.12)**	0.14 (0.10, 0.19)**	0.00 (-0.04, 0.04)	0.02 (-0.00, 0.04)
Parent crime-safety perception	1.1 (1.02, 1.18)**	1.24 (0.95, 1.63)	0.12 (0.04, 0.20)**	0.21 (0.07, 0.35)**	0.11 (-0.01, 0.23)	0.11 (0.04, 0.19)**
Walkability Index#Parent crime-safety perception	1.00 (0.98, 1.02)	1.07 (0.98, 1.16)	-0.01 (-0.03, 0.02)	0.01 (-0.04, 0.06)	0.01 (-0.03, 0.05)	0.00 (-0.02, 0.03)
Model 2						
Walkability Index (1 km buffer)	1.04 (1.01, 1.06)**	1.10 (1.02, 1.20)**	0.09 (0.07, 0.12)**	0.14 (0.10, 0.18)**	0.00 (-0.04, 0.04)	0.02 (-0.00, 0.04)
Adolescent crime-safety perception	1.02 (0.95, 1.09)	0.86 (0.68, 1.09)	0.02 (-0.05, 0.10)	-0.02 (-0.15, 0.12)	-0.00 (-0.12, 0.12)	0.05 (-0.02, 0.12)
Walkability Index#Adolescent crime-safety perception	1.00 (0.97, 1.02)	1.09 (1.00, 1.19)*	0.01 (-0.02, 0.03)	0.02 (-0.02, 0.07)	0.02 (-0.02, 0.06)	0.01 (-0.02, 0.03)
Model 3						
Walkability Index (1 km buffer)	1.03 (1.01, 1.06)**	1.10 (1.01, 1.19)**	0.09 (0.07, 0.11)**	0.14 (0.09, 0.18)**	-0.00 (-0.04, 0.03)	0.02 (-0.01, 0.04)
Parent stranger danger-safety perception	1.11 (1.02, 1.2)**	0.79 (0.58, 1.09)	0.12 (0.02, 0.22)**	0.04 (-0.14, 0.21)	0.12 (-0.03, 0.27)	0.08 (-0.01, 0.17)
Walkability Index#Parent stranger danger-safety perception	1.01 (0.98, 1.04)	1.12 (1.00, 1.26)*	-0.01 (-0.04, 0.03)	0.02 (-0.04, 0.08)	0.02 (-0.03, 0.08)	0.02 (-0.01, 0.05)
Model 4						
Walkability Index (1 km buffer)	1.03 (1.01, 1.06)**	1.10 (1.02, 1.19)**	0.09 (0.07, 0.12)**	0.14 (0.10, 0.18)**	-0.00 (-0.04, 0.04)	0.02 (-0.01, 0.04)
Adolescent stranger danger-safety perception	0.97 (0.9, 1.05)	0.93 (0.70, 1.23)	0.07 (-0.03, 0.16)	0.02 (-0.14, 0.18)	-0.00 (-0.14, 0.14)	0.03 (-0.06, 0.11)
Walkability Index#Adolescent stranger danger-safety perception	0.99 (0.97, 1.02)	1.06 (0.96, 1.16)	0.00 (-0.03, 0.03)	0.02 (-0.04, 0.07)	0.02 (-0.03, 0.07)	0.00 (-0.03, 0.03)
Parks and Recreation Facilities (1 km buffer)						
Model 1						
Parks and Recreation Facilities	1.02 (1.01, 1.03)**	1.04 (1.00, 1.08)	0.04 (0.03, 0.05)**	0.06 (0.04, 0.08)**	-0.01 (-0.02, 0.01)	0.01 (-0.00, 0.02)
Parent crime-safety perception	1.09 (1.02, 1.17)**	1.23 (0.94, 1.62)	0.09 (0.01, 0.17)**	0.17 (0.03, 0.32)**	0.10 (-0.02, 0.23)	0.11 (0.03, 0.18)**
Parks and Recreation Facilities#Parent crime-safety perception	1.01 (0.99, 1.02)	1.02 (0.97, 1.07)	0.00 (-0.01, 0.02)	0.01 (-0.02, 0.04)	-0.01 (-0.03, 0.01)	-0.01 (-0.02, 0.01)
Model 2						
Parks and Recreation Facilities	1.02 (1.01, 1.03)**	1.04 (1.00, 1.08)	0.04 (0.03, 0.05)**	0.06 (0.04, 0.08)**	-0.01 (-0.03, 0.01)	0.01 (-0.00, 0.02)
Adolescent crime-safety perception	1.01 (0.94, 1.08)	0.84 (0.67, 1.07)	0.00 (-0.08, 0.08)	-0.05 (-0.19, 0.09)	-0.01 (-0.13, 0.11)	0.04 (-0.03, 0.11)
Parks and Recreation Facilities#Adolescent crime-safety perception	1.00 (0.99, 1.01)	1.02 (0.98, 1.06)	0.01 (-0.01, 0.02)	0.01 (-0.01, 0.04)	-0.01 (-0.03, 0.01)	-0.00 (-0.01, 0.01)
Model 3						
Parks and Recreation Facilities	1.01 (1.00, 1.03)**	1.03 (0.99, 1.08)	0.04 (0.03, 0.05)**	0.06 (0.04, 0.08)**	-0.01 (-0.03, 0.01)	0.01 (-0.00, 0.02)
Parent stranger danger-safety perception	1.10 (1.01, 1.20)**	0.81 (0.6, 1.11)	0.11 (0.00, 0.21)**	0.01 (-0.17, 0.19)	0.12 (-0.03, 0.28)	0.08 (-0.01, 0.17)
Parks and Recreation Facilities#Parent stranger danger-safety perception	1.00 (0.99, 1.02)	1.03 (0.97, 1.10)	0.00 (-0.02, 0.02)	-0.01 (-0.04, 0.03)	0.00 (-0.03, 0.03)	-0.00 (-0.02, 0.02)
Model 4						
Parks and Recreation Facilities	1.02 (1.01, 1.03)**	1.04 (1.00, 1.08)	0.04 (0.03, 0.05)**	0.06 (0.04, 0.08)**	-0.00 (-0.02, 0.01)	0.01 (-0.00, 0.02)
Adolescent stranger danger-safety perception	0.97 (0.90, 1.05)	0.93 (0.70, 1.23)	0.05 (-0.04, 0.15)	0.00 (-0.16, 0.16)	0.00 (-0.14, 0.14)	0.02 (-0.06, 0.11)
Parks and Recreation Facilities#Adolescent stranger danger-safety perception	0.99 (0.98, 1.01)	1.01 (0.96, 1.06)	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.04)	0.00 (-0.02, 0.03)	-0.00 (-0.02, 0.01)

[a]Mixed-effects linear regression models. [b]Mixed-effects logistic regression models. *p-value<0.10, only for interactions. **p-value<0.05. All models were adjusted by site, adolescent age, adolescent gender, adolescent ethnicity, adolescent working status, adolescent driving license, parent educational level, parent marital status, adults at household, vehicle per driving license at household. Non-school moderate-to-vigorous physical activity models were also adjusted by accelerometer model, accelerometer wearing time. Sample sizes: Non-school moderate-to-vigorous physical activity (n=432), Active Transport to/from school (n=451); Active Transport in other places (n=455), Total Active Transport (n=455), Leisure Time Physical Activity in the neighborhood (n=455), Leisure Time Physical Activity in other places (n=455).

Table 4. Regression models assessing interaction effects of built environment and perceived crime-safety measures to sedentary behaviors in boys sample.

	Non-school sedentary time (accel)	Riding car, bus	Screen time	TV time
Boys sample	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**
Walkability Index (1 km buffer)				
Model 1				
Walkability Index	1.44 (-1.39, 4.28)	-0.55 (-2.11, 1.00)	1.88 (-3.64, 7.41)	-1.60 (-4.20, 1.01)
Parent crime-safety perception	1.32 (-6.72, 9.36)	0.67 (-4.00, 5.33)	-6.42 (-22.97, 10.13)	-4.16 (-11.84, 3.52)
Walkability Index#Parent crime-safety perception	0.54 (-2.00, 3.08)	0.32 (-1.15, 1.79)	2.55 (-2.66, 7.76)	0.93 (-1.50, 3.35)
Model 2				
Walkability Index (1 km buffer)	1.44 (-1.39, 4.27)	-0.48 (-2.05, 1.08)	2.65 (-2.91, 8.22)	-1.43 (-4.04, 1.18)
Adolescent crime-safety perception	2.55 (-5.70, 10.80)	2.87 (-1.91, 7.65)	11.96 (-5.01, 28.94)	1.61 (-6.28, 9.50)
Walkability Index#Adolescent crime-safety perception	-0.12 (-3.07, 2.82)	-0.46 (-2.14, 1.23)	-2.92 (-8.89, 3.04)	-1.20 (-3.98, 1.57)
Model 3				
Walkability Index (1 km buffer)	1.17 (-1.65, 4.00)	-0.72 (-2.24, 0.80)	1.57 (-3.88, 7.03)	-1.60 (-4.18, 0.97)
Parent stranger danger-safety perception	4.07 (-5.75, 13.88)	-0.11 (-5.77, 5.56)	-27.41 (-47.38, -7.43)**	-9.30 (-18.63, 0.03)
Walkability Index#Parent stranger danger-safety perception	-1.31 (-4.53, 1.90)	-1.13 (-2.98, 0.72)	-5.03 (-11.57, 1.50)	-1.27 (-4.33, 1.78)
Model 4				
Walkability Index (1 km buffer)	1.34 (-1.44, 4.12)	-0.64 (-2.16, 0.89)	1.79 (-3.66, 7.24)	-1.61 (-4.17, 0.96)
Adolescent stranger danger-safety perception	2.82 (-8.36, 14.00)	-0.03 (-6.62, 6.55)	-5.52 (-28.92, 17.88)	-5.02 (-15.86, 5.81)
Walkability Index#Adolescent stranger danger-safety perception	1.13 (-2.92, 5.18)	-0.71 (-3.08, 1.66)	-0.23 (-8.64, 8.18)	0.94 (-2.96, 4.83)
Parks and Recreation Facilities (1 km buffer)				
Model 1				
Parks and Recreation Facilities	1.11 (-0.44, 2.66)	-0.07 (-0.91, 0.78)	-0.00 (-3.02, 3.02)	-1.25 (-2.67, 0.16)
Parent crime-safety perception	1.40 (-6.56, 9.37)	1.03 (-3.59, 5.64)	-6.93 (-23.31, 9.46)	-3.88 (-11.47, 3.71)
Parks and Recreation Facilities#Parent crime-safety perception	0.40 (-1.11, 1.91)	0.05 (-0.80, 0.90)	1.41 (-1.60, 4.43)	0.21 (-1.19, 1.60)
Model 2				
Parks and Recreation Facilities	1.04 (-0.48, 2.57)	-0.06 (-0.90, 0.77)	0.03 (-2.99, 3.05)	-1.19 (-2.59, 0.20)
Adolescent crime-safety perception	2.06 (-6.00, 10.12)	3.02 (-1.64, 7.67)	9.89 (-6.69, 26.47)	1.46 (-6.21, 9.14)
Parks and Recreation Facilities#Adolescent crime-safety perception	0.27 (-1.26, 1.80)	-0.22 (-1.11, 0.67)	-0.97 (-4.13, 2.19)	-0.30 (-1.76, 1.17)
Model 3				
Parks and Recreation Facilities	1.00 (-0.55, 2.55)	-0.09 (-0.93, 0.75)	-0.13 (-3.09, 2.83)	-1.21 (-2.60, 0.18)
Parent stranger danger-safety perception	3.58 (-6.23, 13.39)	-0.45 (-6.11, 5.21)	-28.89 (-48.79, -9.00)**	-9.27 (-18.54, -0.01)**
Parks and Recreation Facilities#Parent stranger danger-safety perception	0.08 (-2.09, 2.25)	-0.06 (-1.28, 1.17)	2.19 (-2.12, 6.50)	0.73 (-1.28, 2.74)
Model 4				
Parks and Recreation Facilities	1.03 (-0.49, 2.56)	-0.11 (-0.94, 0.72)	-0.19 (-3.16, 2.78)	-1.25 (-2.63, 0.14)
Adolescent stranger danger-safety perception	3.28 (-7.71, 14.26)	-0.22 (-6.67, 6.24)	-6.12 (-29.03, 16.78)	-4.35 (-14.94, 6.25)
Parks and Recreation Facilities#Adolescent stranger danger-safety perception	0.24 (-2.08, 2.56)	-0.58 (-1.93, 0.76)	-2.76 (-7.53, 2.02)	-1.07 (-3.28, 1.14)

*p-value<0.10, only for interactions. **p-value<0.05. All models were adjusted by site, adolescent age, adolescent gender, adolescent ethnicity, adolescent working status, adolescent driving license, parent educational level, parent marital status, adults at household, vehicle per driving license at household. Non-school sedentary time models were also adjusted by accelerometer model, accelerometer wearing time. Sample sizes: Non-school sedentary time (n=437), Riding car, bus (n=457), Screen time (n=457), TV time (n=457).

Table 5. Regression models assessing interaction effects of built environment and perceived crime-safety measures to physical activity behaviors in girls sample.

	Non-school sedentary time(accel)	Riding car, bus	Screen time	TV time
Girls sample	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**
Walkability Index (1 km buffer)				
Model 1				
Walkability Index	-0.90 (-2.91, 1.10)	0.54 (-1.01, 2.08)	-3.13 (-7.31, 1.04)	-1.91 (-4.10, 0.28)
Parent crime-safety perception	-3.92 (-10.61, 2.76)	-2.11 (-6.89, 2.67)	-6.94 (-20.82, 6.93)	-4.14 (-11.42, 3.14)
Walkability Index#Parent crime-safety perception	0.21 (-2.00, 2.42)	-0.88 (-2.49, 0.72)	-1.01 (-5.66, 3.64)	0.07 (-2.37, 2.51)
Model 2				
Walkability Index (1 km buffer)	-0.64 (-2.64, 1.36)	0.37 (-1.18, 1.92)	-3.03 (-7.24, 1.18)	-1.83 (-4.04, 0.38)
Adolescent crime-safety perception	1.32 (-5.13, 7.76)	-3.58 (-8.14, 0.99)	-3.96 (-17.32, 9.40)	-0.81 (-7.82, 6.21)
Walkability Index#Adolescent crime-safety perception	0.97 (-1.30, 3.24)	-1.29 (-2.91, 0.34)	-0.24 (-5.01, 4.54)	-0.11 (-2.62, 2.39)
Model 3				
Walkability Index (1 km buffer)	-0.73 (-2.71, 1.24)	0.73 (-0.79, 2.25)	-2.84 (-6.98, 1.30)	-1.77 (-3.95, 0.40)
Parent stranger danger-safety perception	-5.47 (-13.72, 2.78)	-3.68 (-9.60, 2.24)	-13.89 (-31.04, 3.26)	-4.62 (-13.64, 4.39)
Walkability Index#Parent stranger danger-safety perception	-1.36 (-4.28, 1.55)	-2.05 (-4.19, 0.10)*	-0.36 (-6.50, 5.78)	-0.36 (-3.59, 2.87)
Model 4				
Walkability Index (1 km buffer)	-0.82 (-2.80, 1.16)	0.57 (-0.98, 2.11)	-2.85 (-7.00, 1.29)	-1.81 (-3.99, 0.36)
Adolescent stranger danger-safety perception	8.04 (0.57, 15.52)**	-2.70 (-8.09, 2.70)	-18.37 (-34.10, -2.64)**	-9.14 (-17.40, -0.88)**
Walkability Index#Adolescent stranger danger-safety perception	-0.42 (-2.94, 2.11)	-0.92 (-2.79, 0.94)	0.05 (-5.29, 5.40)	-0.25 (-3.05, 2.56)
Parks and Recreation Facilities (1 km buffer)				
Model 1				
Parks and Recreation Facilities	-0.37 (-1.35, 0.60)	-0.13 (-0.90, 0.63)	-0.92 (-2.92, 1.08)	-1.08 (-2.12, -0.03)**
Parent crime-safety perception	-3.51 (-10.19, 3.18)	-2.74 (-7.50, 2.03)	-7.44 (-21.23, 6.36)	-3.93 (-11.17, 3.32)
Parks and Recreation Facilities#Parent crime-safety perception	0.27 (-0.97, 1.52)	-0.96 (-1.85, -0.07)**	-3.22 (-5.83, -0.61)**	-0.82 (-2.19, 0.55)
Model 2				
Parks and Recreation Facilities	-0.25 (-1.23, 0.73)	-0.18 (-0.95, 0.60)	-1.06 (-3.09, 0.98)	-1.13 (-2.19, -0.06)**
Adolescent crime-safety perception	1.64 (-4.77, 8.05)	-3.66 (-8.22, 0.91)	-3.54 (-16.84, 9.76)	-0.60 (-7.57, 6.37)
Parks and Recreation Facilities#Adolescent crime-safety perception	0.64 (-0.45, 1.73)	-0.23 (-1.00, 0.55)	-1.22 (-3.51, 1.07)	-0.55 (-1.75, 0.65)
Model 3				
Parks and Recreation Facilities	-0.29 (-1.27, 0.70)	-0.03 (-0.80, 0.75)	-0.52 (-2.57, 1.53)	-0.96 (-2.04, 0.11)
Parent stranger danger-safety perception	-5.66 (-13.95, 2.62)	-4.02 (-10.00, 1.95)	-14.38 (-31.65, 2.89)	-4.38 (-13.44, 4.68)
Parks and Recreation Facilities#Parent stranger danger-safety perception	-0.40 (-2.12, 1.33)	-0.36 (-1.61, 0.89)	-1.62 (-5.25, 2.01)	-0.39 (-2.29, 1.52)
Model 4				
Parks and Recreation Facilities	-0.36 (-1.33, 0.61)	-0.12 (-0.89, 0.64)	-0.74 (-2.73, 1.26)	-1.00 (-2.05, 0.04)
Adolescent stranger danger-safety perception	8.27 (0.79, 15.74)**	-2.72 (-8.13, 2.69)	-18.11 (-33.89, -2.34)**	-8.81 (-17.07, -0.54)**
Parks and Recreation Facilities#Adolescent stranger danger-safety perception	0.67 (-0.63, 1.97)	-0.44 (-1.42, 0.54)	-0.31 (-3.05, 2.43)	-0.36 (-1.79, 1.08)

*p-value<0.10, only for interactions. **p-value<0.05. All models were adjusted by site, adolescent age, adolescent gender, adolescent ethnicity, adolescent working status, adolescent driving license, parent educational level, parent marital status, adults at household, vehicle per driving license at household. Non-school sedentary time models were also adjusted by accelerometer model, accelerometer wearing time. Sample sizes: Non-school sedentary time (n=432), Riding car, bus (n=455), Screen time (n=455), TV time (n=455).

Figures

Figure 1. Plotting Parks and Recreation Facilities × Parent crime-safety perception interaction on active transport to/from other places than school in Boys sample.

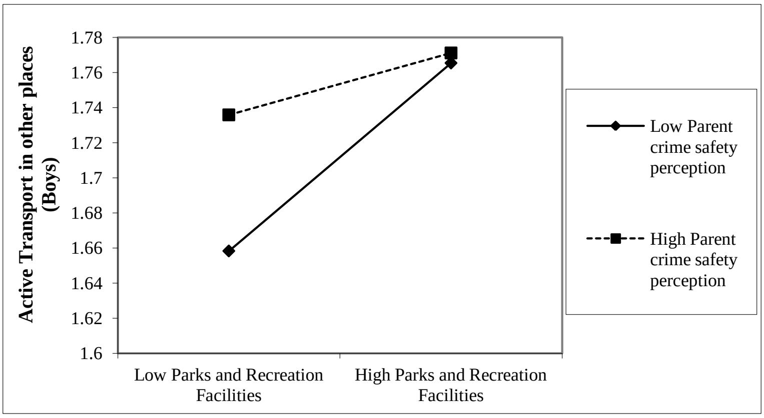


Figure 2. Plotting Parks and Recreation Facilities × Adolescent crime-safety perception interaction on Leisure Time Physical Activity in the neighborhood in Boys sample.

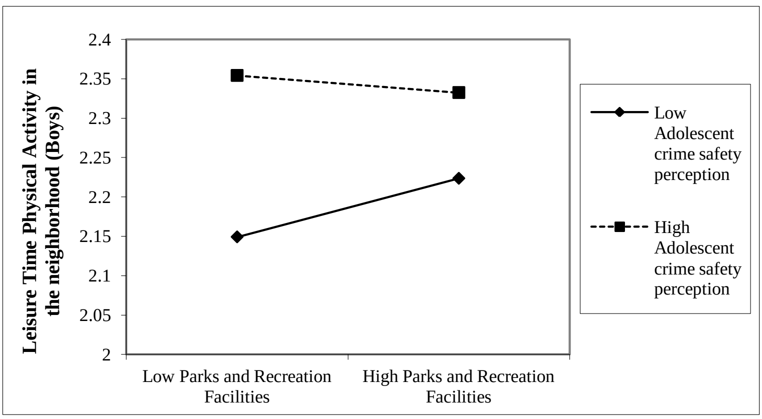


Figure 3. Plotting Parks and Recreation Facilities × Adolescent crime-safety perception interaction on Leisure Time Physical Activity in other places than near participants' home in Boys sample.

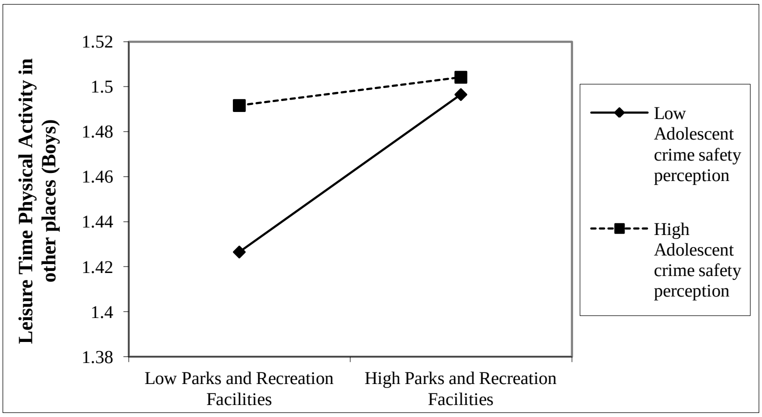


Figure 4. Plotting Walkability Index × Adolescent crime-safety perception interaction on active transport to/from school in Girls sample.

