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Correlates of Walking for Travel in Seven European Cities: The PASTA Project

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Background: Although walking for travel can help in reaching the daily recommended levels of physical activity, we know relatively little about the correlates of walking for travel in the European context.

Objective: Within the framework of the European Physical Activity through Sustainable Transport Approaches (PASTA) project, we aimed to explore the correlates of walking for travel in European cities.

Methods: The same protocol was applied in seven European cities. Using a web-based questionnaire, we collected information on total minutes of walking per week, individual characteristics, mobility behavior, and attitude ($N = 7{,}875$). Characteristics of the built environment (the home and the work/study addresses) were determined with geographic information system (GIS)-based techniques. We conducted negative binomial regression analyses, including city as a random effect. Factor and principal component analyses were also conducted to define profiles of the different variables of interest.

Results: Living in high-density residential areas with richness of facilities and density of public transport stations was associated with increased walking for travel, whereas the same characteristics at the work/study area were less strongly associated with the outcome when the residential and work/study environments were entered in the model jointly. A walk-friendly social environment was associated with walking for travel. All three factors describing different opinions about walking (ranging from good to bad) were associated with increased minutes of walking per week, although the importance given to certain criteria to choose a mode of transport provided different results according to the criteria.

Discussion: The present study supports findings from previous research regarding the role of the built environment in the promotion of walking for travel and provides new findings to help in achieving sustainable, healthy, livable, and walkable cities. https://doi.org/10.1289/EHP4603

Introduction

Lack of physical activity is among the 10 leading risk factors for mortality worldwide and is a key risk factor for obesity and other noncommunicable diseases (NCDs), such as cardiovascular diseases, cancer, and diabetes (WHO 2018). Indeed, it is estimated that people who are insufficiently active have between a 20% and 30% increased risk of premature death compared with people who are sufficiently active (WHO 2018). According to a study conducted in 2015, physical inactivity costs 80.4 billion euros per year in Europe, which is equivalent to 6.2% of all European health spending. The authors also estimated that by 2030 these costs could be as high as 125 billion euros (ISCA and Cebr 2015). Moreover, a recent study including almost 2 million participants worldwide showed that physical inactivity levels have increased in high-income countries in the last 15 y (Guthold et al. 2018). The study noted that "if current trends continue, the 2025 global physical activity target (a 10% relative reduction in insufficient physical activity) will not be met" and urged the implementation of policies to increase population levels of physical activity worldwide (Guthold et al. 2018).

The WHO (2018) recommends that in a typical week adults perform at least 150 min of moderate-intensity aerobic physical activity (which includes walking) or, alternatively, at least 75 min of vigorous-intensity aerobic physical activity or an equivalent combination of moderate- and vigorous-intensity activity. Although walking for travel purposes is an easy and healthy way to reach the recommended levels of physical activity, in the last century the increasing use of motorized modes of transport (e.g., car, motorbike) has contributed to the drop in levels of physical activity among the general population and has led to other traffic-related health problems such as air and noise pollution (Giles-Corti et al. 2016; Nieuwenhuijsen 2016). In the past few years, many studies have been conducted to evaluate possible determinants that contribute to the use of active modes of transport, particularly walking (Christian et al. 2013; Christiansen et al. 2016; D'Haese et al. 2015; Kerr et al. 2016; Knuiman et al. 2014; Marquet et al. 2017; Marquet and Miralles-Guasch 2015; Smith et al. 2017; Sugiyama et al. 2012; Wasfi et al. 2017; Yang 2016).

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However, these studies often contained small sample sizes and most of them focused on a particular domain of influence (e.g., policy context, built environment, social environment, personal or trip attributes) or were heterogeneous regarding the methods followed to assess both exposures and outcomes (Dons et al. 2015; Götschi et al. 2017). Moreover, the majority of these studies were conducted in Australia and the United States, with fewer conducted in other regions worldwide, including Europe (Sugiyama et al. 2012), where the built environment characteristics of the cities are significantly different (Dons et al. 2015; Kelly et al. 2017).

The European Commission–funded Physical Activity through Sustainable Transport Approaches (PASTA) project is a multinational, interdisciplinary research project aiming to understand the correlates of active travel behavior as well as potential confounders and mediators (Dons et al. 2015; Gerike et al. 2016; Götschi et al. 2017). Although PASTA is a longitudinal study, with several waves of assessment, the present study used data from the baseline questionnaire only. The main aim of the present cross-sectional study was to explore the correlates of walking for travel in seven European cities, using a common protocol in all cities, and including a range of correlates such as the built environment (both around the residence and the work or study locations) and the social environment as well as personal characteristics and trip attributes. We also explored whether there were different patterns of association between those participants working (full- or part-time) or studying and those not working (e.g., unemployed, retired) or studying.

Materials and Methods

Study Design and Population

Details of the PASTA project are provided elsewhere (Dons et al. 2015; Gaupp-Berghausen et al. 2019; Gerike et al. 2016). Briefly, PASTA pursues a mixed-method and multilevel approach that is consistently applied in seven case study cities (Antwerp, Barcelona, London, Örebro, Rome, Vienna, and Zurich) following a common protocol. The PASTA framework distinguishes hierarchical levels for various factors (i.e., city, individual, and trips), and three main domains or pathways that influence active mobility behavior (and physical activity), namely socio-geographical factors, socio-psychological factors, and rationale- or mode choice-related factors (Dons et al. 2015).

A standardized recruitment strategy was developed for all cities using an opportunistic approach (e.g., press releases, postcards and leaflets; direct targeting of local stakeholders and community groups; extensive use of social media). To minimize attrition, a user engagement strategy was developed, including incentivizing participation with a lottery. The lottery was done every 3 months, with each city deciding how to award the incentives (cash or vouchers). Those participants with a greater number of completed questionnaires for the previous 3 months had a greater chance of winning. Örebro (Sweden) was the only city that did not do a lottery (nor any other kind of incentive) because it was not allowed due to its workplace recruitment particularities (Dons et al. 2015; Gaupp-Berghausen et al. 2019). Participants had to be at least 18 y of age (at least 16 y in Zurich) and to live, work, study, or regularly travel (i.e., at least once a week) in the PASTA city of interest (Dons et al. 2015). Individual-level information and correlates of active mobility were investigated through a large-scale longitudinal web-based survey (http://pastaproject.eu/fileadmin/editor-upload/sitecontent/City_survey/PASTA-questionnaires.pdf). The baseline questionnaire allowed the collection of sociodemographic, individual, household, health, and attitudinal variables. Information on mobility and physical activity habits was gathered through the use of questions on the frequency of use of different modes of transport and the use of the Global Physical Activity Questionnaire (GPAQ). In total, 10,691 participants answered the baseline questionnaire (Gaupp-Berghausen et al. 2019). However, 2,701 participants were excluded because they did not have acceptable GPAQ indicators based on the validation criteria established by the GPAQ guideline (WHO n.d.). Of the remaining 7,990, 115 participants were excluded because they did not provide a home address at baseline and, therefore, indicators for their residential built environment characteristics were not available. A total of 7,875 participants were included in our main analyses. Out of those, 6,957 participants also provided work or study addresses and were included in our secondary analyses. The rest of the participants, $n = 918$, reported not working or studying and were therefore not included in the secondary analysis. For each partner city, the relevant permission to collect, store, and process data was obtained from the local ethics committees. On enrollment, participants registered on the PASTA website and gave informed consent [see the participant information sheet in the Overview of PASTA Questionnaires (http://pastaproject.eu/fileadmin/editor-upload/sitecontent/City_survey/PASTA-questionnaires.pdf)]. Further details can be found in the paper by Dons et al. (2015).