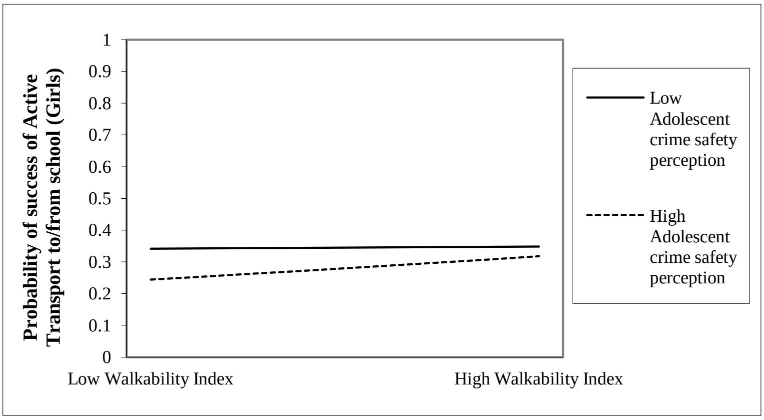


Figure 5. Plotting Walkability Index × Parent stranger danger-safety perception interaction on active transport to/from school in Girls sample.

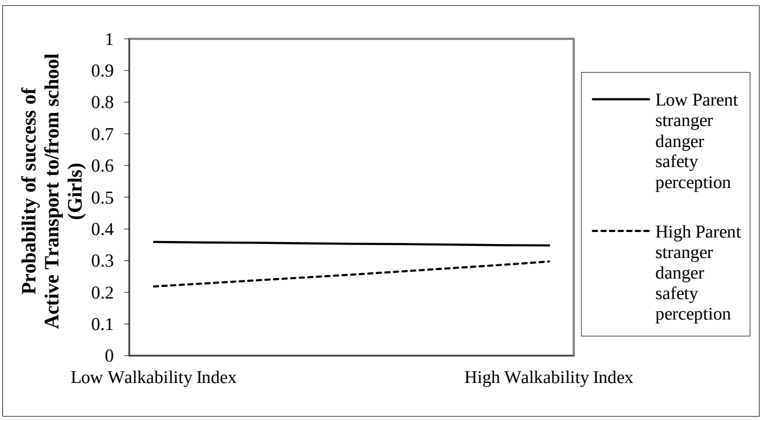


Figure 6. Plotting Walkability Index × Parent stranger danger-safety perception interaction on riding a car, bus, etc., Girls sample.

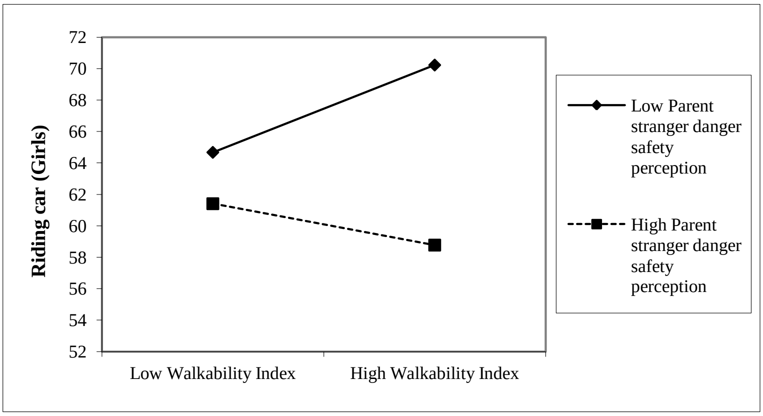


Figure 7. Plotting Parks and Recreation Facilities × Parent crime-safety perception interaction on riding a car, bus, etc., in Girls sample.

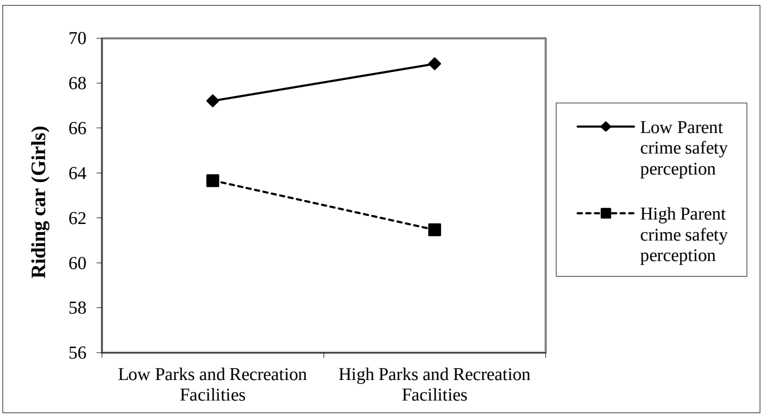
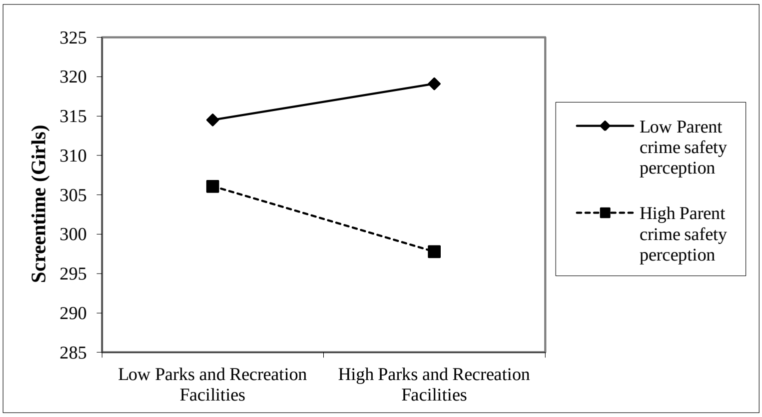


Figure 8. Plotting Parks and Recreation Facilities × Parent crime-safety perception interaction on screen time in Girls sample.



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SUPPLEMENTARY MATERIAL

PAPER I

Supplementary material

Table S1. Single and multiple exposure regression models assessing associations between the built environment/perceived crime-safety measures and physical activity behaviors in boys sample.

	Non-school Moderate to Vigorous Physical Activity (log;accel)[a]	Active Transport to/from school[b]	Active Transport in other places[a]	Total Active Transport[a]	Leisure Time Physical Activity in the neighborhood[a]	Leisure Time Physical Activity in other places[a]
Boys sample	**coef (CI 95%)**	**OR (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**
Single Exposure Models						
Exposures						
Walkability Index	1.01 (0.99, 1.03)	1.17 (1.08, 1.27)**	0.06 (0.03, 0.10)**	0.14 (0.07, 0.20)**	0.00 (-0.05, 0.05)	0.01 (-0.01, 0.04)
Parks and Recreation Facilities	1.01 (0.99, 1.02)	1.08 (1.03, 1.13)**	0.04 (0.02, 0.06)**	0.08 (0.05, 0.12)**	0.01 (-0.01, 0.04)	0.02 (0.01, 0.04)**
Moderators						
Parent crime safety perception	1.02 (0.95, 1.09)	0.92 (0.72, 1.17)	-0.01 (-0.11, 0.09)	-0.08 (-0.26, 0.10)	-0.03 (-0.17, 0.11)	0.02 (-0.06, 0.11)
Adolescent crime safety perception	0.98 (0.91, 1.05)	0.92 (0.72, 1.18)	-0.10 (-0.19, 0.00)	-0.14 (-0.32, 0.04)	0.06 (-0.08, 0.20)	0.00 (-0.08, 0.08)
Parent stranger danger safety perception	1.05 (0.97, 1.14)	1.11 (0.82, 1.51)	0.10 (-0.02, 0.22)	0.16 (-0.06, 0.38)	0.08 (-0.09, 0.25)	0.06 (-0.04, 0.16)
Adolescent stranger danger safety perception	1.00 (0.91, 1.10)	0.85 (0.6, 1.21)	-0.01 (-0.15, 0.12)	-0.12 (-0.37, 0.12)	0.18 (-0.01, 0.38)	0.05 (-0.07, 0.16)
Multiple Exposures Models						
Walkability Index (1 km buffer)						
Model 1						
Walkability Index	1.01 (0.99, 1.04)	1.17 (1.08, 1.27)**	0.06 (0.03, 0.10)**	0.14 (0.07, 0.20)**	0.00 (-0.05, 0.05)	0.02 (-0.01, 0.04)
Parent crime safety perception	1.02 (0.95, 1.10)	0.99 (0.78, 1.27)	0.02 (-0.08, 0.12)	-0.02 (-0.20, 0.15)	-0.03 (-0.17, 0.11)	0.03 (-0.05, 0.11)
Model 2						
Walkability Index (1 km buffer)	1.01 (0.99, 1.03)	1.17 (1.08, 1.27)**	0.06 (0.03, 0.09)**	0.13 (0.07, 0.20)**	0.00 (-0.04, 0.05)	0.01 (-0.01, 0.04)
Adolescent crime safety perception	0.98 (0.92, 1.06)	1.01 (0.79, 1.28)	-0.06 (-0.16, 0.04)	-0.08 (-0.26, 0.10)	0.06 (-0.08, 0.20)	0.01 (-0.08, 0.09)
Model 3						
Walkability Index (1 km buffer)	1.01 (0.99, 1.03)	1.17 (1.08, 1.27)**	0.06 (0.03, 0.10)**	0.14 (0.07, 0.20)**	0.00 (-0.05, 0.05)	0.01 (-0.01, 0.04)
Parent stranger danger safety perception	1.05 (0.97, 1.14)	1.12 (0.83, 1.5)	0.10 (-0.02, 0.22)	0.16 (-0.05, 0.38)	0.08 (-0.09, 0.25)	0.06 (-0.04, 0.16)
Model 4						
Walkability Index (1 km buffer)	1.01 (0.99, 1.03)	1.17 (1.07, 1.27)**	0.06 (0.03, 0.10)**	0.13 (0.07, 0.20)**	0.00 (-0.04, 0.05)	0.02 (-0.01, 0.04)
Adolescent stranger danger safety perception	1.00 (0.91, 1.10)	0.90 (0.64, 1.26)	0.01 (-0.13, 0.14)	-0.09 (-0.33, 0.16)	0.18 (-0.01, 0.38)	0.05 (-0.07, 0.17)
Parks and Recreation Facilities (1 km buffer)						
Model 1						
Parks and Recreation Facilities	1.01 (1.00, 1.02)	1.08 (1.03, 1.13)**	0.04 (0.02, 0.06)**	0.08 (0.05, 0.11)**	0.01 (-0.01, 0.04)	0.02 (0.01, 0.04)**
Parent crime safety perception	1.02 (0.96, 1.10)	0.96 (0.75, 1.22)	0.01 (-0.08, 0.11)	-0.03 (-0.21, 0.14)	-0.02 (-0.16, 0.12)	0.04 (-0.05, 0.12)
Model 2						
Parks and Recreation Facilities	1.01 (0.99, 1.02)	1.08 (1.03, 1.13)**	0.04 (0.02, 0.06)**	0.08 (0.05, 0.11)**	0.01 (-0.01, 0.04)	0.02 (0.01, 0.04)**
Adolescent crime safety perception	0.98 (0.92, 1.05)	0.95 (0.74, 1.21)	-0.08 (-0.18, 0.02)	-0.12 (-0.29, 0.06)	0.07 (-0.07, 0.20)	0.01 (-0.07, 0.09)
Model 3						
Parks and Recreation Facilities	1.01 (0.99, 1.02)	1.08 (1.03, 1.13)**	0.04 (0.02, 0.06)**	0.08 (0.05, 0.11)**	0.01 (-0.01, 0.04)	0.02 (0.01, 0.03)**
Parent stranger danger safety perception	1.05 (0.97, 1.14)	1.09 (0.81, 1.47)	0.09 (-0.03, 0.21)	0.14 (-0.07, 0.36)	0.07 (-0.1, 0.24)	0.05 (-0.05, 0.16)
Model 4						
Parks and Recreation Facilities	1.01 (0.99, 1.02)	1.08 (1.03, 1.13)**	0.04 (0.02, 0.06)**	0.08 (0.05, 0.11)**	0.01 (-0.01, 0.04)	0.02 (0.01, 0.04)**
Adolescent stranger danger safety perception	1.00 (0.91, 1.10)	0.87 (0.62, 1.23)	0.00 (-0.14, 0.13)	-0.10 (-0.34, 0.14)	0.19 (-0.01, 0.38)	0.05 (-0.07, 0.17)

[a]Mixed-effects linear regression models. [b]Mixed-effects logistic regression models. **p-value<0.05. All models were adjusted by site, adolescent age, adolescent gender, adolescent ethnicity, adolescent working status, adolescent driving license, parent educational level, parent marital status, adults at household, vehicle per driving license at household. Non-school Moderate-to-vigorous physical activity models were also adjusted by accelerometer model, accelerometer wearing time. Sample sizes: Non-school Moderate-to-vigorous physical activity (n=437), Active Transport to/from school (n=452); Active Transport in other places (n=457), Total Active Transport (n=457), Leisure Time Physical Activity in the neighborhood (n=457), Leisure Time Physical Activity in other places (n=457).

Table S2. Single and multiple exposure regression models assessing associations between the built environment/perceived crime-safety measures and physical activity behaviors in girls sample.

	Non-school Moderate to Vigorous Physical Activity (log;accel)[a]	Active Transport to/from school[b]	Active Transport in other places [a]	Total Active Transport [a]	Leisure Time Physical Activity in the neighborhood [a]	Leisure Time Physical Activity in other places [a]
Girls sample	**coef (CI 95%)**	**OR (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**
Single Exposure Models						
Exposures						
Walkability Index	1.03 (1.01, 1.06)**	1.09 (1.01, 1.18)**	0.09 (0.07, 0.11)**	0.14 (0.10, 0.18)**	0.00 (-0.04, 0.04)	0.02 (-0.01, 0.04)
Parks and Recreation Facilities	1.02 (1.01, 1.03)**	1.04 (1, 1.08)	0.04 (0.03, 0.05)**	0.06 (0.04, 0.08)**	0.00 (-0.02, 0.01)	0.01 (0.00, 0.02)
Moderators						
Parent crime safety perception	1.08 (1.01, 1.16)**	1.22 (0.93, 1.60)	0.09 (0.00, 0.17)**	0.17 (0.02, 0.32)**	0.11 (-0.01, 0.23)	0.11 (0.04, 0.18)**
Adolescent crime safety perception	1.00 (0.94, 1.07)	0.83 (0.66, 1.06)	-0.01 (-0.09, 0.07)	-0.07 (-0.21, 0.07)	0.00 (-0.12, 0.11)	0.04 (-0.03, 0.11)
Parent stranger danger safety perception	1.11 (1.02, 1.21)**	0.82 (0.60, 1.12)	0.12 (0.02, 0.23)**	0.04 (-0.15, 0.22)	0.12 (-0.03, 0.27)	0.08 (-0.01, 0.17)
Adolescent stranger danger safety perception	0.97 (0.90, 1.05)	0.94 (0.71, 1.24)	0.07 (-0.03, 0.16)	0.02 (-0.15, 0.19)	0.00 (-0.14, 0.14)	0.03 (-0.06, 0.11)
Multiple Exposures Models						
Walkability Index (1 km buffer)						
Model 1						
Walkability Index	1.04 (1.02, 1.06)**	1.10 (1.02, 1.20)**	0.09 (0.07, 0.12)**	0.14 (0.10, 0.19)**	0.00 (-0.04, 0.04)	0.02 (0.00, 0.04)
Parent crime safety perception	1.10 (1.03, 1.18)**	1.26 (0.96, 1.65)	0.12 (0.04, 0.20)**	0.21 (0.07, 0.35)**	0.11 (-0.01, 0.23)	0.11 (0.04, 0.19)**
Model 2						
Walkability Index (1 km buffer)	1.04 (1.01, 1.06)**	1.09 (1.01, 1.18)**	0.09 (0.07, 0.12)**	0.14 (0.09, 0.18)**	0.00 (-0.04, 0.04)	0.02 (0.00, 0.04)
Adolescent crime safety perception	1.02 (0.95, 1.09)	0.86 (0.68, 1.09)	0.02 (-0.06, 0.10)	-0.02 (-0.16, 0.11)	0.00 (-0.12, 0.11)	0.05 (-0.02, 0.12)
Model 3						
Walkability Index (1 km buffer)	1.03 (1.01, 1.06)**	1.10 (1.01, 1.19)**	0.09 (0.07, 0.11)**	0.14 (0.10, 0.18)**	0.00 (-0.04, 0.04)	0.02 (-0.01, 0.04)
Parent stranger danger safety perception	1.11 (1.02, 1.21)**	0.82 (0.60, 1.11)	0.12 (0.02, 0.22)**	0.04 (-0.14, 0.21)	0.12 (-0.03, 0.27)	0.08 (-0.01, 0.17)
Model 4						
Walkability Index (1 km buffer)	1.03 (1.01, 1.06)**	1.09 (1.01, 1.18)**	0.09 (0.07, 0.11)**	0.14 (0.10, 0.18)**	0.00 (-0.04, 0.04)	0.02 (-0.01, 0.04)
Adolescent stranger danger safety perception	0.97 (0.90, 1.05)	0.94 (0.71, 1.24)	0.07 (-0.03, 0.16)	0.02 (-0.14, 0.18)	0.00 (-0.14, 0.14)	0.03 (-0.06, 0.11)
Parks and Recreation Facilities (1 km buffer)						
Model 1						
Parks and Recreation Facilities	1.02 (1.01, 1.03)**	1.04 (1.00, 1.08)	0.04 (0.03, 0.05)**	0.06 (0.04, 0.08)**	-0.01 (-0.02, 0.01)	0.01 (0.00, 0.02)
Parent crime safety perception	1.09 (1.01, 1.16)**	1.23 (0.94, 1.61)	0.09 (0.01, 0.17)**	0.17 (0.03, 0.31)**	0.11 (-0.01, 0.23)	0.11 (0.04, 0.18)**
Model 2						
Parks and Recreation Facilities	1.02 (1.01, 1.03)**	1.03 (1.00, 1.08)	0.04 (0.03, 0.05)**	0.06 (0.04, 0.08)**	-0.01 (-0.02, 0.01)	0.01 (0.00, 0.02)
Adolescent crime safety perception	1.01 (0.94, 1.08)	0.84 (0.66, 1.06)	0.00 (-0.08, 0.08)	-0.06 (-0.19, 0.08)	0.00 (-0.12, 0.11)	0.04 (-0.03, 0.11)
Model 3						
Parks and Recreation Facilities	1.02 (1.01, 1.03)**	1.04 (1.00, 1.08)	0.04 (0.03, 0.05)**	0.06 (0.04, 0.08)**	-0.01 (-0.03, 0.01)	0.01 (0.00, 0.02)
Parent stranger danger safety perception	1.10 (1.01, 1.20)**	0.80 (0.59, 1.09)	0.10 (0.00, 0.21)**	0.01 (-0.17, 0.19)	0.12 (-0.03, 0.28)	0.08 (-0.01, 0.17)
Model 4						
Parks and Recreation Facilities	1.02 (1.01, 1.03)**	1.04 (1.00, 1.08)	0.04 (0.03, 0.05)**	0.06 (0.04, 0.08)**	0.00 (-0.02, 0.01)	0.01 (0.00, 0.02)
Adolescent stranger danger safety perception	0.97 (0.90, 1.05)	0.93 (0.70, 1.23)	0.05 (-0.04, 0.15)	0.00 (-0.16, 0.16)	0.00 (-0.14, 0.14)	0.02 (-0.06, 0.11)

[a]Mixed-effects linear regression models. [b]Mixed-effects logistic regression models. **p-value<0.05. All models were adjusted by site, adolescent age, adolescent gender, adolescent ethnicity, adolescent working status, adolescent driving license, parent educational level, parent marital status, adults at household, vehicle per driving license at household. Non-school Moderate-to-vigorous physical activity models were also adjusted by accelerometer model, accelerometer wearing time. Sample sizes: Non-school Moderate-to-vigorous physical activity (n=437), Active Transport to/from school (n=452); Active Transport in other places (n=457), Total Active Transport (n=457), Leisure Time Physical Activity in the neighborhood (n=457), Leisure Time Physical Activity in other places (n=457).

Table S3. Single and multiple exposure regression models assessing associations between the built environment/perceived crime-safety measures and physical activity behaviors in all sample.

	Non-school Moderate to Vigorous Physical Activity (log;accel)[a]	Active Transport to/from school[b]	Active Transport in other places [a]	Total Active Transport[a]	Leisure Time Physical Activity in the neighborhood [a]	Leisure Time Physical Activity in other places [a]
All sample	**coef (CI 95%)**	**OR (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**
Single Exposure Models						
Exposures						
Walkability Index	1.02 (1.01, 1.04)**	1.13 (1.06, 1.20)**	0.08 (0.06, 0.10)**	0.14 (0.10, 0.17)**	0.00 (-0.03, 0.03)	0.02 (0.00, 0.03)
Parks and Recreation Facilities	1.01 (1.00, 1.02)**	1.05 (1.02, 1.09)**	0.04 (0.03, 0.05)**	0.07 (0.05, 0.09)**	0.00 (-0.01, 0.02)	0.01 (0.00, 0.02)**
Moderators						
Parent crime safety perception	1.06 (1.01, 1.11)**	1.04 (0.87, 1.24)	0.04 (-0.03, 0.10)	0.05 (-0.06, 0.17)	0.04 (-0.05, 0.13)	0.07 (0.01, 0.12)**
Adolescent crime safety perception	0.99 (0.95, 1.04)	0.95 (0.76, 1.17)	-0.05 (-0.12, 0.01)	-0.11 (-0.22, 0.00)	0.03 (-0.06, 0.12)	0.02 (-0.03, 0.07)
Parent stranger danger safety perception	1.08 (1.01, 1.14)**	0.87 (0.73, 1.03)	0.11 (0.03, 0.19)**	0.10 (-0.05, 0.24)	0.10 (-0.01, 0.22)	0.07 (0.00, 0.14)**
Adolescent stranger danger safety perception	0.98 (0.93, 1.05)	0.89 (0.72, 1.10)	0.03 (-0.05, 0.11)	-0.05 (-0.20, 0.09)	0.07 (-0.04, 0.19)	0.03 (-0.04, 0.10)
Multiple Exposures Models						
Walkability Index (1 km buffer)						
Model 1						
Walkability Index	1.03 (1.01, 1.04)**	1.13 (1.07, 1.20)**	0.08 (0.06, 0.10)**	0.14 (0.10, 0.18)**	0.00 (-0.03, 0.03)	0.02 (0.00, 0.04)**
Parent crime safety perception	1.07 (1.01, 1.12)**	1.09 (0.91, 1.30)	0.07 (0.01, 0.14)**	0.09 (-0.02, 0.21)	0.04 (-0.05, 0.13)	0.07 (0.02, 0.13)**
Model 2						
Walkability Index (1 km buffer)	1.02 (1.01, 1.04)**	1.12 (1.06, 1.19)**	0.08 (0.06, 0.10)**	0.13 (0.09, 0.17)**	0.00 (-0.03, 0.03)	0.02 (0.00, 0.03)
Adolescent crime safety perception	1.00 (0.96, 1.05)	0.91 (0.77, 1.08)	-0.02 (-0.08, 0.05)	-0.06 (-0.18, 0.05)	0.03 (-0.06, 0.12)	0.03 (-0.03, 0.08)
Model 3						
Walkability Index (1 km buffer)	1.02 (1.01, 1.04)**	1.13 (1.06, 1.20)**	0.08 (0.06, 0.10)**	0.13 (0.10, 0.17)**	0.00 (-0.03, 0.03)	0.02 (0.00, 0.03)
Parent stranger danger safety perception	1.08 (1.01, 1.14)**	0.94 (0.76, 1.16)	0.11 (0.03, 0.18)**	0.09 (-0.05, 0.23)	0.10 (-0.01, 0.22)	0.07 (0.00, 0.14)**
Model 4						
Walkability Index (1 km buffer)	1.02 (1.01, 1.04)**	1.13 (1.06, 1.20)**	0.08 (0.06, 0.10)**	0.14 (0.10, 0.17)**	0.00 (-0.03, 0.03)	0.02 (0.00, 0.03)
Adolescent stranger danger safety perception	0.99 (0.93, 1.05)	0.90 (0.73, 1.12)	0.05 (-0.03, 0.13)	-0.03 (-0.17, 0.11)	0.07 (-0.04, 0.19)	0.03 (-0.03, 0.10)
Parks and Recreation Facilities (1 km buffer)						
Model 1						
Parks and Recreation Facilities	1.01 (1.00, 1.02)**	1.05 (1.02, 1.09)**	0.04 (0.03, 0.05)**	0.07 (0.05, 0.09)**	0.00 (-0.01, 0.02)	0.01 (0.00, 0.02)**
Parent crime safety perception	1.06 (1.01, 1.11)**	1.06 (0.89, 1.27)	0.05 (-0.01, 0.11)	0.07 (-0.04, 0.18)	0.04 (-0.05, 0.13)	0.07 (0.02, 0.12)**
Model 2						
Parks and Recreation Facilities	1.01 (1.00, 1.02)**	1.05 (1.02, 1.08)**	0.04 (0.03, 0.05)**	0.07 (0.05, 0.09)**	0.00 (-0.01, 0.02)	0.01 (0.00, 0.02)**
Adolescent crime safety perception	1.00 (0.95, 1.05)	0.88 (0.74, 1.04)	-0.04 (-0.10, 0.02)	-0.10 (-0.21, 0.01)	0.03 (-0.06, 0.12)	0.02 (-0.03, 0.08)
Model 3						
Parks and Recreation Facilities	1.01 (1.00, 1.02)**	1.05 (1.02, 1.09)**	0.04 (0.03, 0.05)**	0.07 (0.05, 0.09)**	0.00 (-0.02, 0.01)	0.01 (0.00, 0.02)**
Parent stranger danger safety perception	1.07 (1.01, 1.14)**	0.92 (0.75, 1.15)	0.09 (0.01, 0.17)**	0.07 (-0.07, 0.21)	0.10 (-0.01, 0.22)	0.07 (0.00, 0.13)
Model 4						
Parks and Recreation Facilities	1.01 (1.00, 1.02)**	1.05 (1.02, 1.09)**	0.04 (0.03, 0.05)**	0.07 (0.05, 0.09)**	0.07 (-0.04, 0.19)	0.01 (0.00, 0.02)**
Adolescent stranger danger safety perception	0.99 (0.93, 1.05)	0.88 (0.71, 1.10)	0.04 (-0.04, 0.11)	-0.05 (-0.19, 0.09)	0.00 (-0.01, 0.02)	0.03 (-0.04, 0.10)

[a]Mixed-effects linear regression models. [b]Mixed-effects logistic regression models. **p-value<0.05. All models were adjusted by site, adolescent age, adolescent gender, adolescent ethnicity, adolescent working status, adolescent driving license, parent educational level, parent marital status, adults at household, vehicle per driving license at household. Non-school Moderate-to-vigorous physical activity models were also adjusted by accelerometer model, accelerometer wearing time. Sample sizes: Moderate-to-vigorous physical activity (n=869), Active Transport to/from school (n=903); Active Transport in other places (n=912), Total Active Transport (n=912), Leisure Time Physical Activity in the neighborhood (n=912), Leisure Time Physical Activity in other places (n=912).

Table S4. Single and multiple exposure regression models assessing associations between the built environment/perceived crime-safety measures and sedentary behaviors in boys sample.

	Non-school sedentary time (accel)	Riding car, bus	Screen time	TV time
Boys sample	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**
Single Exposure Models				
Exposures				
Walkability Index	1.28 (-1.50, 4.05)	-0.64 (-2.16, 0.88)	1.87 (-3.55, 7.29)	-1.52 (-4.07, 1.04)
Parks and Recreation Facilities	1.01 (-0.51, 2.53)	-0.10 (-0.92, 0.73)	-0.11 (-3.07, 2.85)	-1.21 (-2.59, 0.17)
Moderators				
Parent crime safety perception	0.91 (-7.00, 8.83)	1.10 (-3.47, 5.66)	-6.21 (-22.43, 10.00)	-3.01 (-10.54, 4.53)
Adolescent crime safety perception	1.74 (-6.26, 9.74)	2.91 (-1.68, 7.51)	8.83 (-7.53, 25.18)	1.77 (-5.84, 9.38)
Parent stranger danger safety perception	3.77 (-6.01, 13.55)	-0.47 (-6.11, 5.17)	-29.28 (-49.11, -9.44)**	-9.79 (-19.05, -0.53)**
Adolescent stranger danger safety perception	2.98 (-8.00, 13.96)	-0.20 (-6.64, 6.25)	-6.18 (-29.05, 16.69)	-4.08 (-14.69, 6.53)
Multiple Exposures Models				
Walkability Index (1 km buffer)				
Model 1				
Walkability Index	1.35 (-1.45, 4.16)	-0.60 (-2.14, 0.94)	1.56 (-3.93, 7.05)	-1.73 (-4.31, 0.86)
Parent crime safety perception	1.47 (-6.53, 9.48)	0.78 (-3.86, 5.41)	-5.46 (-21.92, 10.99)	-3.84 (-11.47, 3.80)
Model 2				
Walkability Index (1 km buffer)	1.44 (-1.38, 4.26)	-0.46 (-2.01, 1.08)	1.84 (-3.51, 7.18)	-1.45 (-4.06, 1.16)
Adolescent crime safety perception	2.50 (-5.64, 10.64)	2.63 (-2.06, 7.32)	-29.30 (-49.14, -9.46)**	0.99 (-6.77, 8.75)
Model 3				
Walkability Index (1 km buffer)	1.31 (-1.50, 4.11)	-0.64 (-2.16, 0.88)	2.57 (-2.97, 8.11)	-1.53 (-4.06, 1.00)
Parent stranger danger safety perception	3.78 (-6.00, 13.56)	-0.49 (-6.13, 5.15)	10.29 (-6.4, 26.97)	-9.78 (-19.03, -0.52)**
Model 4				
Walkability Index (1 km buffer)	1.34 (-1.44, 4.12)	-0.65 (-2.17, 0.87)	1.77 (-3.66, 7.20)	-1.59 (-4.15, 0.97)
Adolescent stranger danger safety perception	3.36 (-7.64, 14.37)	-0.40 (-6.87, 6.06)	-5.66 (-28.6, 17.29)	-4.53 (-15.16, 6.10)
Parks and Recreation Facilities (1 km buffer)				
Model 1				
Parks and Recreation Facilities	1.04 (-0.49, 2.57)	-0.07 (-0.91, 0.76)	-0.24 (-3.22, 2.74)	-1.29 (-2.68, 0.10)
Parent crime safety perception	1.48 (-6.48, 9.43)	1.05 (-3.55, 5.65)	-6.35 (-22.69, 9.99)	-3.80 (-11.36, 3.77)
Model 2				
Parks and Recreation Facilities	1.05 (-0.48, 2.57)	-0.05 (-0.88, 0.77)	0.10 (-2.83, 3.03)	-1.19 (-2.59, 0.20)
Adolescent crime safety perception	2.19 (-5.83, 10.2)	2.89 (-1.73, 7.50)	-29.30 (-49.18, -9.42)**	1.27 (-6.35, 8.89)
Model 3				
Parks and Recreation Facilities	1.00 (-0.54, 2.54)	-0.09 (-0.92, 0.74)	0.02 (-2.97, 3.00)	-1.14 (-2.51, 0.24)
Parent stranger danger safety perception	3.55 (-6.23, 13.32)	-0.44 (-6.09, 5.21)	8.89 (-7.54, 25.32)	-9.42 (-18.67, -0.17)**
Model 4				
Parks and Recreation Facilities	1.03 (-0.49, 2.55)	-0.10 (-0.93, 0.73)	-0.13 (-3.10, 2.83)	-1.23 (-2.61, 0.16)
Adolescent stranger danger safety perception	3.25 (-7.72, 14.22)	-0.22 (-6.67, 6.24)	-6.20 (-29.11, 16.71)	-4.36 (-14.95, 6.23)

**p-value<0.05. All models were adjusted by site, adolescent age, adolescent gender, adolescent ethnicity, adolescent working status, adolescent driving license, parent educational level, parent marital status, adults at household, vehicle per driving license at household. Non-school sedentary time models were also adjusted by accelerometer model, accelerometer wearing time. Sample sizes: Non-school sedentary time (n=437), Riding car, bus (n=457), Screen time (n=457), TV time (n=457).

Table S5. Single and multiple exposure regression models assessing associations between the built environment/perceived crime-safety measures and sedentary behaviors in girls sample.

	Non-school sedentary time (accel)	Riding car, bus	Screen time	TV time
Girls sample	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**
Single Exposure Models				
Exposures				
Walkability Index	-0.79 (-2.76, 1.18)	0.64 (-0.89, 2.17)	-2.86 (-6.99, 1.27)	-1.79 (-3.96, 0.38)
Parks and Recreation Facilities	-0.36 (-1.33, 0.60)	-0.11 (-0.86, 0.65)	-0.83 (-2.82, 1.16)	-1.03 (-2.07, 0.01)
Moderators				
Parent crime safety perception	-3.68 (-10.33, 2.97)	-2.30 (-7.06, 2.47)	-5.98 (-19.79, 7.83)	-3.51 (-10.76, 3.74)
Adolescent crime safety perception	1.44 (-4.95, 7.83)	-3.53 (-8.07, 1.01)	-13.97 (-31.11, 3.18)	-0.13 (-7.1, 6.83)
Parent stranger danger safety perception	-5.63 (-13.86, 2.61)	-3.92 (-9.85, 2.01)	-2.83 (-16.09, 10.42)	-4.68 (-13.70, 4.34)
Adolescent stranger danger safety perception	8.04 (0.58, 15.50)**	-2.70 (-8.10, 2.69)	-18.36 (-34.08, -2.63)**	-9.14 (-17.41, -0.88)**
Multiple Exposures Models				
Walkability Index (1 km buffer)				
Model 1				
Walkability Index	-0.91 (-2.91, 1.08)	0.58 (-0.97, 2.12)	-3.07 (-7.23, 1.09)	-1.91 (-4.09, 0.27)
Parent crime safety perception	-3.91 (-10.59, 2.76)	-2.15 (-6.93, 2.63)	-6.99 (-20.85, 6.88)	-4.14 (-11.41, 3.13)
Model 2				
Walkability Index (1 km buffer)	-0.75 (-2.74, 1.24)	0.53 (-1.01, 2.07)	-3.00 (-7.16, 1.16)	-1.82 (-4.00, 0.37)
Adolescent crime safety perception	1.16 (-5.27, 7.60)	-3.38 (-7.94, 1.19)	-3.92 (-17.25, 9.40)	-0.79 (-7.79, 6.20)
Model 3				
Walkability Index (1 km buffer)	-0.79 (-2.76, 1.18)	0.66 (-0.87, 2.18)	-2.85 (-6.98, 1.28)	-1.79 (-3.96, 0.38)
Parent stranger danger safety perception	-5.62 (-13.87, 2.62)	-3.95 (-9.88, 1.98)	-13.92 (-31.05, 3.20)	-4.65 (-13.65, 4.35)
Model 4				
Walkability Index (1 km buffer)	-0.78 (-2.74, 1.18)	0.65 (-0.88, 2.17)	-2.86 (-6.98, 1.25)	-1.79 (-3.95, 0.37)
Adolescent stranger danger safety perception	8.04 (0.58, 15.50)**	-2.72 (-8.11, 2.68)	-18.36 (-34.07, -2.65)**	-9.14 (-17.39, -0.89)**
Parks and Recreation Facilities (1 km buffer)				
Model 1				
Parks and Recreation Facilities	-0.38 (-1.35, 0.60)	-0.11 (-0.87, 0.65)	-0.83 (-2.82, 1.17)	-1.05 (-2.09, -0.00)**
Parent crime safety perception	-3.65 (-10.3, 3.00)	-2.31 (-7.08, 2.46)	-6.04 (-19.85, 7.78)	-3.59 (-10.81, 3.64)
Model 2				
Parks and Recreation Facilities	-0.36 (-1.32, 0.61)	-0.13 (-0.89, 0.63)	-0.84 (-2.84, 1.15)	-1.03 (-2.08, 0.01)
Adolescent crime safety perception	1.35 (-5.05, 7.75)	-3.56 (-8.11, 0.99)	-3.03 (-16.3, 10.24)	-0.37 (-7.32, 6.58)
Model 3				
Parks and Recreation Facilities	-0.34 (-1.30, 0.62)	-0.08 (-0.83, 0.68)	-0.73 (-2.73, 1.26)	-1.01 (-2.06, 0.03)
Parent stranger danger safety perception	-5.51 (-13.76, 2.74)	-3.88 (-9.83, 2.07)	-13.62 (-30.79, 3.56)	-4.20 (-13.2, 4.81)
Model 4				
Parks and Recreation Facilities	-0.41 (-1.37, 0.55)	-0.09 (-0.84, 0.67)	-0.72 (-2.70, 1.27)	-0.98 (-2.02, 0.06)
Adolescent stranger danger safety perception	8.20 (0.74, 15.67)**	-2.66 (-8.07, 2.74)	-18.08 (-33.83, -2.33)**	-8.77 (-17.02, -0.51)**

**p-value<0.05. All models were adjusted by site, adolescent age, adolescent gender, adolescent ethnicity, adolescent working status, adolescent driving license, parent educational level, parent marital status, adults at household, vehicle per driving license at household. Non-school sedentary time models were also adjusted by accelerometer model, accelerometer wearing time. Sample sizes: Non-school sedentary time (n=437), Riding car, bus (n=457), Screen time (n=457), TV time (n=457).

Table S6. Single and multiple exposure regression models assessing associations between the built environment/perceived crime-safety measures and sedentary behaviors in all sample.

	Non-school sedentary time (accel)	Riding car, bus	Screen time	TV time
All sample	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**
Single Exposure Models				
Exposures				
Walkability Index	-0.08 (-1.75, 1.60)	0.02 (-1.12, 1.16)	-0.77 (-4.23, 2.69)	-1.64 (-3.28, 0.01)
Parks and Recreation Facilities	0.10 (-0.77, 0.96)	-0.16 (-0.74, 0.43)	-0.60 (-2.36, 1.17)	-1.10 (-1.93, -0.26)**
Moderators				
Parent crime safety perception	-2.20 (-7.36, 2.96)	-0.76 (-4.09, 2.57)	-6.43 (-17.11, 4.25)	-3.31 (-8.54, 1.91)
Adolescent crime safety perception	1.31 (-3.75, 6.38)	-0.77 (-4.03, 2.49)	1.97 (-8.50, 12.45)	0.15 (-4.98, 5.28)
Parent stranger danger safety perception	-1.51 (-7.86, 4.83)	-2.62 (-6.72, 1.47)	-22.43 (-35.48, -9.37)**	-8.15 (-14.57, -1.72)**
Adolescent stranger danger safety perception	5.67 (-0.70, 12.04)	-1.99 (-6.14, 2.17)	-12.95 (-26.30, 0.40)	-7.06 (-13.60, -0.52)**
Multiple Exposures Models				
Walkability Index (1 km buffer)				
Model 1				
Walkability Index	-0.17 (-1.86, 1.53)	-0.01 (-1.16, 1.14)	-1.04 (-4.54, 2.47)	-1.79 (-3.45, -0.13)**
Parent crime safety perception	-2.26 (-7.46, 2.94)	-0.77 (-4.12, 2.59)	-6.83 (-17.6, 3.94)	-4.06 (-9.32, 1.20)
Model 2				
Walkability Index (1 km buffer)	-0.02 (-1.71, 1.67)	-0.01 (-1.16, 1.14)	-0.69 (-4.19, 2.81)	-1.66 (-3.33, 0.00)
Adolescent crime safety perception	1.31 (-3.81, 6.42)	-0.78 (-4.07, 2.52)	1.68 (-8.91, 12.27)	-0.63 (-5.81, 4.55)
Model 3				
Walkability Index (1 km buffer)	-0.07 (-1.75, 1.60)	0.03 (-1.12, 1.17)	-0.80 (-4.2, 2.6)	-1.65 (-3.29, -0.02)**
Parent stranger danger safety perception	-1.51 (-7.86, 4.84)	-2.63 (-6.72, 1.47)	-22.40 (-35.46, -9.35)**	-8.13 (-14.54, -1.72)**
Model 4				
Walkability Index (1 km buffer)	-0.02 (-1.69, 1.66)	0.00 (-1.14, 1.15)	-0.88 (-4.35, 2.59)	-1.68 (-3.33, -0.03)**
Adolescent stranger danger safety perception	5.67 (-0.71, 12.05)	-1.99 (-6.15, 2.17)	-13.06 (-26.43, 0.30)	-7.30 (-13.83, -0.76)**
Parks and Recreation Facilities (1 km buffer)				
Model 1				
Parks and Recreation Facilities	0.08 (-0.79, 0.94)	-0.17 (-0.76, 0.42)	-0.65 (-2.43, 1.13)	-1.13 (-1.97, -0.30)**
Parent crime safety perception	-2.17 (-7.34, 3.00)	-0.83 (-4.17, 2.52)	-6.65 (-17.35, 4.04)	-3.72 (-8.93, 1.50)
Model 2				
Parks and Recreation Facilities	0.11 (-0.75, 0.97)	-0.17 (-0.75, 0.42)	-0.58 (-2.35, 1.19)	-1.10 (-1.93, -0.26)**
Adolescent crime safety perception	1.35 (-3.73, 6.43)	-0.82 (-4.09, 2.45)	1.79 (-8.70, 12.29)	-0.24 (-5.36, 4.87)
Model 3				
Parks and Recreation Facilities	0.11 (-0.76, 0.97)	-0.14 (-0.73, 0.45)	-0.44 (-2.18, 1.29)	-1.05 (-1.88, -0.23)**
Parent stranger danger safety perception	-1.55 (-7.9, 4.81)	-2.58 (-6.68, 1.52)	-22.24 (-35.32, -9.17)**	-7.72 (-14.13, -1.31)**
Model 4				
Parks and Recreation Facilities	0.09 (-0.77, 0.95)	-0.16 (-0.74, 0.43)	-0.57 (-2.34, 1.19)	-1.08 (-1.91, -0.24)**
Adolescent stranger danger safety perception	5.67 (-0.71, 12.04)	-1.98 (-6.14, 2.18)	-12.9 (-26.25, 0.46)	-6.95 (-13.47, -0.43)**

**p-value<0.05. All models were adjusted by site, adolescent age, adolescent gender, adolescent ethnicity, adolescent working status, adolescent driving license, parent educational level, parent marital status, adults at household, vehicle per driving license at household. Non-school sedentary time models were also adjusted by accelerometer model, accelerometer wearing time. Sample sizes: Non-school sedentary time (n=869), Riding car, bus (n=912), Screen time (n=912), TV time (n=912).

Table S2. Single and multiple exposure regression models assessing associations between the built environment/perceived crime-safety measures and physical activity behaviors in girls sample.