Outcome Assessment

We followed the GPAQ standard procedures to validate the answers provided by the participants (WHO n.d.) and to calculate our outcome variable of interest, minutes of walking per week for travel, which was the result of combining the GPAQ questions "In a typical week, on how many days do you walk for at least 10 min continuously to get to and from places?" and "Typically, how much time do you spend walking on such a day?"

Correlates of Walking for Travel

According to the PASTA framework of active travel behavior (Götschi et al. 2017), we considered many correlates that could potentially be associated with walking, including those related to the built environment, social context, and individual-level factors. Residential- and work/study-address built environment characteristics were systematically gathered in each city by collecting publicly available geographic information system (GIS)-based data along with information from other data sources such as weather data and population statistics and by means of stakeholder interviews (Dons et al. 2015). The rest of the information was collected through the web-based questionnaire previously mentioned.

Individual characteristics. A wide range of individual characteristics were collected. Based on previous literature (Christian et al. 2013; Christiansen et al. 2016; D'Haese et al. 2015; Kerr et al. 2016; Knuiman et al. 2014; Marquet et al. 2017; Marquet and Miralles-Guasch 2015; Smith et al. 2017; Sugiyama et al. 2012; Wasfi et al. 2017; Yang 2016), we included the following variables in the base model because these individual characteristics have been shown to strongly influence travel model choices: age, gender, level of education [high education: education above secondary school (yes/no)], employment status (full-time, part-time, student, not working), access to car or a van [hereafter referred to as access to a car (never, sometimes, always)], and access to a bicycle or an electric bicycle (e-bicycle) [hereafter referred to as access to a bicycle (yes/no)].

Built environment characteristics. The same built environment characteristics were included in the present analysis for both the residential and the work/study addresses, using a 300-m radial buffer. Table 1 provides the complete details on how each indicator was calculated and/or defined. Briefly, using a diversity

Table 1. Description on how each built environment indicator was defined.

Indicator	Source
Street-length density [length of streets (m/km^2)]	Navteq[a] street data (2012)
Connectivity [number of junctions with node degree >1 (in order to exclude cul-de-sacs) (n/km^2)]	Navteq[a] street intersections data (2012)
Building-area density (m^2/km^2)	OSM / local layers (2015–2017)[b]
Population density (n inhabitants$/km^2$)	Census / neighborhood data (2011–2016)[c]
Facility density index [number of points of interest (POIs) (n facilities$/km^2$)]	Navteq[a] POI data set (2012). For full list of POIs see https://tinyurl.com/PASTA-POI
Facility richness index [number of different facility types (POIs) present, divided by the maximum potential number of facility types specified (n facility types/74)]	Navteq[a] POI data (2012). For full list of POIs see https://tinyurl.com/PASTA-POI
Density of public transport stations (n of public transport stations$/km^2$)	OSM (and local data if available; 2015–2017)[d]
Distance to the nearest public transport station (m)	OSM (and local data if available; 2015–2017)[d]
$PM_{2.5}$ ($\mu g/m^3$)	$PM_{2.5}$ land-use regression models incorporating satellite-derived and chemical transport modeling data (de Hoogh et al. 2016)[e]
NO_2 ($\mu g/m^3$)	NO_2 land-use regression models incorporating satellite-derived and chemical transport modeling data (de Hoogh et al. 2016)[e]
Surrounding greenness (NDVI)	Landsat Satellite Images (2015–2016)[f]
Green and blue spaces indicators	Land-cover map Corine 2006 (available for the whole of Europe for both urban and rural areas)

Note: NDVI, normalized difference vegetation index; NO_2, nitrogen dioxide; OSM, Open Street Maps (https://www.openstreetmap.org/export); $PM_{2.5}$, particulate matter ≤ 2.5 μm in aerodynamic diameter.

[a]Navteq is licensed data under ArcGIS software. This data is prepared for routing analysis over Europe. It contains data on Streets and Points of Interest (POIs), so it identifies a wide range of categories in which the different POIs (e.g., schools, libraries, cinemas, banks, restaurants) are included. (See the full list in this link: https://tinyurl.com/PASTA-POI.)

[b]The source of information varied across cities: Antwerp: local layer (2015) for city center and OSM (2016) for addresses outside the city; Barcelona: local layer (2013) and OSM (2017) for addresses outside the city; London: local layer (2016); and Örebro, Rome, Vienna and Zurich: OSM (2017).

[c]The source of information varied across cities: Antwerp, Barcelona, London, Rome, and Vienna: National Census (2011), Örebro: local layer (2015); and Zurich local and regional layer (2016).

[d]The source of information varied across cities: Antwerp: OSM (2016); Barcelona: local layer (2011) and OSM (2017) for addresses outside the city; London: local layer (2011); Örebro: OSM (2017) but local layer (2015) for bus stations; Rome: OSM (2017); Vienna: OSM (2017); and Zurich: OSM (2017).

[e]The NO_2 and $PM_{2.5}$ air pollution grids [100-m resolution; annual means ($\mu g/m^3$)] used are from the Europe-wide models for these pollutants, developed for 2010. Models are based on routine air pollution monitoring data (AIRBASE database) incorporating satellite-derived and chemical transport model estimates, and road and land-use data. Both NO_2 and $PM_{2.5}$ models explained ~60% of spatial variation in measured NO_2 and $PM_{2.5}$ concentrations (de Hoogh et al. 2016). (http://www.sahsu.org/content/data-download.)

[f]We followed the positive health effects of the natural outdoor environment in typical populations in different regions in Europe (PHENOTYPE) project (Nieuwenhuijsen et al. 2014) protocol to select the images from LANDSAT within the greenest period and having the lowest cloud cover. Green season was considered to be from March to July 2015. However, if additional usable images were needed, these were obtained from the following year, 2016. Different images were merged to cover all the study area, and if different images overlapped in the same area, we selected the one without clouds and having the highest pixel value. Following this process, we were able to completely cover the area of study.