	Non-school Moderate to Vigorous Physical Activity (log;accel)[a]	Active Transport to/from school[b]	Active Transport in other places [a]	Total Active Transport [a]	Leisure Time Physical Activity in the neighborhood [a]	Leisure Time Physical Activity in other places [a]
Girls sample	**coef (CI 95%)**	**OR (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**
Single Exposure Models						
Exposures						
Walkability Index	1.03 (1.01, 1.06)**	1.09 (1.01, 1.18)**	0.09 (0.07, 0.11)**	0.14 (0.10, 0.18)**	0.00 (-0.04, 0.04)	0.02 (-0.01, 0.04)
Parks and Recreation Facilities	1.02 (1.01, 1.03)**	1.04 (1, 1.08)	0.04 (0.03, 0.05)**	0.06 (0.04, 0.08)**	0.00 (-0.02, 0.01)	0.01 (0.00, 0.02)
Moderators						
Parent crime safety perception	1.08 (1.01, 1.16)**	1.22 (0.93, 1.60)	0.09 (0.00, 0.17)**	0.17 (0.02, 0.32)**	0.11 (-0.01, 0.23)	0.11 (0.04, 0.18)**
Adolescent crime safety perception	1.00 (0.94, 1.07)	0.83 (0.66, 1.06)	-0.01 (-0.09, 0.07)	-0.07 (-0.21, 0.07)	0.00 (-0.12, 0.11)	0.04 (-0.03, 0.11)
Parent stranger danger safety perception	1.11 (1.02, 1.21)**	0.82 (0.60, 1.12)	0.12 (0.02, 0.23)**	0.04 (-0.15, 0.22)	0.12 (-0.03, 0.27)	0.08 (-0.01, 0.17)
Adolescent stranger danger safety perception	0.97 (0.90, 1.05)	0.94 (0.71, 1.24)	0.07 (-0.03, 0.16)	0.02 (-0.15, 0.19)	0.00 (-0.14, 0.14)	0.03 (-0.06, 0.11)
Multiple Exposures Models						
Walkability Index (1 km buffer)						
Model 1						
Walkability Index	1.04 (1.02, 1.06)**	1.10 (1.02, 1.20)**	0.09 (0.07, 0.12)**	0.14 (0.10, 0.19)**	0.00 (-0.04, 0.04)	0.02 (0.00, 0.04)
Parent crime safety perception	1.10 (1.03, 1.18)**	1.26 (0.96, 1.65)	0.12 (0.04, 0.20)**	0.21 (0.07, 0.35)**	0.11 (-0.01, 0.23)	0.11 (0.04, 0.19)**
Model 2						
Walkability Index (1 km buffer)	1.04 (1.01, 1.06)**	1.09 (1.01, 1.18)**	0.09 (0.07, 0.12)**	0.14 (0.09, 0.18)**	0.00 (-0.04, 0.04)	0.02 (0.00, 0.04)
Adolescent crime safety perception	1.02 (0.95, 1.09)	0.86 (0.68, 1.09)	0.02 (-0.06, 0.10)	-0.02 (-0.16, 0.11)	0.00 (-0.12, 0.11)	0.05 (-0.02, 0.12)
Model 3						
Walkability Index (1 km buffer)	1.03 (1.01, 1.06)**	1.10 (1.01, 1.19)**	0.09 (0.07, 0.11)**	0.14 (0.10, 0.18)**	0.00 (-0.04, 0.04)	0.02 (-0.01, 0.04)
Parent stranger danger safety perception	1.11 (1.02, 1.21)**	0.82 (0.60, 1.11)	0.12 (0.02, 0.22)**	0.04 (-0.14, 0.21)	0.12 (-0.03, 0.27)	0.08 (-0.01, 0.17)
Model 4						
Walkability Index (1 km buffer)	1.03 (1.01, 1.06)**	1.09 (1.01, 1.18)**	0.09 (0.07, 0.11)**	0.14 (0.10, 0.18)**	0.00 (-0.04, 0.04)	0.02 (-0.01, 0.04)
Adolescent stranger danger safety perception	0.97 (0.90, 1.05)	0.94 (0.71, 1.24)	0.07 (-0.03, 0.16)	0.02 (-0.14, 0.18)	0.00 (-0.14, 0.14)	0.03 (-0.06, 0.11)
Parks and Recreation Facilities (1 km buffer)						
Model 1						
Parks and Recreation Facilities	1.02 (1.01, 1.03)**	1.04 (1.00, 1.08)	0.04 (0.03, 0.05)**	0.06 (0.04, 0.08)**	-0.01 (-0.02, 0.01)	0.01 (0.00, 0.02)
Parent crime safety perception	1.09 (1.01, 1.16)**	1.23 (0.94, 1.61)	0.09 (0.01, 0.17)**	0.17 (0.03, 0.31)**	0.11 (-0.01, 0.23)	0.11 (0.04, 0.18)**
Model 2						
Parks and Recreation Facilities	1.02 (1.01, 1.03)**	1.03 (1.00, 1.08)	0.04 (0.03, 0.05)**	0.06 (0.04, 0.08)**	-0.01 (-0.02, 0.01)	0.01 (0.00, 0.02)
Adolescent crime safety perception	1.01 (0.94, 1.08)	0.84 (0.66, 1.06)	0.00 (-0.08, 0.08)	-0.06 (-0.19, 0.08)	0.00 (-0.12, 0.11)	0.04 (-0.03, 0.11)
Model 3						
Parks and Recreation Facilities	1.02 (1.01, 1.03)**	1.04 (1.00, 1.08)	0.04 (0.03, 0.05)**	0.06 (0.04, 0.08)**	-0.01 (-0.03, 0.01)	0.01 (0.00, 0.02)
Parent stranger danger safety perception	1.10 (1.01, 1.20)**	0.80 (0.59, 1.09)	0.10 (0.00, 0.21)**	0.01 (-0.17, 0.19)	0.12 (-0.03, 0.28)	0.08 (-0.01, 0.17)
Model 4						
Parks and Recreation Facilities	1.02 (1.01, 1.03)**	1.04 (1.00, 1.08)	0.04 (0.03, 0.05)**	0.06 (0.04, 0.08)**	0.00 (-0.02, 0.01)	0.01 (0.00, 0.02)
Adolescent stranger danger safety perception	0.97 (0.90, 1.05)	0.93 (0.70, 1.23)	0.05 (-0.04, 0.15)	0.00 (-0.16, 0.16)	0.00 (-0.14, 0.14)	0.02 (-0.06, 0.11)

[a]Mixed-effects linear regression models. [b]Mixed-effects logistic regression models. **p-value<0.05. All models were adjusted by site, adolescent age, adolescent gender, adolescent ethnicity, adolescent working status, adolescent driving license, parent educational level, parent marital status, adults at household, vehicle per driving license at household. Non-school Moderate-to-vigorous physical activity models were also adjusted by accelerometer model, accelerometer wearing time. Sample sizes: Non-school Moderate-to-vigorous physical activity (n=437), Active Transport to/from school (n=452); Active Transport in other places (n=457), Total Active Transport (n=457), Leisure Time Physical Activity in the neighborhood (n=457), Leisure Time Physical Activity in other places (n=457).

Table S3. Single and multiple exposure regression models assessing associations between the built environment/perceived crime-safety measures and physical activity behaviors in all sample.

	Non-school Moderate to Vigorous Physical Activity (log;accel)[a]	**Active Transport to/from school[b]**	**Active Transport in other places [a]**	**Total Active Transport[a]**	**Leisure Time Physical Activity in the neighborhood [a]**	**Leisure Time Physical Activity in other places [a]**
All sample	**coef (CI 95%)**	**OR (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**
Single Exposure Models						
Exposures						
Walkability Index	1.02 (1.01, 1.04)**	1.13 (1.06, 1.20)**	0.08 (0.06, 0.10)**	0.14 (0.10, 0.17)**	0.00 (-0.03, 0.03)	0.02 (0.00, 0.03)
Parks and Recreation Facilities	1.01 (1.00, 1.02)**	1.05 (1.02, 1.09)**	0.04 (0.03, 0.05)**	0.07 (0.05, 0.09)**	0.00 (-0.01, 0.02)	0.01 (0.00, 0.02)**
Moderators						
Parent crime safety perception	1.06 (1.01, 1.11)**	1.04 (0.87, 1.24)	0.04 (-0.03, 0.10)	0.05 (-0.06, 0.17)	0.04 (-0.05, 0.13)	0.07 (0.01, 0.12)**
Adolescent crime safety perception	0.99 (0.95, 1.04)	0.95 (0.76, 1.17)	-0.05 (-0.12, 0.01)	-0.11 (-0.22, 0.00)	0.03 (-0.06, 0.12)	0.02 (-0.03, 0.07)
Parent stranger danger safety perception	1.08 (1.01, 1.14)**	0.87 (0.73, 1.03)	0.11 (0.03, 0.19)**	0.10 (-0.05, 0.24)	0.10 (-0.01, 0.22)	0.07 (0.00, 0.14)**
Adolescent stranger danger safety perception	0.98 (0.93, 1.05)	0.89 (0.72, 1.10)	0.03 (-0.05, 0.11)	-0.05 (-0.20, 0.09)	0.07 (-0.04, 0.19)	0.03 (-0.04, 0.10)
Multiple Exposures Models						
Walkability Index (1 km buffer)						
Model 1						
Walkability Index	1.03 (1.01, 1.04)**	1.13 (1.07, 1.20)**	0.08 (0.06, 0.10)**	0.14 (0.10, 0.18)**	0.00 (-0.03, 0.03)	0.02 (0.00, 0.04)**
Parent crime safety perception	1.07 (1.01, 1.12)**	1.09 (0.91, 1.30)	0.07 (0.01, 0.14)**	0.09 (-0.02, 0.21)	0.04 (-0.05, 0.13)	0.07 (0.02, 0.13)**
Model 2						
Walkability Index (1 km buffer)	1.02 (1.01, 1.04)**	1.12 (1.06, 1.19)**	0.08 (0.06, 0.10)**	0.13 (0.09, 0.17)**	0.00 (-0.03, 0.03)	0.02 (0.00, 0.03)
Adolescent crime safety perception	1.00 (0.96, 1.05)	0.91 (0.77, 1.08)	-0.02 (-0.08, 0.05)	-0.06 (-0.18, 0.05)	0.03 (-0.06, 0.12)	0.03 (-0.03, 0.08)
Model 3						
Walkability Index (1 km buffer)	1.02 (1.01, 1.04)**	1.13 (1.06, 1.20)**	0.08 (0.06, 0.10)**	0.13 (0.10, 0.17)**	0.00 (-0.03, 0.03)	0.02 (0.00, 0.03)
Parent stranger danger safety perception	1.08 (1.01, 1.14)**	0.94 (0.76, 1.16)	0.11 (0.03, 0.18)**	0.09 (-0.05, 0.23)	0.10 (-0.01, 0.22)	0.07 (0.00, 0.14)**
Model 4						
Walkability Index (1 km buffer)	1.02 (1.01, 1.04)**	1.13 (1.06, 1.20)**	0.08 (0.06, 0.10)**	0.14 (0.10, 0.17)**	0.00 (-0.03, 0.03)	0.02 (0.00, 0.03)
Adolescent stranger danger safety perception	0.99 (0.93, 1.05)	0.90 (0.73, 1.12)	0.05 (-0.03, 0.13)	-0.03 (-0.17, 0.11)	0.07 (-0.04, 0.19)	0.03 (-0.03, 0.10)
Parks and Recreation Facilities (1 km buffer)						
Model 1						
Parks and Recreation Facilities	1.01 (1.00, 1.02)**	1.05 (1.02, 1.09)**	0.04 (0.03, 0.05)**	0.07 (0.05, 0.09)**	0.00 (-0.01, 0.02)	0.01 (0.00, 0.02)**
Parent crime safety perception	1.06 (1.01, 1.11)**	1.06 (0.89, 1.27)	0.05 (-0.01, 0.11)	0.07 (-0.04, 0.18)	0.04 (-0.05, 0.13)	0.07 (0.02, 0.12)**
Model 2						
Parks and Recreation Facilities	1.01 (1.00, 1.02)**	1.05 (1.02, 1.08)**	0.04 (0.03, 0.05)**	0.07 (0.05, 0.09)**	0.00 (-0.01, 0.02)	0.01 (0.00, 0.02)**
Adolescent crime safety perception	1.00 (0.95, 1.05)	0.88 (0.74, 1.04)	-0.04 (-0.10, 0.02)	-0.10 (-0.21, 0.01)	0.03 (-0.06, 0.12)	0.02 (-0.03, 0.08)
Model 3						
Parks and Recreation Facilities	1.01 (1.00, 1.02)**	1.05 (1.02, 1.09)**	0.04 (0.03, 0.05)**	0.07 (0.05, 0.09)**	0.00 (-0.02, 0.01)	0.01 (0.00, 0.02)**
Parent stranger danger safety perception	1.07 (1.01, 1.14)**	0.92 (0.75, 1.15)	0.09 (0.01, 0.17)**	0.07 (-0.07, 0.21)	0.10 (-0.01, 0.22)	0.07 (0.00, 0.13)
Model 4						
Parks and Recreation Facilities	1.01 (1.00, 1.02)**	1.05 (1.02, 1.09)**	0.04 (0.03, 0.05)**	0.07 (0.05, 0.09)**	0.07 (-0.04, 0.19)	0.01 (0.00, 0.02)**
Adolescent stranger danger safety perception	0.99 (0.93, 1.05)	0.88 (0.71, 1.10)	0.04 (-0.04, 0.11)	-0.05 (-0.19, 0.09)	0.00 (-0.01, 0.02)	0.03 (-0.04, 0.10)

[a]Mixed-effects linear regression models. [b]Mixed-effects logistic regression models. **p-value<0.05. All models were adjusted by site, adolescent age, adolescent gender, adolescent ethnicity, adolescent working status, adolescent driving license, parent educational level, parent marital status, adults at household, vehicle per driving license at household. Non-school Moderate-to-vigorous physical activity models were also adjusted by accelerometer model, accelerometer wearing time. Sample sizes: Moderate-to-vigorous physical activity (n=869), Active Transport to/from school (n=903); Active Transport in other places (n=912), Total Active Transport (n=912), Leisure Time Physical Activity in the neighborhood (n=912), Leisure Time Physical Activity in other places (n=912).

Table S4. Single and multiple exposure regression models assessing associations between the built environment/perceived crime-safety measures and sedentary behaviors in boys sample.

	Non-school sedentary time (accel)	Riding car, bus	Screen time	TV time
Boys sample	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**
Single Exposure Models				
Exposures				
Walkability Index	1.28 (-1.50, 4.05)	-0.64 (-2.16, 0.88)	1.87 (-3.55, 7.29)	-1.52 (-4.07, 1.04)
Parks and Recreation Facilities	1.01 (-0.51, 2.53)	-0.10 (-0.92, 0.73)	-0.11 (-3.07, 2.85)	-1.21 (-2.59, 0.17)
Moderators				
Parent crime safety perception	0.91 (-7.00, 8.83)	1.10 (-3.47, 5.66)	-6.21 (-22.43, 10.00)	-3.01 (-10.54, 4.53)
Adolescent crime safety perception	1.74 (-6.26, 9.74)	2.91 (-1.68, 7.51)	8.83 (-7.53, 25.18)	1.77 (-5.84, 9.38)
Parent stranger danger safety perception	3.77 (-6.01, 13.55)	-0.47 (-6.11, 5.17)	-29.28 (-49.11, -9.44)**	-9.79 (-19.05, -0.53)**
Adolescent stranger danger safety perception	2.98 (-8.00, 13.96)	-0.20 (-6.64, 6.25)	-6.18 (-29.05, 16.69)	-4.08 (-14.69, 6.53)
Multiple Exposures Models				
Walkability Index (1 km buffer)				
Model 1				
Walkability Index	1.35 (-1.45, 4.16)	-0.60 (-2.14, 0.94)	1.56 (-3.93, 7.05)	-1.73 (-4.31, 0.86)
Parent crime safety perception	1.47 (-6.53, 9.48)	0.78 (-3.86, 5.41)	-5.46 (-21.92, 10.99)	-3.84 (-11.47, 3.80)
Model 2				
Walkability Index (1 km buffer)	1.44 (-1.38, 4.26)	-0.46 (-2.01, 1.08)	1.84 (-3.51, 7.18)	-1.45 (-4.06, 1.16)
Adolescent crime safety perception	2.50 (-5.64, 10.64)	2.63 (-2.06, 7.32)	-29.30 (-49.14, -9.46)**	0.99 (-6.77, 8.75)
Model 3				
Walkability Index (1 km buffer)	1.31 (-1.50, 4.11)	-0.64 (-2.16, 0.88)	2.57 (-2.97, 8.11)	-1.53 (-4.06, 1.00)
Parent stranger danger safety perception	3.78 (-6.00, 13.56)	-0.49 (-6.13, 5.15)	10.29 (-6.4, 26.97)	-9.78 (-19.03, -0.52)**
Model 4				
Walkability Index (1 km buffer)	1.34 (-1.44, 4.12)	-0.65 (-2.17, 0.87)	1.77 (-3.66, 7.20)	-1.59 (-4.15, 0.97)
Adolescent stranger danger safety perception	3.36 (-7.64, 14.37)	-0.40 (-6.87, 6.06)	-5.66 (-28.6, 17.29)	-4.53 (-15.16, 6.10)
Parks and Recreation Facilities (1 km buffer)				
Model 1				
Parks and Recreation Facilities	1.04 (-0.49, 2.57)	-0.07 (-0.91, 0.76)	-0.24 (-3.22, 2.74)	-1.29 (-2.68, 0.10)
Parent crime safety perception	1.48 (-6.48, 9.43)	1.05 (-3.55, 5.65)	-6.35 (-22.69, 9.99)	-3.80 (-11.36, 3.77)
Model 2				
Parks and Recreation Facilities	1.05 (-0.48, 2.57)	-0.05 (-0.88, 0.77)	0.10 (-2.83, 3.03)	-1.19 (-2.59, 0.20)
Adolescent crime safety perception	2.19 (-5.83, 10.2)	2.89 (-1.73, 7.50)	-29.30 (-49.18, -9.42)**	1.27 (-6.35, 8.89)
Model 3				
Parks and Recreation Facilities	1.00 (-0.54, 2.54)	-0.09 (-0.92, 0.74)	0.02 (-2.97, 3.00)	-1.14 (-2.51, 0.24)
Parent stranger danger safety perception	3.55 (-6.23, 13.32)	-0.44 (-6.09, 5.21)	8.89 (-7.54, 25.32)	-9.42 (-18.67, -0.17)**
Model 4				
Parks and Recreation Facilities	1.03 (-0.49, 2.55)	-0.10 (-0.93, 0.73)	-0.13 (-3.10, 2.83)	-1.23 (-2.61, 0.16)
Adolescent stranger danger safety perception	3.25 (-7.72, 14.22)	-0.22 (-6.67, 6.24)	-6.20 (-29.11, 16.71)	-4.36 (-14.95, 6.23)

**p-value<0.05. All models were adjusted by site, adolescent age, adolescent gender, adolescent ethnicity, adolescent working status, adolescent driving license, parent educational level, parent marital status, adults at household, vehicle per driving license at household. Non-school sedentary time models were also adjusted by accelerometer model, accelerometer wearing time. Sample sizes: Non-school sedentary time (n=437), Riding car, bus (n=457), Screen time (n=457), TV time (n=457).

Table S5. Single and multiple exposure regression models assessing associations between the built environment/perceived crime-safety measures and sedentary behaviors in girls sample.

	Non-school sedentary time (accel)	Riding car, bus	Screen time	TV time
Girls sample	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**
Single Exposure Models				
Exposures				
Walkability Index	-0.79 (-2.76, 1.18)	0.64 (-0.89, 2.17)	-2.86 (-6.99, 1.27)	-1.79 (-3.96, 0.38)
Parks and Recreation Facilities	-0.36 (-1.33, 0.60)	-0.11 (-0.86, 0.65)	-0.83 (-2.82, 1.16)	-1.03 (-2.07, 0.01)
Moderators				
Parent crime safety perception	-3.68 (-10.33, 2.97)	-2.30 (-7.06, 2.47)	-5.98 (-19.79, 7.83)	-3.51 (-10.76, 3.74)
Adolescent crime safety perception	1.44 (-4.95, 7.83)	-3.53 (-8.07, 1.01)	-13.97 (-31.11, 3.18)	-0.13 (-7.1, 6.83)
Parent stranger danger safety perception	-5.63 (-13.86, 2.61)	-3.92 (-9.85, 2.01)	-2.83 (-16.09, 10.42)	-4.68 (-13.70, 4.34)
Adolescent stranger danger safety perception	8.04 (0.58, 15.50)**	-2.70 (-8.10, 2.69)	-18.36 (-34.08, -2.63)**	-9.14 (-17.41, -0.88)**
Multiple Exposures Models				
Walkability Index (1 km buffer)				
Model 1				
Walkability Index	-0.91 (-2.91, 1.08)	0.58 (-0.97, 2.12)	-3.07 (-7.23, 1.09)	-1.91 (-4.09, 0.27)
Parent crime safety perception	-3.91 (-10.59, 2.76)	-2.15 (-6.93, 2.63)	-6.99 (-20.85, 6.88)	-4.14 (-11.41, 3.13)
Model 2				
Walkability Index (1 km buffer)	-0.75 (-2.74, 1.24)	0.53 (-1.01, 2.07)	-3.00 (-7.16, 1.16)	-1.82 (-4.00, 0.37)
Adolescent crime safety perception	1.16 (-5.27, 7.60)	-3.38 (-7.94, 1.19)	-3.92 (-17.25, 9.40)	-0.79 (-7.79, 6.20)
Model 3				
Walkability Index (1 km buffer)	-0.79 (-2.76, 1.18)	0.66 (-0.87, 2.18)	-2.85 (-6.98, 1.28)	-1.79 (-3.96, 0.38)
Parent stranger danger safety perception	-5.62 (-13.87, 2.62)	-3.95 (-9.88, 1.98)	-13.92 (-31.05, 3.20)	-4.65 (-13.65, 4.35)
Model 4				
Walkability Index (1 km buffer)	-0.78 (-2.74, 1.18)	0.65 (-0.88, 2.17)	-2.86 (-6.98, 1.25)	-1.79 (-3.95, 0.37)
Adolescent stranger danger safety perception	8.04 (0.58, 15.50)**	-2.72 (-8.11, 2.68)	-18.36 (-34.07, -2.65)**	-9.14 (-17.39, -0.89)**
Parks and Recreation Facilities (1 km buffer)				
Model 1				
Parks and Recreation Facilities	-0.38 (-1.35, 0.60)	-0.11 (-0.87, 0.65)	-0.83 (-2.82, 1.17)	-1.05 (-2.09, -0.00)**
Parent crime safety perception	-3.65 (-10.3, 3.00)	-2.31 (-7.08, 2.46)	-6.04 (-19.85, 7.78)	-3.59 (-10.81, 3.64)
Model 2				
Parks and Recreation Facilities	-0.36 (-1.32, 0.61)	-0.13 (-0.89, 0.63)	-0.84 (-2.84, 1.15)	-1.03 (-2.08, 0.01)
Adolescent crime safety perception	1.35 (-5.05, 7.75)	-3.56 (-8.11, 0.99)	-3.03 (-16.3, 10.24)	-0.37 (-7.32, 6.58)
Model 3				
Parks and Recreation Facilities	-0.34 (-1.30, 0.62)	-0.08 (-0.83, 0.68)	-0.73 (-2.73, 1.26)	-1.01 (-2.06, 0.03)
Parent stranger danger safety perception	-5.51 (-13.76, 2.74)	-3.88 (-9.83, 2.07)	-13.62 (-30.79, 3.56)	-4.20 (-13.2, 4.81)
Model 4				
Parks and Recreation Facilities	-0.41 (-1.37, 0.55)	-0.09 (-0.84, 0.67)	-0.72 (-2.70, 1.27)	-0.98 (-2.02, 0.06)
Adolescent stranger danger safety perception	8.20 (0.74, 15.67)**	-2.66 (-8.07, 2.74)	-18.08 (-33.83, -2.33)**	-8.77 (-17.02, -0.51)**

**p-value<0.05. All models were adjusted by site, adolescent age, adolescent gender, adolescent ethnicity, adolescent working status, adolescent driving license, parent educational level, parent marital status, adults at household, vehicle per driving license at household. Non-school sedentary time models were also adjusted by accelerometer model, accelerometer wearing time. Sample sizes: Non-school sedentary time (n=437), Riding car, bus (n=457), Screen time (n=457), TV time (n=457).

Table S6. Single and multiple exposure regression models assessing associations between the built environment/perceived crime-safety measures and sedentary behaviors in all sample.

	Non-school sedentary time (accel)	Riding car, bus	Screen time	TV time
All sample	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**
Single Exposure Models				
Exposures				
Walkability Index	-0.08 (-1.75, 1.60)	0.02 (-1.12, 1.16)	-0.77 (-4.23, 2.69)	-1.64 (-3.28, 0.01)
Parks and Recreation Facilities	0.10 (-0.77, 0.96)	-0.16 (-0.74, 0.43)	-0.60 (-2.36, 1.17)	-1.10 (-1.93, -0.26)**
Moderators				
Parent crime safety perception	-2.20 (-7.36, 2.96)	-0.76 (-4.09, 2.57)	-6.43 (-17.11, 4.25)	-3.31 (-8.54, 1.91)
Adolescent crime safety perception	1.31 (-3.75, 6.38)	-0.77 (-4.03, 2.49)	1.97 (-8.50, 12.45)	0.15 (-4.98, 5.28)
Parent stranger danger safety perception	-1.51 (-7.86, 4.83)	-2.62 (-6.72, 1.47)	-22.43 (-35.48, -9.37)**	-8.15 (-14.57, -1.72)**
Adolescent stranger danger safety perception	5.67 (-0.70, 12.04)	-1.99 (-6.14, 2.17)	-12.95 (-26.30, 0.40)	-7.06 (-13.60, -0.52)**
Multiple Exposures Models				
Walkability Index (1 km buffer)				
Model 1				
Walkability Index	-0.17 (-1.86, 1.53)	-0.01 (-1.16, 1.14)	-1.04 (-4.54, 2.47)	-1.79 (-3.45, -0.13)**
Parent crime safety perception	-2.26 (-7.46, 2.94)	-0.77 (-4.12, 2.59)	-6.83 (-17.6, 3.94)	-4.06 (-9.32, 1.20)
Model 2				
Walkability Index (1 km buffer)	-0.02 (-1.71, 1.67)	-0.01 (-1.16, 1.14)	-0.69 (-4.19, 2.81)	-1.66 (-3.33, 0.00)
Adolescent crime safety perception	1.31 (-3.81, 6.42)	-0.78 (-4.07, 2.52)	1.68 (-8.91, 12.27)	-0.63 (-5.81, 4.55)
Model 3				
Walkability Index (1 km buffer)	-0.07 (-1.75, 1.60)	0.03 (-1.12, 1.17)	-0.80 (-4.2, 2.6)	-1.65 (-3.29, -0.02)**
Parent stranger danger safety perception	-1.51 (-7.86, 4.84)	-2.63 (-6.72, 1.47)	-22.40 (-35.46, -9.35)**	-8.13 (-14.54, -1.72)**
Model 4				
Walkability Index (1 km buffer)	-0.02 (-1.69, 1.66)	0.00 (-1.14, 1.15)	-0.88 (-4.35, 2.59)	-1.68 (-3.33, -0.03)**
Adolescent stranger danger safety perception	5.67 (-0.71, 12.05)	-1.99 (-6.15, 2.17)	-13.06 (-26.43, 0.30)	-7.30 (-13.83, -0.76)**
Parks and Recreation Facilities (1 km buffer)				
Model 1				
Parks and Recreation Facilities	0.08 (-0.79, 0.94)	-0.17 (-0.76, 0.42)	-0.65 (-2.43, 1.13)	-1.13 (-1.97, -0.30)**
Parent crime safety perception	-2.17 (-7.34, 3.00)	-0.83 (-4.17, 2.52)	-6.65 (-17.35, 4.04)	-3.72 (-8.93, 1.50)
Model 2				
Parks and Recreation Facilities	0.11 (-0.75, 0.97)	-0.17 (-0.75, 0.42)	-0.58 (-2.35, 1.19)	-1.10 (-1.93, -0.26)**
Adolescent crime safety perception	1.35 (-3.73, 6.43)	-0.82 (-4.09, 2.45)	1.79 (-8.70, 12.29)	-0.24 (-5.36, 4.87)
Model 3				
Parks and Recreation Facilities	0.11 (-0.76, 0.97)	-0.14 (-0.73, 0.45)	-0.44 (-2.18, 1.29)	-1.05 (-1.88, -0.23)**
Parent stranger danger safety perception	-1.55 (-7.9, 4.81)	-2.58 (-6.68, 1.52)	-22.24 (-35.32, -9.17)**	-7.72 (-14.13, -1.31)**
Model 4				
Parks and Recreation Facilities	0.09 (-0.77, 0.95)	-0.16 (-0.74, 0.43)	-0.57 (-2.34, 1.19)	-1.08 (-1.91, -0.24)**
Adolescent stranger danger safety perception	5.67 (-0.71, 12.04)	-1.98 (-6.14, 2.18)	-12.9 (-26.25, 0.46)	-6.95 (-13.47, -0.43)**

**p-value<0.05. All models were adjusted by site, adolescent age, adolescent gender, adolescent ethnicity, adolescent working status, adolescent driving license, parent educational level, parent marital status, adults at household, vehicle per driving license at household. Non-school sedentary time models were also adjusted by accelerometer model, accelerometer wearing time. Sample sizes: Non-school sedentary time (n=869), Riding car, bus (n=912), Screen time (n=912), TV time (n=912).

Table S7. Regression models assessing interaction effects of built environment and perceived crime-safety measures to physical activity behaviors in all sample.

	Non-school Moderate to Vigorous Physical Activity (log;accel)[a]	Active Transport to/from school[b]	Active Transport in other places[a]	Total Active Transport[a]	Leisure Time Physical Activity in the neighborhood[a]	Leisure Time Physical Activity in other places[a]
All sample	**coef (CI 95%)**	**OR (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**
Walkability Index (1 km buffer)						
Model 1						
Walkability Index	1.03 (1.01, 1.04)**	1.14 (1.07, 1.21)**	0.08 (0.06, 0.10)**	0.14 (0.10, 0.18)**	0.00 (-0.03, 0.03)	0.02 (0.00, 0.04)**
Parent crime safety perception	1.07 (1.01, 1.12)**	1.07 (0.90, 1.28)	0.07 (0.01, 0.14)**	0.09 (-0.02, 0.21)	0.04 (-0.05, 0.13)	0.07 (0.02, 0.13)**
Walkability Index#Parent crime safety perception	1.00 (0.98, 1.01)	1.05 (1.00, 1.12)*	-0.01 (-0.03, 0.01)	0.00 (-0.04, 0.04)	0.01 (-0.02, 0.04)	0.00 (-0.01, 0.02)
Model 2						
Walkability Index (1 km buffer)	1.02 (1.01, 1.04)**	1.13 (1.06, 1.20)**	0.08 (0.06, 0.10)**	0.13 (0.09, 0.17)**	0.00 (-0.03, 0.03)	0.02 (-0.00, 0.03)
Adolescent crime safety perception	1.00 (0.96, 1.05)	0.90 (0.76, 1.06)	-0.01 (-0.08, 0.05)	-0.06 (-0.18, 0.05)	0.03 (-0.06, 0.12)	0.03 (-0.03, 0.08)
Walkability Index#Adolescent crime safety perception	0.99 (0.98, 1.01)	1.05 (0.99, 1.12)	-0.01 (-0.03, 0.02)	-0.00 (-0.04, 0.04)	0.00 (-0.03, 0.03)	-0.00 (-0.02, 0.02)
Model 3						
Walkability Index (1 km buffer)	1.02 (1.01, 1.04)**	1.13 (1.07, 1.20)**	0.08 (0.06, 0.10)**	0.14 (0.10, 0.17)**	-0.00 (-0.03, 0.03)	0.02 (-0.00, 0.03)
Parent stranger danger safety perception	1.07 (1.01, 1.14)**	0.92 (0.74, 1.14)	0.10 (0.03, 0.18)**	0.09 (-0.05, 0.22)	0.10 (-0.01, 0.21)	0.07 (-0.00, 0.13)
Walkability Index#Parent stranger danger safety perception	1.01 (0.99, 1.03)	1.06 (0.98, 1.14)	0.01 (-0.01, 0.04)	0.02 (-0.03, 0.07)	0.03 (-0.01, 0.06)	0.02 (-0.00, 0.04)*
Model 4						
Walkability Index (1 km buffer)	1.02 (1.01, 1.04)**	1.13 (1.07, 1.20)**	0.08 (0.06, 0.10)**	0.14 (0.10, 0.17)**	-0.00 (-0.03, 0.03)	0.02 (-0.00, 0.03)
Adolescent stranger danger safety perception	0.99 (0.93, 1.05)	0.88 (0.71, 1.10)	0.05 (-0.02, 0.13)	-0.03 (-0.17, 0.11)	0.07 (-0.05, 0.19)	0.04 (-0.03, 0.10)
Walkability Index#Adolescent stranger danger safety perception	0.99 (0.97, 1.01)	1.06 (0.99, 1.14)	-0.01 (-0.04, 0.01)	0.01 (-0.04, 0.05)	0.01 (-0.02, 0.05)	-0.00 (-0.03, 0.02)
Parks and Recreation Facilities (1 km buffer)						
Model 1						
Parks and Recreation Facilities	1.01 (1.00, 1.02)**	1.06 (1.02, 1.09)**	0.04 (0.03, 0.05)**	0.07 (0.05, 0.09)**	-0.00 (-0.02, 0.01)	0.01 (0.00, 0.02)**
Parent crime safety perception	1.06 (1.01, 1.11)**	1.06 (0.89, 1.26)	0.05 (-0.01, 0.11)	0.07 (-0.04, 0.18)	0.04 (-0.05, 0.13)	0.07 (0.01, 0.12)**
Parks and Recreation Facilities#Parent crime safety perception	1.00 (0.99, 1.01)	1.02 (0.99, 1.05)	-0.01 (-0.02, 0.00)	-0.00 (-0.03, 0.02)	-0.01 (-0.03, 0.00)*	-0.01 (-0.02, 0.00)
Model 2						
Parks and Recreation Facilities	1.01 (1.00, 1.02)**	1.05 (1.02, 1.09)**	0.04 (0.03, 0.05)**	0.07 (0.05, 0.09)**	-0.00 (-0.02, 0.02)	0.01 (0.00, 0.02)**
Adolescent crime safety perception	1.00 (0.95, 1.05)	0.88 (0.74, 1.04)	-0.04 (-0.10, 0.02)	-0.09 (-0.20, 0.02)*	0.03 (-0.06, 0.12)	0.02 (-0.03, 0.08)
Parks and Recreation Facilities#Adolescent crime safety perception	1.00 (0.99, 1.01)	1.03 (0.99, 1.06)	-0.00 (-0.01, 0.01)	0.01 (-0.01, 0.02)	-0.01 (-0.03, 0.01)	-0.01 (-0.02, 0.00)
Model 3						
Parks and Recreation Facilities	1.01 (1.00, 1.02)**	1.05 (1.02, 1.08)**	0.04 (0.03, 0.05)**	0.07 (0.05, 0.09)**	-0.00 (-0.02, 0.01)	0.01 (0.00, 0.02)**
Parent stranger danger safety perception	1.07 (1.01, 1.14)**	0.93 (0.75, 1.15)	0.09 (0.01, 0.17)**	0.07 (-0.07, 0.21)	0.11 (-0.01, 0.22)	0.07 (0.00, 0.14)
Parks and Recreation Facilities#Parent stranger danger safety perception	1.00 (0.99, 1.01)	1.03 (0.98, 1.07)	0.00 (-0.01, 0.02)	0.01 (-0.02, 0.03)	0.01 (-0.02, 0.03)	0.00 (-0.01, 0.02)
Model 4						
Parks and Recreation Facilities	1.01 (1.00, 1.02)**	1.05 (1.02, 1.09)**	0.04 (0.03, 0.05)**	0.07 (0.05, 0.09)**	0.00 (-0.01, 0.02)	0.01 (0.00, 0.02)**
Adolescent stranger danger safety perception	0.98 (0.93, 1.04)	0.88 (0.71, 1.10)	0.03 (-0.04, 0.11)	-0.05 (-0.19, 0.09)	0.07 (-0.04, 0.19)	0.03 (-0.04, 0.10)
Parks and Recreation Facilities#Adolescent stranger danger safety perception	0.99 (0.98, 1.00)	1.01 (0.97, 1.06)	-0.00 (-0.01, 0.01)	0.00 (-0.02, 0.03)	-0.00 (-0.02, 0.02)	-0.00 (-0.01, 0.01)

[a]Mixed-effects linear regression models. [b]Mixed-effects logistic regression models. *p-value<0.10, only for interactions. **p-value<0.05. All models were adjusted by site, adolescent age, adolescent gender, adolescent ethnicity, adolescent working status, adolescent driving license, parent educational level, parent marital status, adults at household, vehicle per driving license at household. Non-school moderate-to-vigorous physical activity models were also adjusted by accelerometer model, accelerometer wearing time. Sample sizes: Non-school moderate-to-vigorous physical activity (n=869), Active Transport to/from school (n=903); Active Transport in other places (n=912), Total Active Transport (n=912), Leisure Time Physical Activity in the neighborhood (n=912), Leisure Time Physical Activity in other places (n=912).

Table S8. Regression models assessing interaction effects of built environment and perceived crime-safety measures to sedentary behaviors in all sample.

	Non-school sedentary time (accel)	Riding car, bus	Screen time	TV time
All sample	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**	**coef (CI 95%)**
Walkability Index (1 km buffer)				
Model 1				
Walkability Index	-0.10 (-1.81, 1.60)	-0.04 (-1.20, 1.12)	-0.98 (-4.50, 2.54)	-1.77 (-3.44, -0.10)**
Parent crime safety perception	-2.35 (-7.56, 2.85)	-0.73 (-4.09, 2.63)	-6.92 (-17.71, 3.87)	-4.14 (-9.42, 1.13)
Walkability Index#Parent crime safety perception	0.56 (-1.10, 2.23)	-0.30 (-1.39, 0.80)	0.52 (-2.98, 4.02)	0.40 (-1.31, 2.10)
Model 2				
Walkability Index (1 km buffer)	0.06 (-1.64, 1.75)	-0.10 (-1.26, 1.06)	-0.76 (-4.28, 2.76)	-1.71 (-3.38, -0.04)**
Adolescent crime safety perception	1.23 (-3.90, 6.35)	-0.69 (-3.98, 2.61)	1.82 (-8.79, 12.43)	-0.52 (-5.71, 4.67)
Walkability Index#Adolescent crime safety perception	0.89 (-0.91, 2.68)	-0.93 (-2.09, 0.24)	-0.93 (-4.67, 2.81)	-0.70 (-2.53, 1.12)
Model 3				
Walkability Index (1 km buffer)	-0.10 (-1.77, 1.58)	-0.02 (-1.16, 1.12)	-0.83 (-4.24, 2.58)	-1.65 (-3.29, -0.02)**
Parent stranger danger safety perception	-1.30 (-7.67, 5.07)	-2.26 (-6.36, 1.84)	-21.71 (-34.82, -8.61)**	-7.98 (-14.41, -1.55)**
Walkability Index#Parent stranger danger safety perception	-0.95 (-3.10, 1.19)	-1.63 (-3.04, -0.23)**	-2.77 (-7.23, 1.69)	-0.64 (-2.82, 1.55)
Model 4				
Walkability Index (1 km buffer)	0.02 (-1.66, 1.70)	-0.07 (-1.22, 1.08)	-0.83 (-4.31, 2.65)	-1.68 (-3.33, -0.02)**
Adolescent stranger danger safety perception	5.56 (-0.84, 11.95)	-1.76 (-5.93, 2.41)	-13.22 (-26.62, 0.19)	-7.31 (-13.87, -0.76)**
Walkability Index#Adolescent stranger danger safety perception	0.52 (-1.60, 2.65)	-1.17 (-2.57, 0.23)	0.71 (-3.74, 5.17)	0.07 (-2.10, 2.25)
Parks and Recreation Facilities (1 km buffer)				
Model 1				
Parks and Recreation Facilities	0.11 (-0.76, 0.98)	-0.23 (-0.83, 0.37)	-0.74 (-2.54, 1.07)	-1.15 (-1.99, -0.30)**
Parent crime safety perception	-2.12 (-7.29, 3.06)	-0.91 (-4.25, 2.43)	-6.73 (-17.45, 3.98)	-3.72 (-8.94, 1.50)
Parks and Recreation Facilities#Parent crime safety perception	0.39 (-0.57, 1.35)	-0.53 (-1.15, 0.09)*	-0.89 (-2.88, 1.10)	-0.21 (-1.18, 0.76)
Model 2				
Parks and Recreation Facilities	0.20 (-0.68, 1.07)	-0.21 (-0.80, 0.39)	-0.70 (-2.50, 1.10)	-1.15 (-1.99, -0.31)**
Adolescent crime safety perception	1.40 (-3.68, 6.47)	-0.84 (-4.11, 2.44)	1.84 (-8.67, 12.34)	-0.22 (-5.34, 4.90)
Parks and Recreation Facilities#Adolescent crime safety perception	0.64 (-0.25, 1.53)	-0.27 (-0.85, 0.31)	-0.89 (-2.75, 0.97)	-0.44 (-1.35, 0.47)
Model 3				
Parks and Recreation Facilities	0.11 (-0.76, 0.98)	-0.11 (-0.71, 0.48)	-0.50 (-2.26, 1.26)	-1.08 (-1.92, -0.24)**
Parent stranger danger safety perception	-1.56 (-7.93, 4.82)	-2.67 (-6.78, 1.45)	-22.08 (-35.19, -8.97)**	-7.62 (-14.05, -1.19)**
Parks and Recreation Facilities#Parent stranger danger safety perception	-0.03 (-1.37, 1.31)	-0.28 (-1.15, 0.59)	0.52 (-2.25, 3.30)	0.30 (-1.07, 1.66)
Model 4				
Parks and Recreation Facilities	0.17 (-0.70, 1.04)	-0.21 (-0.80, 0.38)	-0.66 (-2.45, 1.12)	-1.13 (-1.97, -0.30)**
Adolescent stranger danger safety perception	5.76 (-0.61, 12.13)	-2.05 (-6.20, 2.11)	-12.97 (-26.33, 0.39)	-7.00 (-13.52, -0.49)**
Parks and Recreation Facilities#Adolescent stranger danger safety perception	0.81 (-0.33, 1.95)	-0.56 (-1.32, 0.20)	-0.96 (-3.35, 1.43)	-0.62 (-1.77, 0.54)

*p-value<0.10, only for interactions. **p-value<0.05. All models were adjusted by site, adolescent age, adolescent gender, adolescent ethnicity, adolescent working status, adolescent driving license, parent educational level, parent marital status, adults at household, vehicle per driving license at household. Sedentary time models were also adjusted by accelerometer model, accelerometer wearing time. Sample sizes: Non-school sedentary time (n=869), Riding car, bus (n=912), Screen time (n=912), TV time (n=912).

Figure S1. Plotting Walkability Index × Parent crime safety perception interaction on active transport to/from school in all sample.

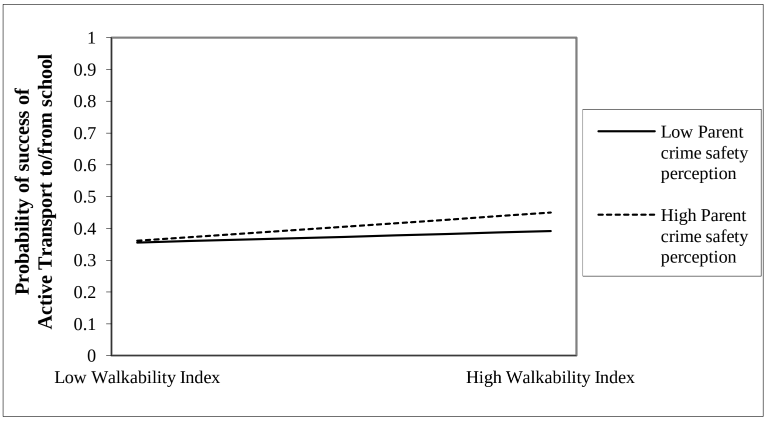


Figure S2. Plotting Parks and Recreation Facilities × Parent crime safety perception interaction on Leisure Time Physical Activity in the neighborhood in all sample.

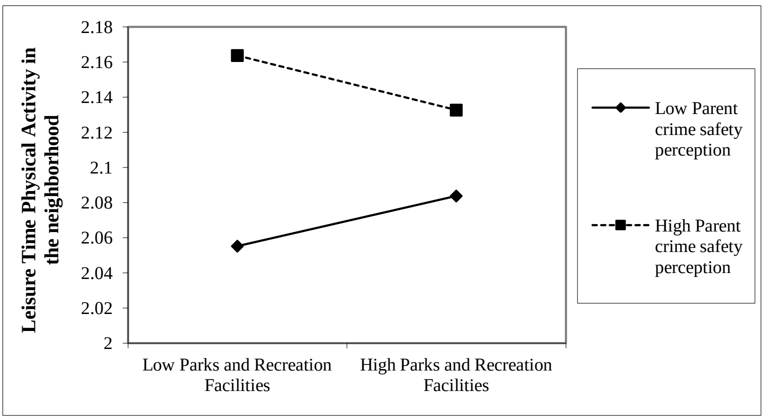


Figure S3. Plotting Walkability Index × Parent stranger danger safety perception interaction on Leisure Time Physical Activity in other places than near participants' home in all sample.

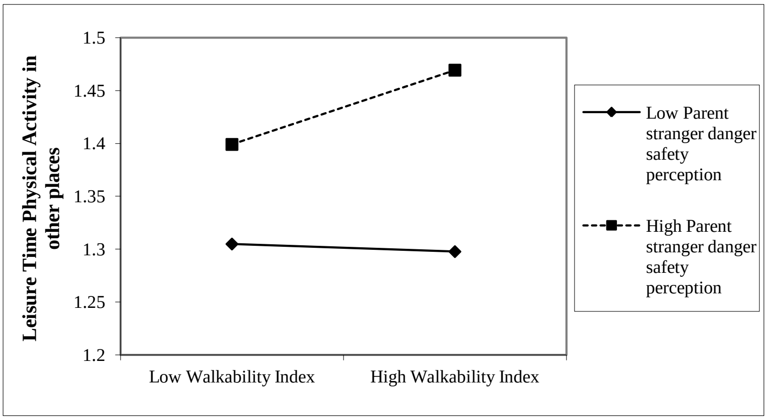


Figure S4. Plotting Walkability Index × Parent stranger danger safety perception interaction on riding a car, bus, etc., in all sample.