of sources depending on the variable of interest and the sources available in each city [Navteq (2012), Open Street Map (OSM) and local layers (2015–2017), or census/neighborhood data (2011–2016)], we obtained information for street-length density (in meters per kilometer squared), street connectivity (in intersections per kilometer squared), building-area density (in meters squared per kilometer squared), population density (in number of inhabitants per kilometer squared), facilities density (in number of facilities per kilometer squared), facilities richness (in number of facilities type/total number facilities), density of public transport stations (in number of stations per kilometer squared), distance to the nearest public transport station (in meters). Levels of the air pollutants particulate matter ≤ 2.5 μm in aerodynamic diameter ($PM_{2.5}$) and nitrogen dioxide (NO_2) (both in micrograms per cubic meter) were estimated based on land-use regression models (de Hoogh et al. 2016), and surrounding greenness was defined based on the normalized difference vegetation index [NDVI; images from the years 2015–2016 (Nieuwenhuijsen et al. 2014), which go from −1 (less green) to 1 (more green)]. We used land-cover map Corine (2006) to assess distance (in meters) and area (in kilometers squared) of the closest major (≥ 0.5 ha) green space, access to a major green space [i.e., location is <300 m from a major green space (yes/no)], distance (in meters) and area (in kilometers squared) of the closest major (≥ 0.5 ha) blue space, and access to a major blue space [i.e., location is <300 m from a major blue space (yes/no)]. We chose the 300-m buffer for several reasons: First, 300 m is commonly used in epidemiological studies on built environment and health (Nieuwenhuijsen and Khreis 2019); second, it is a distance that most of the population, including the elderly, can walk; and third, some of the built environment indicators (e.g., facilities richness) were not available for other buffer sizes (e.g., 100 m or 500 m). Finally, the 300-m buffer allowed for more exposure variability among study participants in the context of European cities than the 500-m buffer, particularly in dense cities such as Barcelona. However, we conducted a sensitivity analyses with the available built environment indicators at a radial buffer of 500 m. We also included information on the distance between the residential and the work/study addresses (in meters), the altitude difference (in meters), and the slope between both addresses. Finally, although city was included in the model as a random effect (see the "Statistical Analysis" section), in order to explore the influence of each of the cities we conducted a sensitivity analysis excluding each city one by one from the model.

Social norms and mobility culture in the neighborhood. Three different questions were used to determine the community context of each individual with regard to walking (Götschi et al. 2017): *a*) "Most people who are important to me think that I should walk for travel," *b*) "In my neighborhood walking is well regarded, and *c*) "In my neighborhood it is common for people to walk for travel." Response options were on a 5-point Likert-type scale with 1 for "very much disagree" to 5 for "very much agree."

Values and attitude toward walking for travel. Two sets of questions were used to evaluate, on the one hand, the importance of certain criteria when choosing a mode of transport to travel and, on the other hand, the opinion about walking for travel in relation to different criteria. In particular, participants had to report the level of importance to them (5-point Likert-type scale from "not important" to "very important") of the following criteria: short travel time, lower travel cost, higher travel comfort, safer travel (with regard to traffic), safer travel (with regard to crime), lower exposure to air pollution, privacy, personal health benefits, low environmental impact, flexible departure time, more predictable time, and journey reliability. Regarding opinion about walking for travel, the questionnaire asked "With your day-to-day travel needs in mind, would you say that walking for travel" (5-point Likert-type scale from "very much disagree" to "very much agree" for each item): saves time, is comfortable, is safe (with regard to traffic), is safe (with regard to crime), is unpleasant due to high levels of air pollution, offers privacy, offers personal health benefits, offers flexibility (e.g., with regard to departure time), and offers a predictable travel time.

Transport habits. The question "How often do you currently use each of the following methods of travel to get to and from places? (walk, bicycle or e-bicycle, motorcycle or moped, public transport, car or van)" was used to evaluate the influence of transport habits on the minutes spent walking per week and also to understand behavioral patterns of mobility. There were six possible answers: never, less than once a month, 1–3 d/month, 1–3 d/week, daily or almost daily, don't know (this last answer was treated as missing).

Statistical Analysis

Multiple imputation of the data. Because there were some participants with missing information for some of the variables of interest (mostly between 0% and 6.6%, except income, which had 21.9% of missing values; see Tables S1–S3 for further details on the proportions of observations with missing data for questionnaire and built environment variables, respectively) and assuming that data was missing at random (MAR), we followed multiple imputation procedures prior to analyzing the data in order to avoid loss of participants (Royston 2005). The procedure of the imputation process and the variables considered are detailed in Table S4. Briefly, we conducted multiple imputations by chained equations, carrying out 20 imputations with 10 cycles for each imputation that generated 20 complete data sets. For the imputation process, we used many more variables than the ones finally included in the analyses in order to have the richest information possible (see Table S4). Because the demographic composition and the built environment characteristics varied among cities (see Tables S1–S3), the imputations were carried out separately for each city, and afterward the seven databases were merged into one single database. We analyzed the data sets following the standard combination rules for multiple imputations, which consist of three phases: *a*) imputation (i.e., creating multiply imputed data), *b*) completing data analysis of multiply imputed data, and *c*) pooling of individual analyses from phase 2 using Rubin's combination rules (Marshall et al. 2009; Rubin 1987).

Negative binomial regression analysis. Negative binomial regression analyses including city as a random effect were conducted to obtain incidence rate ratios (IRRs) in order to explore the correlates of minutes of walking per week for travel, the outcome variable of interest. As explained in the "Individual Characteristics" section, we created a base model that included age, gender, level of education, employment status, access to a car, and access to a bicycle (Table 2). Then, all potential correlates of walking were included one by one to the base model to evaluate the association with minutes of walking per week. All built environment characteristic variables were scaled to the mean [thus, IRRs were derived using the standard deviation (SD) as the exposure contrast] except surrounding greenness, for which we used the interquartile range (IQR), and access to green spaces and access to blue spaces, which were binary variables. Street length, connectivity, building area, population, facilities, and public transport stations are expressed per kilometer squared (density). However, in terms of interpretation, the reader might desire to use the indicators per area of the buffer (area of a 300-m buffer $= 0.2809\ \mathrm{km}^2$). In this case, the SD of each of these variables has to be multiplied by 0.2809 [e.g., if the SD of street-length density is $7{,}031\ \mathrm{m}/\mathrm{km}^2$, then the new value for the area of the buffer is 1,975 m]. In addition, some of the 5-point Likert-type variables had very low prevalence in some of the categories of reference and were therefore recategorized into four or three categories instead of five for the purpose of this analysis. The criteria to collapse categories was whether the category or the sum of two or more categories reached a prevalence of at least 5% within each city. (The original categories are described in Table S1, whereas the new categories are provided in the tables of the supplemental material including the associations with the outcomes.) These variables were modeled using categorical indicator terms with a single reference category. These same analyses were conducted for the total study population ($N = 7{,}875$) and the

Table 2. Description of the variables included in the base model of the associations between correlates of walking for travel and minutes of walking per week (whole study population, $N = 7{,}875$).

			Association	
Variable	Description	Minutes walking per week (mean, SD) by category	IRR (95% CI)	*p*-Value
Age {y [mean (min–max)]}	39.6 (16.1–91.4)	—	1.00 (0.99, 1.00)	0.76
Gender (%)				
Male	47.1	172 (382)	1	
Female	52.9	186 (352)	1.03 (0.91, 1.15)	0.66
High level of education (%)				
No[a]	27.3	213 (406)	1	
Yes[a]	72.7	166 (350)	0.82 (0.72, 0.93)	<0.001
Employment status (%)				
Full-time worker	61.6	164 (368)	1	
Part-time worker	16.6	150 (293)	0.91 (0.77, 1.07)	0.24
Student	14.1	215 (333)	0.98 (0.81, 1.18)	0.81
Not working[b]	7.8	275 (417)	1.65 (1.32, 2.06)	<0.001
Access to a car or van (%)				
Never	22.7	247 (432)	1	
Sometimes	26.6	179 (379)	0.80 (0.68, 0.94)	0.01
Always	50.7	149 (323)	0.73 (0.62, 0.84)	<0.001
Access to a bicycle (%)				
No	19.2	303 (472)	1	
Yes	80.8	150 (331)	0.66 (0.57, 0.77)	<0.001

Note: All variables are included in the model at the same time (base model), and city was included as a random effect. (See Table S1 for proportions of observations in each variable category.) —, Not applicable; CI, confidence interval; IRR, incidence rate ratio; max, maximum; min, minimum; SD, standard deviation.