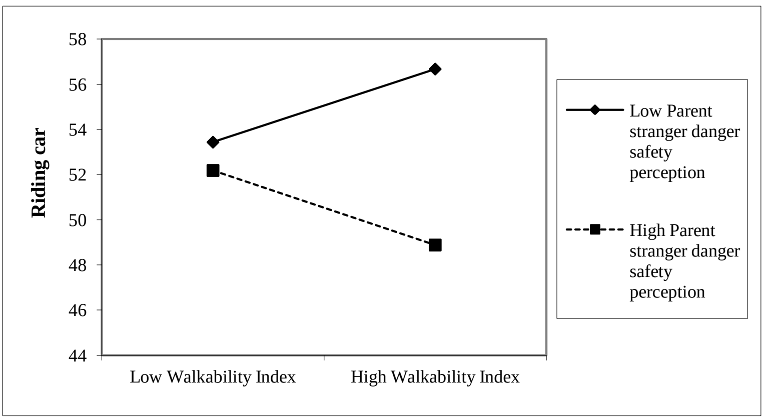
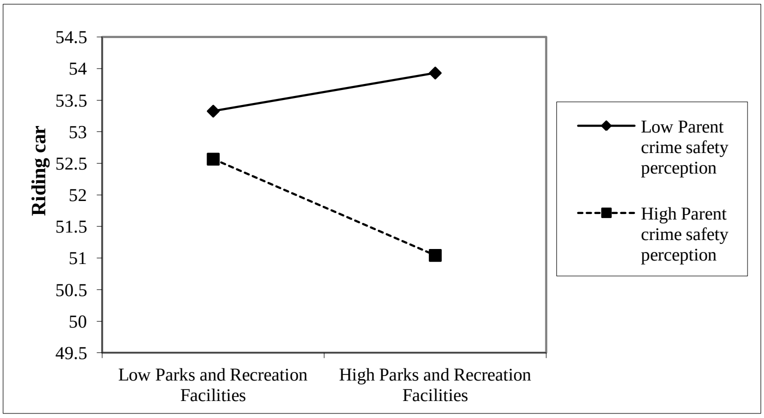


Figure S5. Plotting Parks and Recreation Facilities × Parent crime safety perception interaction on riding a car, bus, etc., in all sample.



5.2 Paper II

Avila-Palencia, I., de Nazelle, A., Cole-Hunter, T., Donaire-Gonzalez, D., Jerrett, M., Rodriguez, D.A., Nieuwenhuijsen, M.J.

The relationship between bicycle commuting and perceived stress: a cross-sectional study

BMJ Open. 2017;7(6):e013542. doi:10.1136/bmjopen-2016-013542.

5.3 Paper III

Avila-Palencia, I., Int Panis, L., Dons, E., Gaupp-Berghausen, M., Raser, E., Götschi, T., Gerike, R., Brand, C., de Nazelle, A., Orjuela, J.P., Anaya-Boig, E., Stigell, E., Kahlmeier, S., Iacorossi, F., Nieuwenhuijsen, M.J.

The effects of transport mode use on self-perceived health, mental health, and social contact measures: A cross-sectional and longitudinal study

Environ Int. 2018;120:199-206.
doi:10.1016/J.ENVINT.2018.08.002.

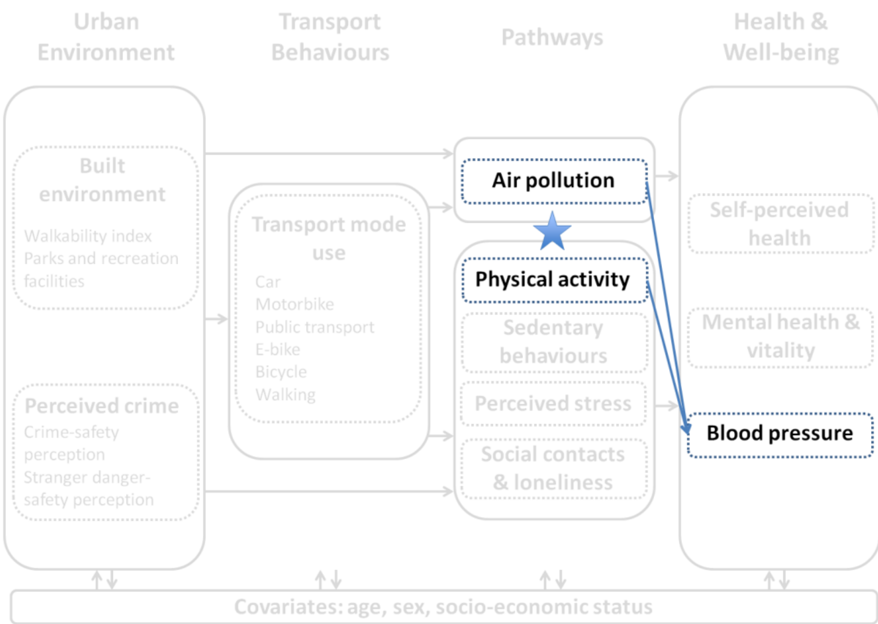
5.4 Paper IV

Avila-Palencia, I., Laeremans, M., Hoffmann, B., Carrasco-Turigas, G., Cole-Hunter, T., de Nazelle, A., Dons, E., Götschi, T., Int Panis, L., Orjuela, J.P., Nieuwenhuijsen, M.J.

Effects of physical activity and air pollution on blood pressure

Environ Res. 2019 Jun;173:387–96. DOI: 10.1016/j.envres.2019.03.032

Urban determinants of health, health outcomes, and relationship between them evaluated in Paper IV.



6 DISCUSSION

In order to address the thesis' general objective to evaluate associations and interactions between different urban determinants of health and different health outcomes, four research papers were presented. First, a cross-sectional study evaluated the effect modifications of parental and adolescents' perceptions of neighbourhood crime-related safety (crime rate and stranger danger) in the associations between built environment and adolescents' physical activity and sedentary behaviour (Paper I). Then, two studies evaluated the association between different transport modes and several health and social contact measures in adult (Papers II and III). Finally, the main and interaction effects of black carbon and physical activity on arterial blood pressure were assessed in a panel study of healthy adults (Paper IV).

In Paper I, findings indicated that perceived crime and built environment may work together in explaining adolescent physical activity and sedentary behaviours. Papers II and III showed that active transport, mainly bicycling, is associated with several positive health effects. Finally, results from Paper IV provided evidence that short-term and long-term exposure to moderate-to-vigorous physical activity is associated with a decrease in systolic blood pressure levels.

The following sections aim to provide an overall and integrated interpretation of the present thesis by discussing main findings and contributions to current knowledge, limitations and strengths, implications for public health, and finally future research.

6.1 Main findings and contributions to current knowledge

6.1.1 The role of perceived crime in the association between built environment and physical activity and sedentary behaviours

Paper I is the first study to evaluate effect modifications of parental and adolescent's perceptions of neighbourhood crime-related safety (crime rate and stranger danger) in the associations between objective built environment and multiple indicators of adolescents' physical activity and sedentary behaviours. Findings of Paper I indicated that crime-related safety perceptions and built environment may work together to explain adolescent physical activity and sedentary behaviours, showing some differences between genders.

On one hand, the results of Paper I showed that higher walkability and more parks and recreation facilities were associated to higher levels of adolescents' active transport. These findings are consistent with previous literature from adults [96–99] and youth population [100]. On the other hand, the results of Paper I showed that higher crime-safety perceptions (perceptions of feeling safe in relation to crime) were associated to higher physical activity levels in all domains (overall, transport, recreation) only in girls' sample. The statistically significant results were for parents' perceptions, which go in line with results presented in a previous study done with the same study population [49]. Regarding to sedentary behaviours, the results of Paper I showed that higher crime-safety perceptions were mainly associated to less time spent watching a screen and the TV in both genders.

The most conclusive results about interaction effects were found in the girls' sample. Results showed that a high safety perception (regarding adolescent crime-safety perception and parent stranger danger-safety perception) may reinforce the walkability effect on active transport to/from school among girls. Those results go in line with the ones found by a study done with the same population [101]. Wang 2017 [101] found that the built environment seems to have stronger facilitating effects on active transport among adolescents who had lower perceived neighborhood barriers, which included being afraid because of crime.

Paper I results also showed that girls with parents who have low safety perceptions were more likely to ride a car/bus if there were higher walkability index and more parks and recreation facilities in a 1 km buffer from participants' residence. Additionally, girls with parents who have low safety perceptions were more likely to spend more time in front of a screen having more parks and recreation facilities around their home.

There is the idea that increasing walkability and street lighting, increases the number of pedestrians in the street, and therefore increases surveillance. But, the social environment can determine the effectiveness of that surveillance [88]. Having more people in the street can be beneficial if there is a general sense of trust established in the streets and also if the walkability infrastructure follows some aesthetics that make people feel more secure and willing to walk through it. However, it has also been suggested that walkable and accessible streets can provide increased opportunities for crime, particularly if they are located in low density suburbs, where 'eyes on the street' are reduced [102]. This idea goes in line with the results of Paper I, which showed that if there is a low safety perception of the neighbourhood, having potentially more people in the streets could encourage more isolating behaviours such as using motorized transport to feel more protected from the "outside hazards".

6.1.2 Effects of transport on health and social contacts measures

The results of the present thesis have shown that active transport, mainly bicycling, is associated with several positive health effects. In Paper II and Paper III the association between bicycle use and perceived stress was assessed. In both papers, the same direction of effects on perceived stress was obtained for bicycling, having measured bicycle commuting in Paper II and general bicycle use in Paper III. The similar results reinforce the idea that bicycle use could lead to stress reduction, independently of the trip purpose. In Paper III bicycle use was also associated with good self-perceived health, better mental health, and higher vitality. Similarly, walking was positively associated with better self-perceived health and vitality. In regards to bicycle results, the results are in line with previous studies that associated bicycle use with better health outcomes: perceived general health [103], perceived stress [24], mental well-being [25,104], and quality of life [27]. Regarding to walking results, Paper III added more evidence about positive health effects of walking to the inconsistent current evidence.

All these positive results regarding active transport modes are hypothesized to be related to how the trip is perceived. Qualitative research has suggested that the choice of travel mode may affect well-being due to the fact that travelling (mainly commuting) can be perceived as a relaxing or transitional time between home and work life, which can also be about enjoying pleasant landscape, nature, and wildlife [105]. Previous studies have found that cyclists and walkers perceived their work commute as relatively relaxing and exciting [89,106], cyclists being the most satisfied travellers [107]. The quantity of public bicycles (*Bicing*) stations and the amount of greenness have also been related to bicycle commuting propensity [108], which could imply that commuting by bicycle provides people with more opportunities to “enjoy” or “experience” greenness than commuting in public transport or a car. At the same time, the availability of green space close to one’s home has been shown to be related to better self-perceived general health and better mental health [109–111]. Zijlema 2018 [112] found that commuting through natural environments is associated with better mental health and this association is reinforced if the commuting is done actively. Therefore, it seems that perceptual and environmental factors related to active transport could affect positively to mental health outcomes. This general idea is consistent with results of Paper II which show an inverse association between perceived stress and bicycle-friendly environments (public bicycle stations and bikeability levels) in work/study address area and the commute route. Therefore, all the positive health effects we found could be a result of a repeated high travel satisfaction in daily life.

Furthermore, in the present thesis, for the first time, the association of transport mode use with social contact measures was assessed. Results of Paper III showed an association of bicycle use with fewer feelings of loneliness, and walking with having contact with friends/family at least once a week. These results suggest that the use of active transport (i.e. bicycle and walking) could help to improve social cohesion in communities and neighbourhoods, ergo reduce feelings of loneliness of the population.

It has been suggested that transport mode use can affect social perceptions and therefore it can have significant implications for community well-being and cohesion. This suggestion relies on the "thin slicing" theory which says that people have the ability to create judgements of others with a very small amount of information (100 milliseconds), and generally negative judgements tend to be formed more rapidly than positive ones [113]. To assess the application of "thin slicing" theory in transport mode use, Gatersleben et. al. 2013 [114] did a study to explore whether the mode by which people travel through a neighbourhood affects the views they form of the environment and the social situation. They made participants watch a video showing a journey in which the participant saw a view of young people from a walking, cycling, sitting on a bus or sitting in a car perspective. The results found that cyclists felt less annoyance about what they were seeing and, together with walking, reported significantly more positive views of the young people in the street than car drivers [114]. That means that modes of transport like walking and bicycle make travellers more prone to form “good judgement” of their social environment than travellers of faster modes of transport (e.g. motorized). Thus, it seems that active modes of transport can be a tool to increase trust levels in neighbourhoods.

6.1.3 Effects of physical activity and black carbon on blood pressure

Results from Paper IV provide evidence that short-term and long-term exposure to moderate-to-vigorous physical activity is associated with a decrease on systolic blood pressure levels. The study results support the positive effect of physical activity on systolic blood pressure previously found in the literature [93,115]. In regards to the effects of black carbon, evidence for a consistent main effect of black carbon exposure on blood pressure was not found, neither an interaction between black carbon exposure and physical activity levels. Results found for black carbon do not support the majority of evidence which concluded that air pollution is significantly associated with higher blood pressure levels [74,75]. This result inconsistency means that the relationship between black carbon and blood pressure needs further research.

Paper IV main contribution to current knowledge is related to its unique study design, which helped to infer conclusions to real-life physical activity levels. More details about the study design strengths can be found in Paper IV.

6.2 Limitations and strengths

6.2.1 Limitations

The representativeness of the study populations needs to be questioned. In the four studies (Paper I to Paper IV), all adult participants were highly educated (university degree and higher), not being representative of the general population. Therefore, in Paper I to Paper IV the adult populations reported behaviours might not be necessarily those of the general population and therefore generalizability of the findings needs to be questioned.

In addition, all studies were carried out in western societies; as a consequence, the results are not fully applicable to other geographical contexts. Particularly Papers I and III presented some results that can be explained by their specific geographical context. Paper I was carried in the US context, where crime-related safety perceptions are a more important issue than in other geographical and social contexts like in Europe. One of the main results was that girls with parents who have low safety perceptions were more likely to ride a car/bus if there were higher walkability index and more parks and recreation facilities in a 1 km buffer from participants' residence. This result could be a consequence of a lack of general sense of trust in the streets, which makes us think that in a context where a general sense of trust is established results would be different. Furthermore, Paper III indicated that more frequent car use was associated with fewer feelings of loneliness. Participants of Paper III were recruited within European cities, were not very frequent car users (mean(SD) of days/month= 6.67 (7.54)), and had their median distance from home to work/study around 5 km. In a context with higher car dependency and urban sprawl (e.g. US), it is very likely that the presented participants' characteristics would be different. Therefore, we can think that the results could be more similar to what has been found in previous literature, associating car use with social isolation.

In Paper III, the study population had a low representation of car, motorbike, and e-bike use, which might have led to an underestimation of the health effects of car, motorbike, and e-bike use, and therefore results on these modes of transport need to be understood as inconclusive.

Regarding the exposure assessment, there are different limitations that can be found in each paper. In Paper I, 1km buffers of walkability index and parks and recreation facilities were used as proxies for built environment indicators. For instance, using the number of parks and recreational facilities as a proxy of recreation environments makes sense in terms of conceptualizing the space in relation to its use, but it could be lacking of rigor due to the different types, quality, and maintenance of these spaces that are not considered in this definition, and could be differently affected by covariates such as for instance socio-economic status. In Papers II and III, the exposure assessment was done by a questionnaire which may be prone to recall bias and have random misclassification error of transport behaviours.

Regarding outcome assessment, different limitations can be found in each paper. The majority of the outcomes assessed in Papers I, II, and III were self-reported, which can be prone to recall bias and have random misclassification. Additionally in Paper II, the modification of the 5-point PSS-4 Likert scale into a 4-point Likert scale could incorrectly-estimate the perceived stress. In Paper IV, blood pressure was measured three times a week. A more accurate measurement of blood pressure could have been done with a real-time monitoring.

Three of the four studies (Paper I to Paper III) applied a cross-sectional study design. Since repeated measurements over time of exposures and health outcomes were unavailable, causality cannot be inferred. In fact, reversed causality cannot be ruled out. It might be that, for example, those individuals who are more stressed would bicycle less, or those who feel more fatigue walk less.

6.2.2 Strengths

In the present thesis a wide range of urban related exposures and different health outcomes were covered, allowing to produce a holistic perspective of how the urban environment can influence transport behaviours and physical activity participation, that subsequently may affect human health and well-being distinctively.

A great strength of Paper I and Paper IV was the use of objective measures to assess exposures and health outcomes, which adds reliability to the findings. Built environment measures (walkability index and parks and recreational facilities) were assessed with GIS, personal black carbon concentrations were measured using a microAeth (model AE51, Aethlabs, USA), physical activity and sedentary behaviours were assessed with validated personal sensors (Actigraph and SenseWear), and blood pressure was assessed with a blood pressure monitor (model M10-IT, Omron).

Another great strength of Paper I to Paper III is that validated questionnaires were used for the health and social contact measures (PSS-4 [66], SF-36 [57], UCLA loneliness scale [95]), and crime-related safety perceptions (NEWS-Y [94]).

Moreover, in Papers I, III, and IV single and multiple exposure analyses were conducted in order to discard residual confounding. Multiple exposure models may be more realistic as they isolate the effect of specific exposures after adjustment for others. Papers I and IV aimed to assess interaction effects. Previous to the interaction assessment, single and multiple exposure analyses were done to assess the main effects of the corresponding exposures and then adjusted one by the other. In Paper III, single and multiple exposure approaches were done to study the different transport behaviours separately and then adjust for all the transport behaviours together. Paper III used multiple exposure to represent multiple transport mode use which is a reality for many people nowadays.

In Papers III and IV, associations were analyzed using both pooled analyses and stratified by city using the meta-analyses as sensitivity analyses. The use of meta-analyses as sensitivity analyses allowed us to check if city effects were properly accounted for in Papers III and IV. The pooled analyses results were fairly consistent with the meta-analyses results, suggesting that city effects were properly accounted for, which may be due to cultural, social, exposures, and other differences between cities.

Furthermore, the results across the different papers were consistent. In Papers II and III the same direction of effects of bicycling as a commuting mode (Paper II) and as a transport mode in general (Paper III) on perceived stress was found. Those who bicycled more had less perceived stress.

All studies presented large sample size and good internal validity due to the recruitment strategy. Papers I and IV used exclusion criteria designed to maximize internal validity while eliminating factors that might interfere with the ability to test the hypotheses. Papers II and III oversampled bicycle users in order to have a good representation of this transport behaviour and to be able to study the effects of bicycle use separately to the effects of walking.

An innovative aspect of the present work is that participants were recruited from different western geographical regions featuring different socio-cultural environments making the results more generalizable. In Paper I, participants were from two regions of the United States (Baltimore, Maryland-Washington DC and Seattle-King County, Washington) that differed in demographic composition, climate, geography, and era of development. In Paper II, participants were from a Southern European city (i.e. Barcelona) with a very compact and dense urban design, in contrast with the majority of the previously studied urban contexts of related literature. Finally, in Papers III and IV participants were from different European cities (Antwerp, Barcelona, London, Örebro, Rome, Vienna, and Zurich) with different urban designs and transport systems facilitating different travel behaviours.

Paper IV had a unique design: an observational real world study with participants from three European cities exposed to their everyday life conditions. This design gave the opportunity to study the associations and interactions in real conditions and in different cities, making the results more generalizable to European context.

6.3 Implications for public health and for policy making

The present thesis showed that perceived crime and built environment may work together to explain adolescent physical activity and sedentary behaviours, mainly in transport domain (Paper I). Active transport, mainly bicycling, was found to be associated with several positive health effects (Paper II and Paper III). Furthermore, short-term and long-term exposure to moderate-to-vigorous physical activity levels was associated with a decrease in systolic blood pressure levels (Paper IV). All the different associations and interactions found were related to increase physical activity levels in urban environments. Thus, policies should be directed to increase physical activity levels in cities by promoting active transport, mainly bicycle use.

Paper I showed that higher walkability and more parks and recreation facilities were associated to higher levels of adolescents' active transport. Similar findings were shown in previous literature for other age groups (adults and youth population) [96–99,100], which shows that increasing walkability levels and the number of parks and recreation facilities could be a good approach to increase active transport in all age-range populations. Moreover, results from Paper I showed that high crime-safety perceptions may reinforce the walkability effect on active transport to/from school. Those results suggest that the implementation of combined interventions improving crime-safety perceptions and increasing walkability levels is needed to promote active transport in neighbourhoods. This might be true mainly in contexts where crime-safety perceptions are an important issue (e.g. US context as in Paper I). Previous literature proposed that built environment interventions such as reducing incivilities (e.g. broken urban furniture, dirty streets, vacant and abandoned lots, etc.) from neighbourhoods can improve individual's perceptions of the built environment [46], therefore, increase crime-safety perceptions [116]. To conclude, policies should tackle factors to increase walkability index (residential density, street connectivity, retail floor area ratio, and land use mix), at the same time that quality of the approached built environment is improved.

The findings of this thesis also showed that more frequent active transport, mainly through bicycle use, is associated with good self-perceived health, better mental health, more vitality, less perceived stress, as well as more social contacts (Papers II and III). All the positive health effects related to bicycle use and walking, have been suggested to be the result of a repeated high travel satisfaction in daily life (Paper III). To improve the trip experience, and therefore affect positively to mental health outcomes, perceptual and environmental factors related to active transport seem to have a role (Paper II). It seems that active commuting through natural environments is also associated with better mental health [112]. Additionally, those living in neighbourhoods with better aesthetics, more water and green space, higher safety perception, more functional, with a larger social network, more social cohesion and who trust their neighbours are more likely to be happy [117]. So, urban and transport planning should consider environmental factors while promoting active transport.

Active transport is an accessible form of physical activity. Therefore, blood pressure reductions due to physical activity (Paper IV) could be achieved by promoting the uptake of active transport behaviours. In order to maintain population's state of cardiovascular health and optimal blood pressure, a solid population-based strategy, combining policy and environmental change, behavioural incentives, education, and community-level actions are needed [69]. In 2016, the Lancet Commission of hypertension identified ten key actions to improve the management of blood pressure at population and individual level. Two of these key actions were creating "health-promoting environments" and promoting "healthy behaviours". These two actions are directly related to what has been discussed throughout this thesis.

Moreover, collateral health benefits could be achieved through the reduction of adverse environmental exposures such as air pollution as a consequence of a transport shift from passive to active modes of transport (i.e. non-emitting modes of transport).

6.4 Future research

Low representativeness of all study populations (Paper I to Paper IV) was identified. In order to be able to extrapolate results to the general population, future studies need to design recruitment strategies in order to ensure the representativeness of the study population, with special emphasis in socio-economical status factors (e.g. educational level and employment status.). More representative study population would increase the generalizability of the results and therefore give better information to approach policy making. Also, in order to get results translatable to different populations and different contexts, more research is needed studying sex effects, different age groups (e.g. children, adolescents, elderly people), different socio-economic subgroups (e.g. deprived communities), and different socio-demographical settings (e.g. middle and low-income countries).

In Paper III, the health effects of motorbike use were unclear and no statistically significant results were found for e-bike. Motorbike and e-bike were the least represented transport modes in the study population leading to low statistical power and inconclusive results. Therefore, future research also needs to design recruitment strategies to ensure a fair distribution of all the different transport modes use to be able to get conclusive results.

The built environment assessment used in Paper I may lack some rigor. More microscale audits about built environment should be used as exposure assessment to better understand perceptions of social decontrol and disorder and thus measure how it can affect the crime-safety perception. Microscale factors of the built environment differ from macro-level design elements such as street connectivity and residential density. It includes details about streets, sidewalks, intersections, and design characteristics (e.g. road crossing features, presence of trees, bicycle lanes, curbs), as well as characteristics of the social environment (e.g. stray dogs, graffiti, trash). One of the suggested main determinants of fear of crime is the individual's perceptions of the built environment. Therefore, Paper I interaction results for sedentary behaviours could be explained in part by the presence of built environment incivilities (e.g. broken urban furniture, littering, abandoned lots, dirty streets, etc.).

More research assessing transport behaviours objectively is needed. The use of smartphone apps with transport mode recognition using the travel speed (e.g. Moves app) could be a good option to avoid potential misclassification error typical of questionnaire use.

Multiple transport mode analyses should be more used in future research. This approach seems to be closer to real life transport use and there are not many studies in the literature considering it. Walking results of Paper III suggested studying walking effects taking into account all the different transport behaviours to be able to identify its health effects.

Paper III was the first study to assess association between transport mode use and social contact measures. Therefore, more studies on how different built environments and transport use affect social contact outcomes are needed. In addition, a better assessment of social contacts is needed in those studies in order to capture frequency and quality of the social contacts. Social contacts need to be measured at the community level (e.g. neighbours), and at the individual level taking into account the trust in those who surround the individual, in order to measure social cohesion.

There is a need to obtain a clear understanding of the effects of built environments and different transport mode use on mental health and well-being. Moreover, the associations between environmental exposures and mental health outcomes [117,118]suggest to explore possible modifying effects of exposures like green space on the association between transport and mental health. There is a need to better understand the role of social contact measures in the urban environment and associated health outcomes. It has been suggested that more frequent social participation (i.e. more social contacts) is associated with better self-perceived health [53]. Moreover, the mediation effect of social factors has also been suggested in the study of associations between environmental exposures and different health outcomes [111]. Therefore, more research is needed to understand a possible mediation role of social contact measures between built environment/transport behaviours and health outcomes.

There is a need to conduct more longitudinal studies and quasi-experimental studies. Longitudinal studies with repeated measures can improve our understanding of the detected associations and rule-out reversed causality (i.e. is cycling reducing the cyclist’s stress level or are cyclists less stressed and therefore choose the bicycle?). Quasi-experimental studies such as pre-post intervention studies that aim to evaluate the effectiveness of urban and transport planning interventions are needed to provide decision makers and professionals with evidence on what policies really work. Research evidence should be incorporated by the urban and transport planning fields to ensure informed decision-making.

7 CONCLUSIONS

Overall, and in line with the objectives, the current thesis contributed to (1) understand the role of perceived crime in the association between built environment and physical activity and sedentary behaviours in adolescents; (2) understand the effects of transport mode use on self-perceived health, mental health, and social contact measures; and (3) understand the effects of physical activity and black carbon on blood pressure in the urban context.

The results of the present thesis suggest that neighbourhoods designed with high levels of walkability and high number of parks and recreation facilities are likely to increase adolescents' physical activity levels, mainly through active transport. The results also indicated that built environment measures (walkability and parks and recreation facilities) and crime-safety perceptions may work together to explain adolescent physical activity, the most conclusive interactions being the ones referring to transport behaviours (active and sedentary) in the girl sample.

Results also indicate that active transport, mainly bicycle use, can be a promoter of mental health and well-being, and a tool to boost social capital production.

Moreover, the results suggest that physical activity engagement in daily life appears protective for cardiovascular health through blood pressure levels reduction. Taking into account the results on active transport, it seems that active transport, mainly bicycle use, would help to reach the physical activity levels desired.

Urban and transport planning have a great potential to promote healthy behaviours and ensure mental and physical health of city dwellers.

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ANNEX I

Co-authored papers

1. Gascon M, Götschid T, Nazelle A de, et al. Determinants of walking in seven European cities: the PASTA project. *In Prep*.

2. Branion-Calles M, Gerike R, de Nazelle A, et al. Bicycling crash rates and risk factors adjusted by exposure in seven European cities: exploring different exposure measures as part of the PASTA project. *Under Rev*.

3. Castro A, Gaupp-Berhausen M, Nazelle A de, et al. Physical activity of electric bicycle users compared to conventional bicycle users: Insights based on health and transport from an online survey in seven European cities. *Under Rev*.

4. Gaupp-Berghausen M, Raser E, Anaya E, et al. Evaluating different recruitment methods in a longitudinal survey: Findings from the pan-European PASTA project. *Preprint*. doi:10.2196/preprints.11492.

5. Zijlema W, Avila-Palencia I, Mas MT, et al. Active commuting through natural environments is associated with better mental health: Results from the PHENOTYPE project. *Under Rev*.

6. Dons E, Laeremans M, Anaya-Boig E, et al. Concern over health effects of air pollution is associated to NO2 in seven European cities. *Air Qual Atmos Heal*. 2018. doi:10.1007/s11869-018-0567-3.

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12. Laeremans M, Dons E, Avila-Palencia I, et al. Physical activity and sedentary behaviour in daily life: A comparative analysis of the Global Physical Activity Questionnaire (GPAQ) and the SenseWear armband. *PLoS One*. 2017;12(5):e0177765. doi:10.1371/journal.pone.0177765.

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14. Dons E, Götschi T, Nieuwenhuijsen M, et al. Physical Activity through Sustainable Transport Approaches (PASTA): protocol for a multi-centre, longitudinal study. *BMC Public Health*. 2015;15(1):1126. doi:10.1186/s12889-015-2453-3.

ANNEX II

Outreach

March 2018	Environmental Sciences students visit to PRBB installations (Barcelona).
June 2017	Oxbridge Academic Programme. PRBB, Barcelona
May 2017	Science Party (“Festa de la Ciència”). Ciutadella Park, Barcelona
April 2017	Ambient Crític seminar. Barcelona Autonomous University (UAB)
April 2017	Talk: Què respirem a Sant Adrià? La contaminació i els efectes sobre la salut. Sant Adrià del Besòs
April 2017	Pol de Ciència. PRBB, Barcelona
March 2017	Environmental Sciences students visit to PRBB installations. PRBB, Barcelona
Jan-June 2017	STEM project. IES Barri Besòs, Barcelona
July 2016	Oxbridge Academic Programme. PRBB, Barcelona
June 2016	Science Party (“Festa de la Ciència”) 2016. Ciutadella Park, Barcelona
June 2016	MOVEMUS Fair. Terrassa
May 2016	Environmental Sciences students visit to PRBB installations. PRBB, Barcelona

April 2016	UPF Mobility Week. UPF Campus Poblenou, Barcelona
Oct 2015	Park(ing) Day 2015 Closing event. Barcelona
Oct 2015	PRBB Open Day 2015. PRBB, Barcelona
Sep 2015	Park(ing) Day 2015. Barcelona
April 2015	Science Party (NOVUM 2015). Barcelona
April 2015	Barcelona Citizen Science Day (NOVUM 2015). Barcelona
Oct 2014	PRBB Open Day 2014. PRBB, Barcelona

ANNEX III

Specialized courses - Given

June 2018 **Junta de Andalucía**. Málaga, Spain

Speaker

Giving a talk about "Healthy Public Space" and participating in workshops to give tips and tools to professionals from different municipalities from Andalucía (Spain). Everything was part of the "II Jornada La Ciudad Sostenible y Humana 2018".

May 2018 **Diputació de Barcelona**. Barcelona, Spain.

Teacher

Teaching the section of "Urban health and mobility" from the "XII Course about Local Mobility, Management, and Planning". Annual course addressed to mobility and urban planning technicians from Diputació de Barcelona.

Jan 2018 **Diputació de Barcelona**. Barcelona, Spain.

Teacher

Elaboration and teaching the course entitled "Study about the effects of mobility planning and management on health", in collaboration with Dr Natalie Müller. The course was created by demand of the Diputació de Barcelona Mobility Department.

Ione Ávila-Palencia

Es licenciada en Ciencias Ambientales desde 2007, Técnico Superior en Prevención de Riesgos Laborales desde 2010 y Máster en Salud Pública desde 2014. Actualmente es investigadora predoctoral en el Instituto de Salud Global (ISGlobal) bajo la supervisión de Dr. Mark Nieuwenhuijsen. Ha trabajado tres años en el proyecto PASTA (http://www.pastaproject.eu/home/), financiado por la Unión Europea (UE), cuyo objetivo era evaluar la asociación entre transporte y salud en siete ciudades europeas. Actualmente está analizando los datos de PASTA y dando cursos sobre transporte y salud en la Diputación de Barcelona. Su tesis doctoral examina las asociaciones entre entorno urbano, transporte y diferentes resultados en salud.

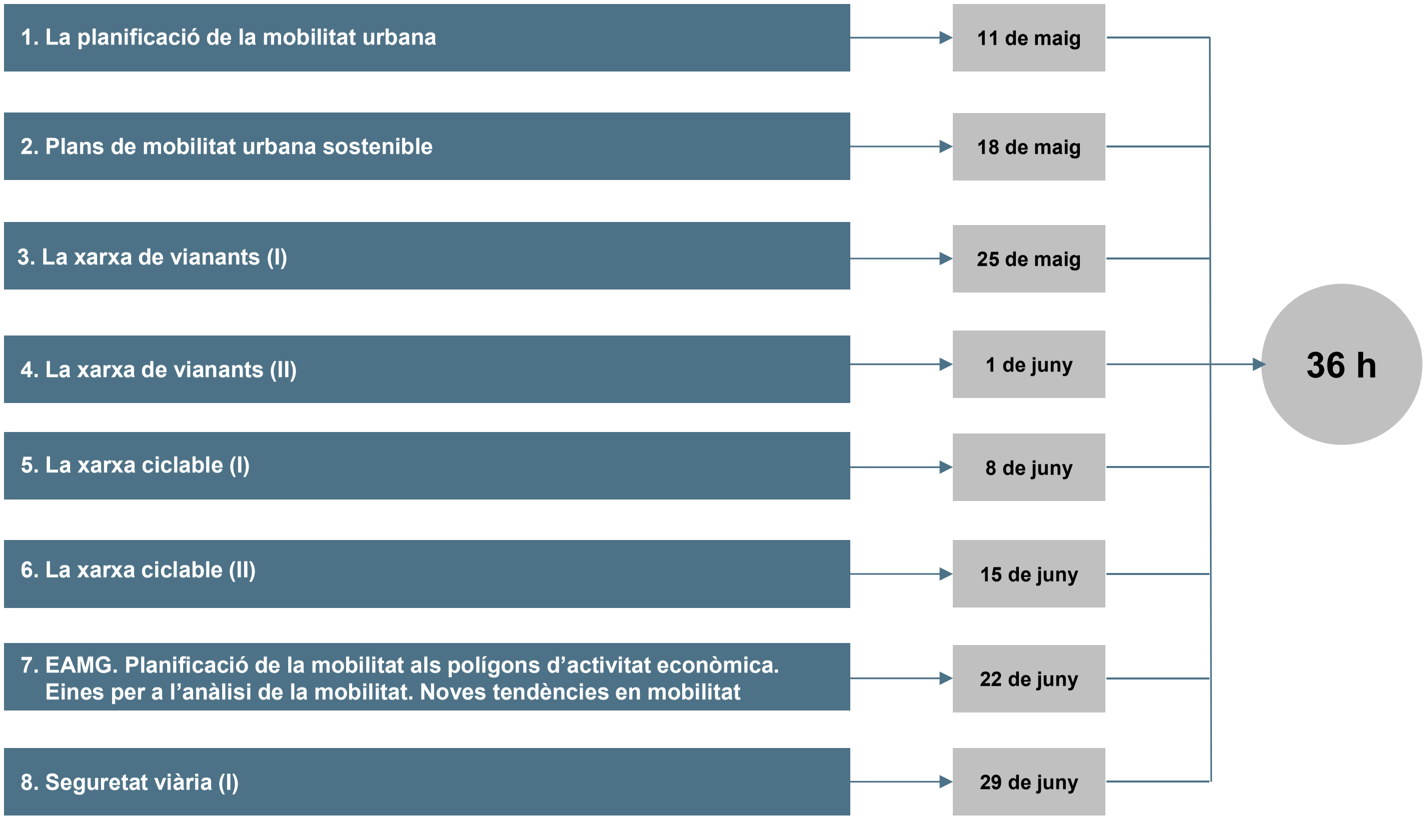
RESUMEN DE LA PONENCIA

El entorno urbano presenta múltiples factores de riesgo para la salud. La ponencia se centrará en presentar evidencia científica actual de los cinco factores de riesgo urbanos principales: polución del aire, ruido, calor, falta de espacios verdes/azules y bajos niveles de actividad física. Veremos cómo se interrelacionan entre ellos y como una buena planificación urbana y del transporte son claves para determinar sus efectos. Se darán ejemplos concretos de intervenciones donde se puede ver los retos y oportunidades en la planificación para tener un impacto en la salud y el bienestar.

XII Curs de Planificació i Gestió de la Mobilitat Local

Mòdul I

Diputació Barcelona | Àrea de Territori i Sostenibilitat



1a Sessió. La planificació de la mobilitat local

Divendres, 11 de maig de 2018

9:30 a 10:00	**Benvinguda i presentació a càrrec de la direcció del Curs** **PALOMA SÀNCHEZ-CONTADOR, enginyera de camins, canals i ports** **Cap de l'Oficina de Mobilitat i Seguretat Viària. Diputació de Barcelona**
10:00 a 11:00	**Marc de referència funcional en la planificació de la mobilitat a Catalunya** **LLUÍS ALEGRE, enginyer de camins, canals i ports** **Director tècnic de l'ATM**
11:00 a 11:30	**Pausa cafè**
11:30 a 12:20	**La planificació de la mobilitat als municipis de Barcelona** **HUGO MORENO MORENO, enginyer tècnic d'obres públiques** **Cap de la Secció de Mobilitat i Seguretat Viària. Diputació de Barcelona**
12:20 a 13:10	**Salut i mobilitat urbana** **Ione Avila-Palencia, ambientòloga** **Institut de Salut Global de Barcelona (ISGLOBAL)**
13:10 a 14:00	**Mobilitat i via pública** **MÀRIUS NAVAZO, geògraf** **Gea21**

XII Curs de Planificació i Gestió de la mobilitat local. Mòdul I

Maig – juny de 2018

11, 18 i 25 de maig

1, 8, 15, 22 i 29 de juny

Divendres de 9:30 a 14:00h

Lloc: Col·legi d'enginyers de camins, canals i ports
C/ Els Vergós, núm.16
08017 Barcelona

Propuesta Técnica para formación de sesión sobre Transporte y Salud (4 horas)

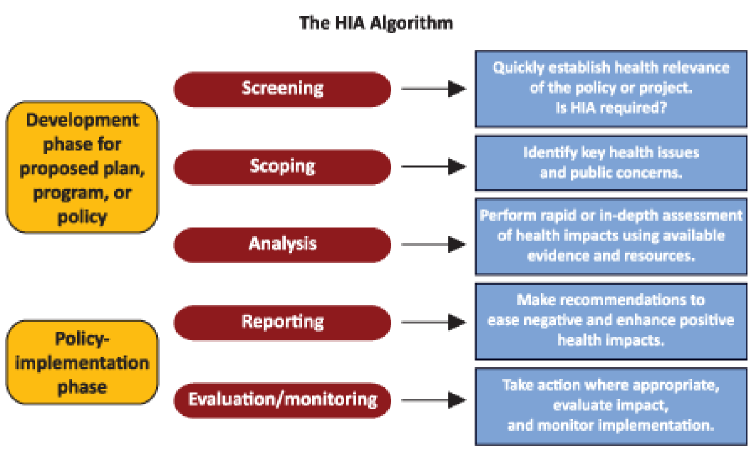
Introducción (1h)

El entorno urbano presenta múltiples factores de riesgo para la salud. En esta introducción nos centraremos en presentar evidencia científica actual de los cinco factores de riesgo en salud urbanos principales: actividad física, polución del aire, ruido, calor, y espacios verdes. Veremos cómo se interrelacionan entre ellos y como una buena planificación urbana y del transporte son claves para determinar sus efectos. Daremos unos ejemplos concretos de intervenciones donde se puede ver los retos y oportunidades en la planificación de movilidad para tener un impacto en la salud y bienestar.

Evaluación de los impactos de movilidad en la salud (health impact assessment; HIA) (1 h)

En esta sesión sobre los impactos de movilidad en salud nos centraremos en presentar las metodologías, herramientas e indicadores para entender y quantificar los vínculos entre el transporte y la salud.

Principalmente el enfoque al Health Impact Assessment como metodología. Se incluye el origen de HIA, su relación con evaluaciones de riesgos (risk assessment) y evaluaciones de impactos en el medioambiente (environmental impact assessment) y su aplicación en la Unión Europea ('health in all policies'). Presentaremos los pasos técnicos de HIA (screening, scoping, analaysis, reporting, evaluation/monitoring) y unas herramientas disponibles para evaluar los impactos de movilidad en la salud [*UTOPHIA tool* concepto, su aplicación en Barcelona y resultados; *health economic assessment tool for walking and cycling (HEAT)*, aplicación a un ejemplo)].



Case study con feedback (2h)

Ejemplo práctico de un HIA cualitativo basando en un ejemplo de un PMU local. En 3 grupos de 5 personas (o dos de 7), usaremos un PMU para poder empezar a aplicar los criterios de salud en los procesos de planificación de movilidad.

1.15 minutos revisión del caso PMU y trabajo en grupo, facilitado por las dos formadores.

45 minutos para presentación del plan de cada grupo y retroalimentación

Nota: esta parte lo podemos ampliar más en cuanto tengamos un ejemplo PMU para ver cuales aspectos y apartados se pueden trabajar y con cuales métodos.

ANNEX IV

Media impact of the papers and studies (Selection)

PROGRAMA SOBRE TRANSPORTE SOSTENIBLE

Laboratorios itinerantes

Voluntarios cargados de sensores participan en Barcelona en un gran estudio europeo

El proyecto pretende evaluar la movilidad y la salud en siete ciudades

MONICA PELLICCIA

Ionne Ávila-Palencia, investigadora del Creal, en el Parc de Recerca Biomèdica de Barcelona.

MICHELE CATANZARO
BARCELONA

Veinticuatro *cyborgs* andan estos días por Barcelona. Su presencia se nota poco, quizá solo por el extremo de un dispositivo que asoma en una mochila o una camiseta. Sin embargo, debajo de la ropa llevan media docena de sensores que miden sus desplazamientos, el estado de su organismo y el del ambiente donde se mueven. Son voluntarios de un proyecto de investigación que pretende monitorear durante dos años a 14.000 adultos de siete ciudades europeas. Los científicos buscan voluntarios para llegar a 40 personas en Barcelona este año.

El proyecto, llamado PASTA (Actividad Física mediante Planteamientos de Transporte Sostenible, por sus siglas en inglés), estudia cómo afecta la elección de ciertos medios de transporte (por ejemplo, la bicicleta o el coche) a la salud de los ciudadanos, en particular a la actividad física y el riesgo de accidentes. En Barcelona, Amberes y Londres se lleva a cabo un subproyecto que añade una pregunta más: el efecto de la calidad del aire en la salud respiratoria y cardiovascular. Los laboratorios con piernas que deambulan estos días por la ciudad pertenecen a este subproyecto, que echó a andar en febrero.

«El dispositivo para medir la calidad del aire [una caja de las dimensiones de un *walkie-talkie* con un tubo que tiene que estar siempre al aire] es bastante visible. Cuando algún conocido lo ve se pone curioso y pregunta. Y es una oportunidad para explicarle el proyecto», comenta Luca Tancredi Barone, uno de los voluntarios. «Lo tengo en el bolso y no se ve mucho, pero el dispositivo que llevo con una cinta en el brazo [un medidor de actividad física] se nota y la gente pregunta», apunta Gemma Castaño, otra voluntaria. «Todo el instrumental me ha hecho más consciente de mis prácticas diarias, de cómo me muevo por Barcelona y de la actividad física que hago», dice otra voluntaria, Teresa Arechavala.

GPS Y TELÉFONO // Los participantes en el proyecto llevan también un pequeño GPS y un *smartphone* fijado debajo del ombligo. Algunos días también se aplican un medidor del latido del corazón y se toman la presión. Además, tienen que recargar los dispositivos por la noche, cambiar los filtros del medidor de calidad del aire, rellenar varios cuestionarios y acudir a revisiones médicas. Todo esto durante tres semanas, repartidas durante un año, con una pequeña compensación de 150 euros. «Al principio te desconcierta porque son muchos dispositivos, pero luego te acostumbras», afirma Castaño.

«Cuando cambio el filtro y veo que está negro, me da qué pensar», afirma Barone. La preocupación por la calidad del aire es la motivación de la mayoría de los voluntarios. Pero también les interesa la movilidad. «Es importante tener datos objetivos sobre el aire y cómo nos movemos», afirma Barone, que se desplaza principalmente en bicicleta por Barcelona. «Vivimos en una ciudad muy contaminada, y me gustaría saber cómo afecta a quien se desplaza en moto», dice Castaño, que usa ese medio de transporte. Además, diversos voluntarios tienen educación científica: Barone en astronomía, Castaño en ciencias ambientales y Arechavala en biología.