[a]No: no degree, primary school or secondary school, Yes: education above secondary school.

[b]Not working due to home duties/unemployed/retired/sickness leave/parental leave.

working/studying population ($n = 6{,}957$), which additionally had information on the built environment characteristics at the place of work or study.

Factor and principal component analyses. We created factors and principal components for the different sets of variables in order to reduce the number of variables and capture patterns of built environment characteristics, social norms, and mobility culture in the neighborhood; values and attitude toward walking; and transport habits. We combined the use of the eigenvalue as a value of reference with the application of subjective criteria (e.g., whether the factors obtained made sense or provided new information with respect to other factors) to decide the final number of factors and principal components. The aim was to detect profiles that were of interest for the purpose and aim of the present study. For the built environment characteristics, we chose to conduct a factor analysis because the aim was to create latent variables describing walkable and/or non-walkable areas (within a 300-m buffer). All the built environment variables were included in the factor analysis except access to green and blue spaces given that these two variables were created based on distance to the closest major green or blue space, respectively, and which were variables already included in the factor analysis. This procedure was conducted for the residential built environment characteristics ($N = 7{,}875$), the work/study built environment characteristics ($n = 6{,}957$) and for the residential and the work/study built environment characteristics altogether ($n = 6{,}957$). For social norms and mobility culture in the neighborhood, values and attitude toward walking, and transport habits, we conducted principal component analysis (PCA) because the aim was to reduce all the information from the single variables into a reduced number of components. The different groups of factors and principal components thus derived were then also included one by one into the base model and, in a second step, altogether at the same time.

Collinearity. After evaluating each single correlate of walking for travel, we introduced all the different factors and principal components into one single model (Model A). Given that transport habits, attitudes, and values toward modes of transport influence one another (Kroesen et al. 2017), we applied another model that excluded the transport habits principal components from the main model (Model B). We calculated the variance inflation factors (VIFs) to assess collinearity among the variables of the base model, city, and the principal components and factors obtained for the built environment characteristics, the importance of certain criteria when choosing a mode of transport, opinions about walking, social norms and mobility culture in the neighborhood, and transport habits. Data analysis was conducted with STATA (version 14.0; StataCorp) for imputation and for factor and principal component analysis and with R (version 3.5.0; R Development Core Team) for negative binomial regression analysis. We considered that there was an association and statistical significance when $p < 0.05$.

Results

Characteristics of the Study Population

There were differences among participants of the different PASTA cities (see Table S1). Overall, the mean age of the study population was 39.6 y (minimum = 16.1 y, maximum = 91.4 y), with Barcelona's participants being the youngest (36.3 y) and Örebro's the eldest (44.4 y) (see Table S1). Females accounted for 52.9% of the participants, ranging between 37.2% in Rome to 62.5% in Örebro. Our study population was highly educated, with more than 70% of the participants reporting a high level of education (university education), ranging from 62.3% in Zurich to 84.6% in London. Only 7.8% reported not working (due to home duties, unemployment, retirement, sickness leave, or parental leave), and full-time workers were more prevalent in Antwerp (70.7%) than in other cities (e.g., Vienna, 47.6%). On average, 50.7% reported to always have access to a car and 80.8% to have access to a bicycle, with certain differences among cities.

On average, participants from Barcelona walked the most minutes per week (258.8 min/week), whereas participants from Antwerp walked the least (49.6 min/week). Results of the base model showed that age and gender were not statistically significantly associated with minutes of walking per week (Table 2). However, having a high level of education {IRR = 0.82 [95% confidence interval (CI): 0.72, 0.93]}; access to a car, either sometimes or always [IRR = 0.80 (95% CI: 0.68, 0.94) and 0.73 (95% CI: 0.62, 0.84), respectively], and access to a bicycle [IRR = 0.66 (95% CI: 0.57, 0.77)] were statistically significantly associated with fewer minutes of walking per week. On the contrary, participants who did not work or study walked 65% (95% CI: 32%, 106%) more minutes per week compared with those working full-time (full-time workers walked, on average, 111 min per week less than those not working) (Table 2).

Correlates of Walking for travel

Residential built environment characteristics. There were clear differences among cities regarding residential built environment characteristics. For instance, comparing the two cities in the extremes, Barcelona and Örebro: Barcelona participants lived in much denser areas, in terms of street-length area ($26{,}410\ m/km^2$), building area ($441{,}064\ m^2/km^2$), and population density ($33{,}502$ inhabitants$/km^2$), with more street connectivity (279 intersections/km^2) and more facilities ($300/km^2$) within a 300-m buffer than participants from Örebro ($12{,}312\ m/km^2$, $128{,}912\ m^2/km^2$, 3,702 inhabitants$/km^2$, 78 intersections$/km^2$, and 18 facilities$/km^2$, respectively). However, Örebro participants had greener residential surroundings than participants from other cities (see Table S2).

A number of residential built environment characteristics were statistically significantly associated with more minutes of walking per week (Table 3). These included street-length density [for each standard deviation (SD) = $7{,}031\ m/km^2$, the increase was 11% (95% CI: 3%, 19%)]; street connectivity [for each SD = 108 intersections$/km^2$, the increase was 8% (95% CI: 1%, 16%)]; building-area density [for each SD = $157{,}735\ m^2/km^2$, the increase was 8% (95% CI: 0%, 16%)]; population density [for each SD = 12,822 inhabitants$/km^2$, the increase was of 9% (95% CI: 1%, 19%)]; richness of facilities [for each SD = 0.09 facilities types/total number of facilities, the increase was 9% (95% CI: 3%, 17%)], density of public transport stations [for each SD = 20.2 stations$/km^2$, the increase was 7% (95% CI: 1%, 14%)]; and levels of NO_2 [for each SD = $10.5\ \mu g/m^3$, the increase was 11% (95% CI: 1%, 21%)]. On the contrary, there was a statistically significant reduction in the minutes spent walking per week with greater distance from the nearest public transport station [for each SD = 117 m, the decrease was −6% (95% CI: −11%, 0%)] and the more surrounding greenness [for each IQR = 0.26 NDVI increase, the statistically significant reduction was −20% (95% CI: −30%, −10%)]. The rest of the variables were not statistically significantly associated with the outcome variable of interest (i.e., minutes of walking per week for travel) although the magnitude of the estimated effect varied across the different variables evaluated (Table 3).

Regarding the factor analysis for the residential built environment, we obtained two main factors, which were labeled based on the factor loadings and the correlations we observed between the factors and each single built environment characteristic (see Table S5). Factor 1 (explaining 75% of the total variance) was labeled "high-density residential area" and Factor 2 (explaining

Table 3. Associations between residential built environment characteristics (300-m buffer) and minutes of walking per week (whole study population, $N = 7{,}875$).