TRABAJO PIONERO // No se había hecho nunca un estudio de este tipo en tantas ciudades y de forma tan extendida en el tiempo. «El objetivo principal del proyecto es cuantificar cómo ciertos modos de transporte aumentan la actividad física de la población y su relación con el número de accidentes», explica Ione Ávila-Palencia, investigadora del Centre de Recerca en Epidemiologia Ambiental (Creal), que coordina las mediciones en Barcelona. La teoría detrás del proyecto es la del transporte activo: es decir, que integrar la actividad física en los desplazamientos diarios (por ejemplo, yendo en bicicleta o a pie para tomar el transporte público) puede ser más efectivo en promover la salud que esperar a que la población se apunte masivamente al gimnasio. En las tres ciudades del subproyecto actual se va a estudiar el papel que desempeña este escenario en la calidad del aire. «La idea es comparar ciudades para tener una visión a nivel europeo», explica Ávila-Palencia.

De momento, la investigadora está muy contenta con el nivel de cumplimiento de sus compromisos por parte de los voluntarios. «Es un pequeño sacrificio, pero no quita mucho tiempo», observa Barone. «Yo personalemnte no sacaré nada de esto, pero espero que los resultados se trasladen en mejores políticas de aire y movilidad», dice Castaño.

MONICA PELLICCIA

Gemma Castaño y Luca Tancredi Barone, dos de los voluntarios.

BCN, por encima de los niveles de contaminación

Los efectos nefastos de la contaminación en Barcelona están bien documentados. Si las partículas PM10 presentes en el aire cumplieran los niveles recomendados por la Organización Mundial de la Salud (OMS), se evitarían 3.500 muertes anuales en el área metropolitana, según un estudio del 2009 del Creal. A los voluntarios de PASTA les gustaría que los científicos del proyecto les dieran información más personalizada. «Me gustaría tener una evaluación del aire que respiro en mis recorridos diarios», dice Barone.

EL ADN de la semana

PERE Puigdomènech

Mamuts

El genoma de la semana es el de dos mamuts de Siberia que vivieron uno hace más de 40.000 años y el otro hace más de 4.000. La comparación de los dos genomas nos da un testimonio del destino de la especie hacia su extinción. La calidad de estos genomas nos plantea además la pregunta de si un día nos podremos proponer revivir a este animal.

El trabajo lo han realizado investigadores suecos y estadounidenses con un grupo ruso que ha colaborado en el acceso a las muestras. Una de estas proviene de los restos de un animal joven encontrado congelado en el este de Siberia y datado hace 44.800 años, cuando los mamuts lanudos poblaban muchos lugares de Europa y Asia. El otro vivió hace 4.300 años en la isla ártica de Wrangel, refugio de los últimos mamuts. La comparación de los dos genomas y de otro publicado hace siete años nos permite ver cómo la diversidad genética de la especie se había ido reduciendo entre las dos fechas, un preludio de su extinción.

¿Vale la pena revivir especies que el hombre contribuyó a extinguir?

Los cambios en el clima que sucedieron en el planeta hace 12 milenios tuvieron enormes efectos. Fueron el punto de partida de la revolución agrícola, pero también fue un momento de grandes extinciones de mamíferos. Es posible que a ello también contribuyera la acción de los humanos. Cuando vivió el primero de los ejemplares de mamut estudiados, el *Homo sapiens* aún no ocupaba toda Europa ni había llegado a América. El segundo lo hizo cuando se construían las pirámides de Egipto, y las ciudades de Mesopotamia hacía siglos que existían.

La pregunta ahora es si debemos revivirlos después de haber colaborado a extinguirlos. Si hay una especie en que esto sea factible, es justamente el mamut: hay muestras congeladas y no parece imposible algún día reemplazar el ADN de un embrión de elefante e implantarlo en una hembra. Pero habría todo tipo de complicaciones para quizá ver al final solo un ejemplar o dos. Sería fascinante ver un mamut vivo, pero no es seguro que valga la pena.

CONTAMINACIÓ DE L'AIRE

Històries de pol·lució quotidiana

Cinc voluntaris, que han portat a sobre durant tres setmanes sensors de qualitat de l'aire, han comprovat el desbocat nivell de contaminació al qual s'exposen cada dia a Barcelona. Estan convençuts que a la ciutat hi sobren cotxes.

PER **MICHELE CATANZARO**

Luca Tancredi viu a l'Eixample i treballa a la Zona Universitària. Cada dia, quan va i torna en bici per la Diagonal, pren la seva ració de 4.000 nanograms de carboni negre per metre cúbic d'aire. Marcos López viu a Canovelles i es desplaça en tren fins al seu centre de treball al passeig Marítim. A ell li toquen **«tan sols»** 2.000 nanograms durant el desplaçament. Charlotte Bouchet és a l'atur i fa voltes per la ciutat per buscar feina: la seva dosi és alta, però se la pren a glops durant tot el dia. Aquestes són algunes de les històries d'intoxicació diària que pateixen tots els habitants de Barcelona.

Normalment, els efectes de la contaminació atmosfèrica es presenten com a estadístiques globals: 1,4 milions de morts anuals per ictus, 1,7 per diverses patologies pulmonars, etcètera, segons dades de l'Organització Mundial de la Salut (OMS). Així mateix, se succeeixen un darrere l'altre estudis que alerten del subtil retard mental induït per la pol·lució en els escolars, o del risc més gran de malalties neurodegeneratives en les proximitats de les carreteres.

També se sap que Barcelona se salta des de fa anys els límits imposats per la Unió Europea, que són més imprudents que els aconsellats per l'OMS. No obstant, el pànic no s'estén. Al contrari, les mesures contra el trànsit de cotxes (el principal responsable de la pol·lució a la ciutat) troben rebuig.

Un projecte d'investigació portat a terme fa un any i mig, que comença ara a obtenir resultats, ha trencat l'embruix dels grans números i les estadístiques abstractes. El projecte PASTA (acrònim de Physical Activity through Sustainable Transport Approaches) va reclutar 40 voluntaris a Barcelona (i la mateixa quantitat a Londres i Anvers), que van portar a sobre durant tres setmanes un conjunt de sensors que mesuraven la qualitat de l'aire, entre altres coses. En les setmanes passades, els investigadors del projecte van repartir els resultats que n'havien obtingut. Aquests inclouen, entre altres gràfiques, la mitjana de l'exposició diària (hora per hora) dels voluntaris al carboni negre. Aquest component de la contaminació és un bon indicador dels efectes en la salut del particular. Els informes han generat verdadera sorpresa.

«Estem en una ciutat molt contaminada i ens hem de mobilitzar», diu la Charlotte

«Em sorprèn la quantitat d'intoxicació a què estem exposats», admet el Marco

¡Socors!

«¡Ara estic molt preocupat! Ajuntament de Barcelona, ¡auxili!», va tuitejar el Luca, un dels voluntaris, poc després de rebre les seves dades. **«Els meus resultats em fan una mica de por. Estem en una ciutat molt contaminada i ens hem de mobilitzar»**, afirma la Charlotte. **«M'ha sorprès la quantitat de contaminació a la qual estem exposats»**, observa el Marco.

L'anàlisi científica de les dades encara està pendent, precisa Ione Ávila-Palencia, investigadora de l'Institut de Salut Global de Barcelona (ISGlobal, una institució científica impulsada per l'Obra Social La Caixa), que coordina els mesuraments a Barcelona. No obstant, les històries personals d'alguns voluntaris són per si mateixes molt il·lustratives.

«Estic exposat al doble de la mitjana de la pol·lució de Barcelona», observa el Luca, periodista i comissari de continguts, que es desplaça cada dia en bici de casa seva al centre d'investigació on treballa. A aquest moviment li corresponen dos marcats pics en la seva gràfica d'exposició. **«Em fa ràbia saber que no contribueixo a la contaminació però en pago les conseqüències fins i tot més que altres»**, explica. El seu cas és agut, pel trajecte utilitzat: la Diagonal.

No obstant, les coses no li han anat millor a la Charlotte, que durant dues setmanes de l'assaig estava en atur, abans d'incorporar-se a una feina a Sant Cugat durant l'última. En la seva gràfica d'exposició hi ha pics repartits durant tot el dia. **«Anava en bici a tota hora: a entrevistes, al gimnàs a la Barceloneta, a un lloc del Poblenou...»**, explica la Charlotte, que viu al Raval. **«Em va sorprendre que Barcelona tingués més contaminació que Londres»**, observa comentant les corbes mitjanes de les tres ciutats del projecte.

«El lloc on es viu, el lloc on es treballa i el trajecte i el mitjà utilitzat semblen jugar un paper en l'exposició», afirma cautament Ávila-Palencia. Els casos del Marcos i Montserrat Bustos en són exemples. El Marcos, doctorand en biomedicina, viu a Canovelles i treballa al mateix centre d'investigació d'Ávila-Palencia, al ventilat front marítim de la ciutat. La seva exposició és baixa: no obstant, és suficient el trajecte a peu des de la parada de tren d'Arc de Triomf fins al mar (i tornada) per plantar dos pics en la seva gràfica.

La Montserrat viu a Sarrià i baixa a la plaça de Sants pel carrer de Numància, dos dies per setmana en moto i tres caminant. **«Em va sorprendre que tingués una exposició relativament baixa»**, observa. Aquesta meteoròloga s'ho explica perquè el barri on viu és alt i ventilat i sobretot té àmplies àrees prohibides als cotxes.

No obstant, no totes les històries són de fàcil interpretació. En el moment de l'assaig, Àlex Esteban era investigador i treballava al mateix centre a primera línia de platja que el Marcos. Es desplaçava cap allà cada dia en metro, des de Badalona. La seva gràfica té un misteriós pic molt alt a l'hora de tornar a casa. **«¿Potser en algun desplaçament ha passat per una zona molt contaminada? Només són interpretacions»**, observa Ávila-Palencia.

Tots els voluntaris ara veuen el seu dia dia de manera diferent. El Luca pensa estudiar si existeixen mascaretes protectores eficaces (l'eficàcia de les comercials no està demostrada). El Marcos no es planteja mudar-se a Barcelona, encara que això li estalviaria temps. La Montserrat ja no baixa per Numància, sinó per Equador. **«No soc jo la que he de canviar. Els que poden fer-hi alguna cosa són els que van en cotxe»**, observa la Charlotte. **«No tinc intenció de tancar-me i deixar de fer activitats a l'aire lliure»**, exclama l'Àlex.

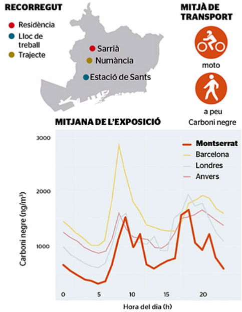
La realitat és que es pot fer poca cosa a nivell individual: desplaçar-se per carrers menys transitats o no esperar damunt el pas zebra, sinó una mica enrere (especialment si es va amb carretó). Abandonar la bici és mala idea, ja que els beneficis de l'exercici compensen l'exposició a la pol·lució. Tampoc és bona idea marxar de la ciutat, si després s'utilitza el cotxe per anar i tornar.

«No tinc intenció de tancar-me i deixar de fer activitats a l'aire lliure», exclama l'Àlex

Els cotxes

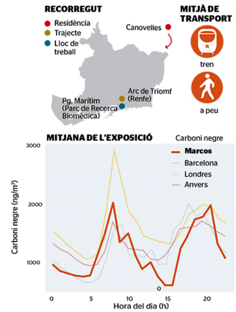
«La solució real és frenar la font emissora: els cotxes», resumeix Ávila-Palencia. **«D'aquí 20 o 30 anys mirarem enrere i la contaminació actual ens farà el mateix efecte que veure una sala de cine plena de fum de tabac»**, afirma el Luca. **«És una qüestió d'higiene pública: abans van ser les aigües residuals, després les escombraries... ara li toca a la contaminació»**, observa la Montserrat. **«El rebuig [a les mesures contra el trànsit] és normal, com quan es va prohibir fumar als locals. El benefici es va veure després»**, comenta l'Àlex.

La Montserrat es queda amb una imatge: **«Quan vaig tornar els sensors, vaig sortir del centre d'investigació davant del mar: havia plogut, la sorra estava mullada, tot net, sense contaminació...»**. Qui sap si, en algun moment, tots els dies a Barcelona seran així. ≡

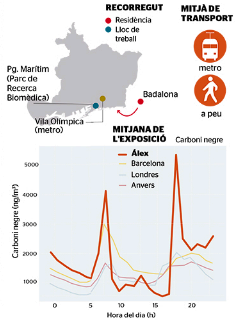


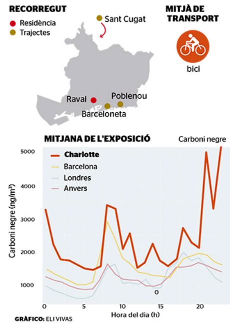

Montserrat Bustos
EDAT 49
PROFESSIÓ Meteoròloga
FOTO: RICARD CUGAT


Marcos López
EDAT 30
PROFESSIÓ Doctorand
FOTO: JOAN PUIG



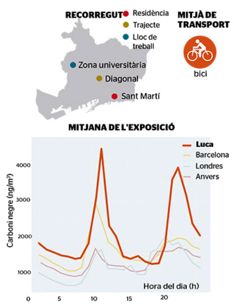

Àlex Esteban
EDAT 39
PROFESSIÓ Investigador*
*en el moment de l'estudi. Actualment, gestor del projecte
FOTO: JOAN PUIG





GRÀFICO: ELI VIVAS


Charlotte Bouchet
EDAT 39
PROFESSIÓ Aturada*
*en el moment de l'estudi. Actualment, consultora
FOTO: JOAN PUIG



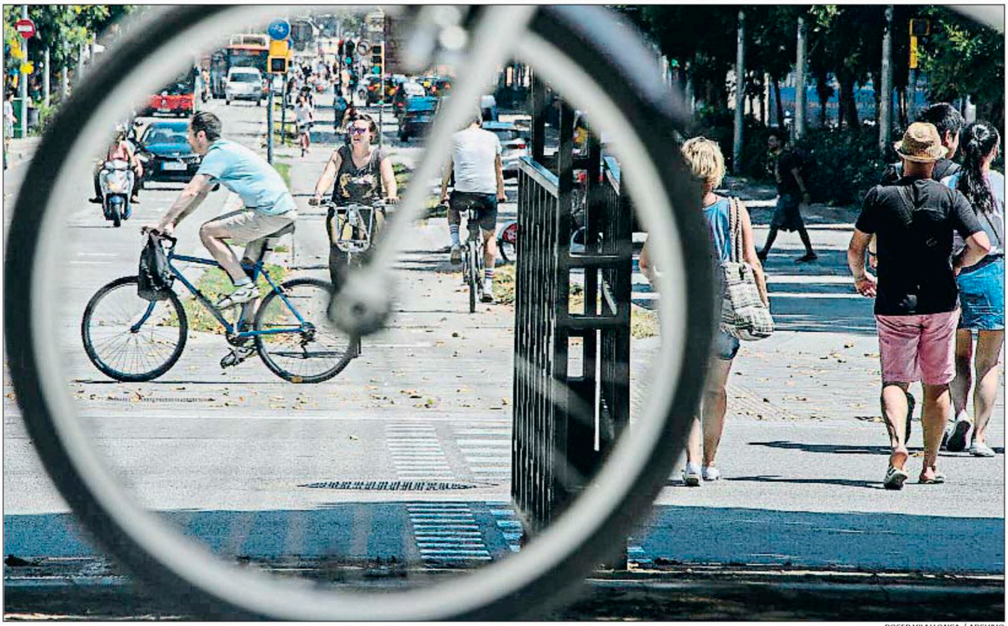

Luca Tancredi Barone
EDAT 42
PROFESSIÓ Periodista i gestor de continguts
FOTO: RICARD CUGAT

LA VANGUARDIA

28 Julio, 2017

PAÍS: España
PÁGINAS: 25
TARIFA: 17215 €
ÁREA: 624 CM² - 55%

FRECUENCIA: Diario
O.J.D.: 120418
E.G.M.: 549000
SECCIÓN: TENDENCIAS



ROSER VILALLONGA / ARCHIVO

"Los responsables políticos deben promover el uso de la bicicleta", sostienen los autores de la investigación, del instituto ISGlobal

Las personas que van a estudiar o a trabajar en bici tienen menos estrés

Pedalear cuatro veces por semana se asocia a una reducción de riesgo del 52%

BARCELONA Redacción

Las personas que van a trabajar o a estudiar en bici tienen menos riesgo de sufrir estrés que aquellas que se desplazan con otros medios de transporte, según un estudio del Institut de Salut Global de Barcelona (ISGlobal) publicado en la revista BMJ Open.

La investigación, basada en una encuesta a la que respondieron 788 voluntarios de Barcelona de entre 18 y 69 años, no aclara la dirección de la causalidad. Es decir, no permite saber si ir en bici reduce el estrés o si las personas menos estresadas tienden a ir más en bici. O bien ambas cosas a la vez. O incluso que las dos sean consecuencias independientes de alguna causa no identificada. Pero el estudio muestra que quienes van en bici al lugar de trabajo o de estudios por lo menos una vez por semana tienen un 20% menos de riesgo de sufrir estrés que quienes nunca van en bici. Y si van en bici cuatro días por semana, el riesgo se reduce hasta un 52%, informó ayer la Fundació Bancària La Caixa, que financia el instituto ISGlobal.

Los datos recabados en la encuesta muestran que suelen ir más en bici cuanto más cortos son los desplazamientos y cuando tienen estaciones de Bicing cerca de sus domicilios y centros de trabajo o estudio.

La investigación muestra también que el riesgo de estrés es menor cuando el entorno urbano es más amigable para ir en bicicleta; por ejemplo, cuando hay estaciones de Bicing cerca y carriles bici. Los autores del estudio concluyen que un diseño del entorno urbano que tenga en cuenta la bici puede potenciar el uso de este medio de transporte y podría reducir el riesgo de estrés. "Se trata del primer estudio que se centra en la relación entre los desplazamientos en bici y el estrés autopercibido", explica Ione Avila-Palencia, investigadora de ISGlobal y primera autora del trabajo. "Tenemos una sociedad bastante estresada y las conclusiones señalan que la bicicleta puede ayudar a reducir los niveles de estrés en la población", añade la investigadora.

El estudio no aclara si el medio de transporte reduce el malestar o si quienes se sienten bien lo utilizan más

Mark J. Nieuwenhuijsen, director de la Iniciativa de Planificación Urbana, Medio Ambiente y Salud de ISGlobal y coautor del estudio, destaca que "estos resultados sugieren que los responsables políticos deben promover el uso de la bicicleta y priorizarlo en la planificación urbana y de transportes para reducir los niveles de estrés y mejorar la salud pública y el bienestar".●

EL MUNDO

PAÍS: España
PÁGINAS: 29
TARIFA: 27318 €
ÁREA: 601 CM² - 58%

FRECUENCIA: Diario
O.J.D.: 94659
E.G.M.: 701000
SECCIÓN: SALUD

14 Agosto, 2018

En siete ciudades. Un estudio muestra los beneficios físicos y mentales que aporta optar por la bicicleta como medio de transporte habitual

EN LA CIUDAD, MEJOR A BICI QUE A PIE PARA CUIDAR LA SALUD

POR RAQUEL DÍAZ MADRID

En una gran ciudad, decantarse por un único medio de transporte es difícil. Para hacer un mismo trayecto suelen existir varias alternativas. Elegir una u otra, incluso cuando se trata de la misma persona, a veces depende de la estación del año o incluso del estado anímico. Por primera vez, un estudio ha tenido en cuenta esta forma dinámica de desplazarse en las grandes urbes y ha analizado la influencia de la frecuencia de uso de los distintos medios de transporte sobre la salud, tanto mental como física.

Este trabajo, liderado por el Instituto de Salud Global de Barcelona (ISGlobal), centro impulsado por la Fundación Bancaria 'la Caixa', ha sido publicado en la revista *Environment International* y coloca a uno de los posibles medios de transporte en las ciudades como claro ganador en cuanto a efectos positivos. El vencedor es... la bicicleta. Sí. Su uso se asocia con una mejor percepción de la salud general, mejor salud mental y una menor sensación de soledad.

En segundo lugar se sitúa el desplazamiento a pie, que se vinculó también con una buena salud general, mayor vitalidad y mayor contacto con familiares y amigos.

En Barcelona, una de las ciudades analizadas, se promueve el uso de la bicicleta. ALBERTO DI LOLLI

La investigación, desarrollada en el marco del Proyecto europeo PASTA –que busca promover la movilidad activa en las ciudades–, se ha realizado en siete ciudades europeas: Amberes, Barcelona, Londres, Örebro (Suecia), Roma, Viena y Zúrich. El total, participaron más de 8.800 personas, que rellenaron un cuestionario inicial. De ellas, más de 3.500 realizó otro test final, con preguntas sobre los transportes y la salud.

¿Y qué pasa con el coche? Mientras que el uso exclusivo o muy frecuente del automóvil y del transporte público «se asoció con una mala salud autopercibida, al realizar el análisis combinado, estos efectos desaparecen y se aprecia una disminución de la sensación de soledad en el caso concreto del coche», explica a este medio Ione Ávila Palencia, investigadora de ISGlobal y principal autora.

La clave está, por tanto, en la frecuencia con la que cojamos el coche. Durante el estudio cada persona debía de indicar con qué asiduidad tomaba cada uno de los distintos transportes analizados: automóvil, motocicleta, transporte público, bicicleta clásica o eléctrica y a pie. Al tratarse de personas adultas (de más de 18 años y sin límite de edad) residentes en grandes ciudades, «durante la investigación declararon que el uso del coche era poco frecuente», subraya Ávila. Esto, junto al hecho de que la «distancia media entre el lugar de residencia y el de trabajo era de menos de cinco kilómetros, nos llevó a pensar que el uso del coche tenía finalidades más lúdicas (como excursiones en fines de semana o desplazamientos a casas de familiares o amigos). De ahí la menor sensación de soledad y estrés», explica la investigadora.

Estos resultados evidencian el efecto positivo de la bici, un medio de transporte ecológico que a pesar de sus beneficios sigue siendo minoritario en las grandes ciudades europeas, a excepción de las de Holanda y Dinamarca.