Characteristic	Exposure contrast[a]	IRR (95% CI)	p-Value
Built environment correlates (300-m buffer)[b]			
Street-length density (m/km^2)	7,031	1.11 (1.03, 1.19)	<0.001
Street connectivity (n intersections$/km^2$)	108	1.08 (1.01, 1.16)	0.03
Building-area density (m^2/km^2)	157,735	1.08 (1.00, 1.16)	0.04
Population density (n inhabitants$/km^2$)	12,822	1.09 (1.01, 1.19)	0.03
Facilities[c] density (n facilities$/km^2$)	244	1.05 (0.98, 1.12)	0.15
Facilities[c] richness (n facilities types/n facilities)	0.09	1.09 (1.03, 1.17)	0.01
Density of public transport stations (n stations$/km^2$)	20.2	1.07 (1.01, 1.14)	0.02
Distance to the nearest public transport station (m)	117	0.94 (0.89, 1.00)	0.04
$PM_{2.5}$ ($\mu g/m^3$)	3.5	1.11 (0.93, 1.31)	0.24
NO_2 ($\mu g/m^3$)	10.5	1.11 (1.01, 1.21)	0.03
Surrounding greenness (NDVI)	0.26	0.80 (0.70, 0.90)	<0.001
Distance to the closest major GS (m)	1,179	1.01 (0.94, 1.07)	0.87
Area of the closest GS (km^2)	186	1.00 (0.94, 1.06)	0.96
Access to major GS (within 300 m)	Yes	0.93 (0.80, 1.08)	0.35
Distance to the closest major BS (m)	2,712	0.98 (0.93, 1.04)	0.54
Area of the closest BS (km^2)	37,506	1.07 (0.99, 1.16)	0.09
Access to major BS (within 300 m)	Yes	0.96 (0.71, 1.31)	0.80
Factors for built environment correlates obtained through factor analysis[d] (% of the total variance explained by each factor)			
1) High-density residential area (75%)[e]	—	1.12 (1.03, 1.22)	0.01
2) Low-density residential area (11%)[f]	—	0.97 (0.88, 1.06)	0.49

Note: —, Not applicable; BS, blue spaces; CI, confidence interval; GS, green spaces; IQR, interquartile range; IRR, incidence rate ratio; NDVI, normalized difference vegetation index; NO_2, nitrogen dioxide; $PM_{2.5}$), particulate matter ≤ 2.5 μm in aerodynamic diameter; SD, standard deviation.
[a]All variables were scaled based on the mean and SD (all cities together), and therefore the unit of contrast is the SD, with the exception of access to green and blue spaces (binary variables) and surrounding greenness (we used the IQR).
[b]Variables were included one by one to the base model (base model: age, gender, employment status, access to a car and access to a bicycle). City was included as a random effect.
[c]Facilities: private and public points of interest including shops, schools, theaters and leisure activities, supermarkets, administration offices, banks, and hospitals. Motorized vehicle-related points were excluded (e.g. parking lots, gas stations).
[d]Variables (none scaled) included in the factor analysis: residential street-length density, connectivity, built-area density, population density, density and richness of facilities, public transport station distance and density, $PM_{2.5}$, NO_2, surrounding greenness and area of and distance to the closest green and blue spaces. (See Table S5 for factor loadings.)
[e]High-density residential area: high street-length density and connectivity, building-area density, population density, density and richness of facilities, density of public transport stations, and high air pollution but low surrounding greenness.
[f]Low-density residential area: low street-length density and connectivity and low-density of public transport stations, certain air pollution factors.

11% of the total variance) was labeled "low-density residential area." Although this labeling might seem to define two factors with totally opposite characteristics, this is not completely true. For instance, we observed positive correlations between Factor 1 and street-length density and connectivity and negative correlations between Factor 2 and these two variables. However, building-area density and population density were both positively correlated with both factors, but the correlations with Factor 1 were much stronger. Air pollutants (NO_2 and $PM_{2.5}$) were also positively and strongly correlated with both factors (see Table S5). The factor high-density residential area was statistically significantly associated with more walking [IRR = 1.12 (95% CI: 1.03, 1.22)], whereas the IRR for low-density residential area was not statistically significant [IRR = 0.97 (0.88, 1.06)] (Table 3).

Sensitivity analyses that were performed using built environment indicators within a 500-m buffer (see Table S6) or by excluding each city one by one (see Table S7) provided similar results. However, data from Antwerp seemed to be somewhat influential, although results remained in the same direction. For instance, the association between street-length density and minutes walked per week was 1.11 (95% CI: 1.03, 1.19) when including all cities and 1.05 (95% CI: 0.98, 1.13) excluding Antwerp (see Table S7).

Social norms and mobility culture in the neighborhood. Increasing agreement with the statements "Most people who are important to me think that I should walk for travel" and "In my neighborhood it is common for people to walk for travel" was statistically significantly associated with more minutes of walking per week [e.g., 97% increase (95% CI: 42%, 172%) for "very much agree" vs. "very much disagree," and 65% (95% CI: 33%, 105%) for "very much agree" vs. "very much disagree or disagree," respectively]. No significant associations were observed with "In my neighborhood walking is well regarded" [e.g., 11% (95% CI: −11%, 38%)] for "very much agree" versus "very much disagree or disagree" (see Table S8).

A PCA of the social and mobility culture variables resulted into one single principal component (53% of total variance explained), which we named the walk-friendly social environment because all three of the items for social norms and mobility culture in the neighborhood were positively correlated with it (see Table S9). This principal component was associated with more minutes of walking per week [9% increase (95% CI: 5%, 14%)] (Table 4).

Values and attitude toward walking for travel. Regarding the importance of different criteria for choosing a method of travel, minutes of walking per week were significantly lower in relation to the importance of short travel time [e.g., −32% (95% CI: −45%, −15%) for "very important" vs. "not important or less important"], flexible departure time [−27% (95% CI: −38%, −14%) for "very important" vs. "not important, less important, or neutral"], and more predictable time and journey reliability [−21% (95% CI: −44%, −6%) for "very important" vs. "not important, less important, or neutral"], with monotonic trends in IRRs as importance increased for all predictors except predictable time and reliability (see Table S10). On the contrary, "very important" responses for safer travel with regard to traffic [25% (95% CI: 3%, 52%) vs. "not important or less important"] and crime [44% (95% CI: 16%, 78%) vs. "not important"], lower exposure to air pollution [40% (95% CI: 16%, 68%) vs. "not important or less important"] and privacy [59% (95% CI: 17%, 115%) vs. "not important"] were statistically significantly associated with increased minutes of walking per week, with monotonic trends as importance increased. Other variables, such as lower travel cost, personal health benefits, low environmental impact,

Table 4. Associations between principal components of *a*) social norms and mobility culture in the neighborhood, *b*) attitude toward walking (based on importance of criteria and opinion about walking), and *c*) transport habits and minutes of walking per week (whole study population, $N = 7{,}875$).

Principal component [total variance explained by each principal component (%)]	IRR (95% CI)	*p*-Value
Model 1: Social norms and mobility culture in the neighborhood with regard to walking[a]		
"The walk-friendly social environment": most people think that I should walk "for travel," my neighborhood walking is well regarded, and in my neighborhood it is common for people to walk "for travel" (53%)	1.09 (1.05, 1.14)	<0.001
Values and attitude toward walking for travel		
Model 2: Importance of (criteria)[b]		
"Safe, healthy, sustainable, and private travel": safety (traffic and crime), low exposure to air pollution, privacy, health benefits, and low environmental impact (26%)	1.06 (1.02, 1.09)	<0.001
"Short, flexible, and predictable travel; do not care about health or environment": short travel time, predictable travel time and journey reliability, and flexible departure time. Health benefits and low environmental impact are not important (15%)	0.93 (0.89, 0.97)	<0.001
"Flexible and predictable travel. Health and environment are relevant, but not comfort or safety": low exposure to air pollution and health benefits are important, as well as flexibility and predictability, but not being comfortable, safe or providing privacy (12%)	0.87 (0.83, 0.92)	<0.001
"Cheap and short travel": cost and short travel are very important, but not flexibility, privacy or predictability (9%)	1.03 (0.98, 1.09)	0.26
Model 3: Opinion about walking[c]		
"Very good opinion about walking": is comfortable, safe (traffic and crime), is flexible and predictable, saves time and is good for health (32%)	1.10 (1.07, 1.14)	<0.001
"Walking is unpleasant, but it is fast": is unpleasant due to high levels of air pollution, it saves time but it is not particularly safe (traffic and crime) (13%)	1.23 (1.16, 1.30)	<0.001
"Walk is not flexible, but it is comfortable": it is not flexible (departure time), nor predictable, and does not offer personal health benefits. It is safe and comfortable and somehow saves time (12%)	1.13 (1.07, 1.19)	<0.001
Model 4: Transport habits[d]		
Walk and use public transport (32%)	1.70 (1.59, 1.82)	<0.001
Use the car and motorbike, but not the bicycle (24%)	1.18 (1.10, 1.27)	<0.001
Use the motorbike, but not the car (19%)	0.92 (0.86, 0.98)	0.02
Walk but also use other modes of transport except public transport (15%)	1.32 (1.22, 1.42)	<0.001
Use public transport and the bicycle (but do not walk) (9%)	0.81 (0.73, 0.88)	<0.001

Note: Each type of factor was included separately in the base model (base model: age, gender, employment status, access to a car, and access to a bicycle), so Table 4 shows the results of four separate models (Models 1 to 4). City was included as a random effect. CI, confidence interval; IRR, incidence rate ratio; PCA, principal component analysis.
[a]Variables included in the PCA: most people who are important to me think that I should walk "for travel," in my neighborhood walking is well regarded, in my neighborhood it is common for people to walk "for travel." (See Table S9 for factor loadings.)
[b]Variables included in the PCA: "importance of" short travel time, lower travel cost, higher travel comfort, safer travel with regard to traffic, safer travel with regard to crime, lower exposure to air pollution, privacy, personal health benefits, low environmental impact, flexible departure time, more predictable time, and journey reliability. (See Table S11 for factor loadings.)
[c]Variables included in the PCA: "walking for travel" saves time, is comfortable, is safe with regard to traffic, is safe with regard to crime, is unpleasant because of high levels of air pollution, offers privacy, offers personal health benefits, offers flexibility, and offers predictable travel time. (See Table S13 for factor loadings.)
[d]Variables included in the PCA: answers provided for each type of transport (walk, e-bicycle, motorcycle, public transport, car or van) to the question "How often you use (transport type) to get to and from places?" Possible answers: daily or almost daily, 1–3 d/week, 1–3 d/month, less than once a month, never, don't know. (See Table S14 for factor loadings.)

or travel comfort were not statistically significantly or consistently associated with amount of walking (see Table S10).

A PCA of the criteria variables when choosing a mode of transport for travel led to four principal components (see Table S11). The first describes those that value safety (traffic and crime), low exposure to air pollution, privacy, health benefits, and low environmental impact (named "Safe, healthy, sustainable, and private travel," 26% of the total variance explained). It was associated with more minutes of walking per week [6% (95% CI: 2%, 9%)] (Table 4). The second describes those that value short travel time, predictability, reliability, and flexibility while health and environment are not important (named "Short, flexible, and predictable travel; do not care about health or environment," 15% of the total variance explained). It was associated with fewer minutes of walking per week [−7% (95% CI: −11%, −3%)]. The third principal component describes those that value flexibility and predictability, but also low exposure to air pollution and health benefits; comfort, safety, and privacy are not important (named "Flexible and predictable travel. Health and environment are relevant, but not comfort or safety," 12% of the total variance explained). It was associated with fewer minutes of walking per week [−13% (95% CI: −17%, −8%)] (Table 4). The last component, named "Cheap and short travel" (9% of the total variance explained), basically described those who value the cost and a short travel, but not flexibility, privacy, or predictability. "Cheap and short travel" was not associated with minutes of walking per week [3% (95% CI: −2%, 9%)] (Table 4).

Regarding the opinion that participants had about walking for travel, minutes of walking increased monotonically with greater agreement that walking "saves time" [142% higher (95% CI: 100%, 193%) for "agree" and 181% higher (95% CI: 110%, 276%) for "very much agree," relative to "very much disagree"] (see Table S12). Increasing agreement with the statement that "walking is comfortable" also was monotonically associated with higher minutes of walking [e.g., 116% higher (95% CI: 73%, 170%) for "very much agree" versus "very much disagree or disagree"] (see Table S12). Increased associations with "very much agree" responses regarding opinions about walking for travel were weaker but statistically significant for safety with regard to traffic and privacy (both relative to "very much disagree or disagree" responses) and personal health benefits (relative to "very much disagree, disagree, or neutral") (see Table S12). Minutes of walking were significantly greater among those who responded "agree" versus "very much disagree or disagree" that walking "is unpleasant due to high levels of air pollution," but walking was not associated with "very much agree" responses to the same question. Safety with regard to crime, flexibility, and predictable travel time were not clearly associated with minutes of walking per week.

Regarding the PCA of the attitude toward walking, three principal components were obtained (see Table S13). The first, explaining 32% of the total variability, described those who think that walking is comfortable, safe (with regard to traffic and crime), flexible and predictable, saves time and is good for health. Basically, these are those who have a "very good opinion about walking." This factor was associated with more minutes of walking per week [10% (95% CI: 7%, 14%)] (Table 4). The second principal component (13% of the total variability), describes those who think walking is unpleasant due to high levels of air pollution and that it is not particularly safe (with regard to traffic and crime) but think that it saves time (see Table S13). The "walking is unpleasant, but it is fast" principal factor was even more strongly associated with walking than the first principal component [23% (95% CI: 16%, 30%)] (Table 4). Finally, the third principal component describes those who think that walking is not flexible nor predictable, and does not offer personal health benefits. However, they think it is safe (with regard to traffic and crime), comfortable, and, in a lesser extent, saves time (12% of the total variability) (see Table S13). This principal component, named "walk is not flexible, but it is comfortable" was also associated with more minutes of walking per week [13% (95% CI: 7%, 19%)] (Table 4).

Transport habits. We obtained five principal components describing five patterns of transport habits (see Table S14): *a*) those who walk and use public transport (32% of the total variability), which was strongly associated with increased minutes of walking per week [70% (95% CI: 59%, 82%)] (Table 4); *b*) those who use the motorbike and the car, but not the bicycle (24% of the total variability), which was also associated with increased minutes of walking per week [18% (95% CI: 10%, 27%)]; *c*) those who use the motorbike but not the car (19% of the total variability), which was associated with fewer minutes of walking per week [−8% (95% CI: –14%, −2%)]; *d*) those who mainly walk but can also use other modes of transport except public transport (15% of the total variability), which was also associated with increased minutes of walking per week [32% (95% CI: 22%, 42%)]; and *e*) those who combine public transport and the bicycle and do not walk (9% of the total variability), which was associated with fewer minutes of walking per week [−19% (95% CI: −27%, −12%)] (Table 4).

All correlates in the same model. When we included all the different factors and principal components into one single model (Model A; Table 5), we observed that the association with having access to a car lost statistical significance, although it went toward the same direction. In contrast, the association with having access to a bicycle also lost statistical significance but changed direction (Model A; Table 5). The rest of associations evaluated remained similar in relation to the magnitude observed, with two exceptions: *a*) the association between "high-density residential built environment" and minutes of walking per week was closer to the null and lost statistical significance, and *b*) the inverse association between "low-density residential built environment" and minutes of walking per week became stronger but was still not statistically significant [−8% (95% CI: −16%, 1%)] (Model A; Table 5).

We did not observe evidence of collinearity among the variables included in Model A given that the mean VIF value obtained was 1.28 and the highest individual VIF was 1.91 (for the variable car access). However, we observed that certain principal components of transport habits were moderately correlated with other correlates evaluated (see Table S15). Model B (Table 5), which excluded transport habits principal components, produced estimates that were very similar to those from models that included the base variables and only one predictor at a time (Tables 2–4).

Table 5. Associations between the different factors or principal components and minutes of walking per week (whole study population, $N = 7,875$).

	Model A[a]		Model B[a]	
Population characteristics, and factor or principal component[a]	IRR (95% CI)	*p*-Value	IRR (95% CI)	*p*-Value
Age	1.00 (0.99, 1.00)	0.19	1.00 (0.99, 1.00)	0.08
Gender (female)	0.96 (0.85, 1.08)	0.47	1.01 (0.90, 1.14)	0.85
High level of education (yes)[b]	0.75 (0.65, 0.85)	<0.001	0.82 (0.72, 0.93)	<0.001
Employment status (full-time worker is reference)				
Part-time worker	0.86 (0.73, 1.02)	0.08	0.91 (0.77, 1.06)	0.22
Student	0.91 (0.75, 1.09)	0.30	0.97 (0.80, 1.17)	0.73
Not working[c]	1.43 (1.15, 1.78)	<0.001	1.54 (1.23, 1.91)	<0.001
Access to a car or van (never is reference)				
Sometimes	0.92 (0.77, 1.09)	0.33	0.87 (0.74, 1.02)	0.09
Always	0.89 (0.73, 1.08)	0.22	0.82 (0.70, 0.95)	0.01
Access to a bicycle (yes)	1.09 (0.89, 1.32)	0.41	0.67 (0.57, 0.77)	<0.001
Factors of the residential built environment characteristics (300-m buffer)				
High-density residential area	1.06 (0.98, 1.16)	0.15	1.09 (1.00, 1.18)	0.05
Low-density residential area	0.92 (0.84, 1.01)	0.09	0.96 (0.88, 1.06)	0.46
PCs of the social norms and mobility culture in the neighborhood with regard to walking				
Walk-friendly social environment	1.06 (1.01, 1.11)	0.02	1.05 (1.01, 1.10)	0.02
PCs of the values and attitude toward walking for travel				
Importance of (criteria)				
Safe, healthy, sustainable, and private travel	1.05 (1.01, 1.09)	0.01	1.03 (1.00, 1.07)	0.08
Short, flexible, and predictable travel; do not care about health or environment	0.96 (0.92, 1.00)	0.05	0.95 (0.91, 0.99)	0.02
Flexible and predictable travel. Health and environment are relevant, but not comfort or safety	0.88 (0.84, 0.93)	<0.001	0.85 (0.81, 0.90)	<0.001
Cheap and short travel	1.01 (0.96, 1.06)	0.76	1.03 (0.98, 1.09)	0.29
Opinion about walking				
Very good opinion about walking	1.09 (1.05, 1.12)	<0.001	1.11 (1.07, 1.15)	<0.001
Walking is unpleasant, but it is fast	1.15 (1.08, 1.22)	<0.001	1.19 (1.13, 1.27)	<0.001
Walk is not flexible, but it is comfortable	1.12 (1.07, 1.18)	<0.001	1.11 (1.05, 1.17)	<0.001
PCs of the transport habits				
Walk and use public transport	1.65 (1.54, 1.77)	<0.001	—	—
Use the car and motorbike, but not the bicycle	1.24 (1.15, 1.33)	<0.001	—	—
Use the motorbike, but not the car	0.92 (0.86, 0.98)	0.02	—	—
Walk but use other modes of transport except public transport	1.31 (1.22, 1.41)	<0.001	—	—
Use public transport and the bicycle (but do not walk)	0.82 (0.75, 0.90)	<0.001	—	—

Note: —, Not applicable; CI, confidence interval; IRR, incidence rate ratio; PCs, principal components.
[a]Model A includes all factors; Model B excludes "transport habits." City was included as a random effect. See Table 3 for factor loadings (built environment) and Table 4 for the description of each principal component.
[b]No: no degree, primary school or secondary school, Yes: education above secondary school.
[c]Not working due to home duties/unemployed/retired/sickness leave/parental leave.

Working/Studying Population

Residential built environment characteristics and other correlates. Besides the fact that on average the working/studying population walked fewer minutes than those not working, the associations between the different correlates of walking for travel and the minutes of walking per week for the working/studying population ($n = 6{,}957$) (see Tables S16–S18) were consistent with the ones obtained for the whole study population ($N = 7{,}875$).

Work/study built environment characteristics and other correlates. Within the working/studying population, street-length density of the work/study built environment was associated with minutes of walking per week, with a similar magnitude [1.10 (95% CI: 1.03, 1.18)] to that of the residential built environment [1.11 (95% CI: 1.03, 1.19)] (see Table S16). The magnitude of the estimated effect was a little bit smaller for other characteristics of the work/study built environment as compared with the residential built environment (see Table S16), and in some cases the association lost statistical significance. The magnitude of the estimated effect was particularly closer to the null and not statistically significant for facility richness [1.04 (95% CI: 0.98, 1.11)] and density of public transport stations [1.02 (95% CI: 0.95, 1.09)] in the work/study environment as compared with the residential built environment [1.11 (95% CI: 1.03, 1.19) and 1.08 (95% CI: 1.02, 1.16), respectively] (see Table S16). The factor analysis for the work/study built environment characteristics provided similar factors to the ones obtained for the characteristics of the residential address. The first factor described a "high-density work/study area" (66% of the total variance) and the second one a "low-density work/study area" (14% of the total variability) (see Table S19). When these factors were included in the base model, "high-density work/study area" was statistically significantly associated with increased minutes of walking per week [12% (95% CI: 3%, 21%)], but "low-density work/study area" was not [8% (95% CI: −6%, 23%)] (see Table S16). When including all correlates together in one model, results were very similar to those obtained in previous models that included the residential address (see Table S20). However, both in Model A and Model B the importance of "short, flexible, and predictable travel; do not care about health or environment" lost statistical significance. In Model A, "high-density work/study area" also lost statistical significance [5% (95% CI: −3%, 13%)], whereas in Model B, statistical significance remained [9% (95% CI: 0%, 18%)] (see Table S20).

Residential and work/study built environment characteristics and other correlates. Most participants worked or studied >300 m from their residence (only 263 participants lived ≤300 m from their work/study place), and only 37 lived farther than 100 km from their work/study place). Distance [for each SD = 23,486 m, the association was 5% (95% CI: −3%, 14%)]; altitude difference [for each one SD = 59.4 m, the association was of −3% (95% CI: −7%, 2%)]; and slope [for each one SD = 1.08, the association was of −5% (95% CI: −11%, 1%)] between both addresses was not statistically significantly associated with minutes of walking per week.

When we conducted a factor analysis combining both the residential and the work/study built environment characteristics, we obtained two main factors. The first characterized "high-density residential and work/study areas" (44% of the total variability), whereas the second characterized "low-density residential areas, but high-density work/study areas" (19% of the total variability) (see Table S19). The model including only these factors in the base model showed that the "high-density residential and work/study areas" factor was associated with increased minutes of walking per week [21% (95% CI: 10%, 32%)], whereas the "low-density residential areas, but high-density work/study areas" factor was not [−2% (95% CI: −8%, 5%)] (see Table S16). When the rest of the correlates were included in the model, independent of whether principal components for transport habits were included in the model (Model A) or not (Model B), the association between "high-density residential and work/study areas" and minutes of walking per week remained very stable [Model A = 14% (95% CI: 4%, 25%), Model B = 15% (95% CI: 5%, 26%)] (Table 6).

Discussion

The PASTA project is a unique opportunity to evaluate a number of correlates of walking for travel in different urban and cultural contexts. The study considers individual characteristics, social norms, and mobility culture of the neighborhood; values and attitude toward walking; transport habits; and the built environment characteristics to provide a complete picture of transport-related decision making (Götschi et al. 2017). Moreover, to our knowledge, this is the first study to incorporate not only the characteristics of the residential built environment but also those of the work/study built environment, thus providing rich information about the built environment to which participants are exposed. The present study provides a number of important and innovative findings, which can be summarized in the following statements that will be discussed below: *a*) living in high-density residential areas, with richness of facilities, and density of public transport was associated with increased walking for travel; *b*) although the presence of similar characteristics at the work/study area also associated with walking for travel, we observed that for some characteristics of the built environment the magnitude of the estimated effect was greater for the residential area than for the work/study area; *c*) a "walk-friendly social environment" was associated with increased walking for travel; *d*) minutes of walking for travel were higher among participants who valued safety, privacy, and low exposure to air pollution; contrary to those who tended to value flexibility, predictability, and short travel time; *e*) all three factors describing different opinions about walking (ranging from good to bad) were associated with increased minutes of walking per week; *f*) those who mostly used the bicycle or motorized vehicles (particularly the motorbike) to travel were less likely to walk for travel, whereas being a public transport user was strongly associated with the outcome variable of interest (i.e., more minutes of walking); and *g*) people who did not work or study, walked for travel more than those who were working (full or part-time) or studying.

We used several objective (GIS-based) indicators to define the characteristics of the built environment. We observed that a number of built environment characteristics typically related to urban dense areas were associated with more minutes of walking per week, particularly those related to density (e.g., street-length density and connectivity), richness of facilities, and availability of public transport: results which are similar to those obtained in previous studies (Knuiman et al. 2014; Smith et al. 2017; Sugiyama et al. 2012), including a multi-country study involving data from 14 cities worldwide (Christiansen et al. 2016). The fact that these characteristics are highly correlated with each other (r between 0.60 and 0.94 in our study) might indicate that, in order to be a walkable urban area, these characteristics need to somehow coexist to provide the maximum benefits of each of these characteristics, as previous studies have also suggested (Bentley et al. 2018; Christiansen et al. 2016; Knuiman et al. 2014). However, given the high correlation between them, it is difficult to disentangle the actual relevance of each characteristic and the degree of coexistence needed to achieve walkable urban areas. In fact, our results are in line with those observed in studies using

Table 6. Associations between factors of residential and work/study built environment characteristics and other principal components and minutes of walking per week (working/studying study population, $n = 6{,}957$).

Population characteristics, and factor or principal component of each factors	Model A		Model B	
	IRR (95% CI)	p-Value	IRR (95% CI)	p-Value
Age	1.00 (0.99, 1.00)	0.65	1.00 (0.99, 1.00)	0.18
Gender (female)	0.95 (0.84, 1.08)	0.45	1.02 (0.90, 1.16)	0.76
High level of education (yes)[a]	0.73 (0.63, 0.84)	<0.001	0.81 (0.70, 0.93)	<0.001
Employment status (full-time worker is reference)				
Part-time worker	0.87 (0.74, 1.02)	0.08	0.92 (0.78, 1.08)	0.29
Student	0.90 (0.74, 1.09)	0.28	0.99 (0.81, 1.20)	0.91
Access to a car or van ("Never" is reference)				
Sometimes	0.94 (0.79, 1.12)	0.51	0.87 (0.73, 1.03)	0.11
Always	0.94 (0.78, 1.15)	0.57	0.81 (0.69, 0.96)	0.01
Access to a bicycle (yes)	1.21 (0.99, 1.48)	0.07	0.65 (0.55, 0.76)	<0.001
Factors of the residential and work/study built environment characteristics (300-m buffer)				
High-density residential and work/study areas	1.14 (1.04, 1.25)	<0.001	1.15 (1.05, 1.26)	<0.001
Low-density residential, but high work/study areas	0.94 (0.88, 1.00)	0.06	0.99 (0.93, 1.06)	0.85
PCs of the social norms and mobility culture in the neighborhood				
Walk-friendly social environment	1.06 (1.01, 1.11)	0.02	1.05 (1.00, 1.10)	0.06
PCs of the values and attitude toward walking for travel				
Importance of (criteria)				
Safe, healthy, sustainable, and private travel	1.05 (1.01 1.09)	0.01	1.04 (1.00, 1.07)	0.06
Short, flexible, and predictable travel; do not care about health or environment	0.98 (0.93, 1.02)	0.35	0.96 (0.92, 1.01)	0.12
Flexible and predictable travel. Health and environment are relevant, but not comfort or safety	0.89 (0.84, 0.94)	<0.001	0.85 (0.81, 0.90)	<0.001
Cheap and short travel	1.00 (0.94, 1.06)	0.91	1.02 (0.96, 1.08)	0.62
Opinion about walking				
Very good opinion about walking	1.08 (1.04, 1.12)	<0.001	1.11 (1.07, 1.15)	<0.001
Walking is unpleasant, but it is fast	1.13 (1.06, 1.20)	<0.001	1.19 (1.12, 1.27)	<0.001
Walk is not flexible, but it is comfortable	1.14 (1.07, 1.20)	<0.001	1.12 (1.06, 1.19)	<0.001
PCs of the transport habits				
Walk and use public transport	1.78 (1.67, 1.90)	<0.001	—	—
Use the car and motorbike, but not the bicycle	1.31 (1.21, 1.41)	<0.001	—	—
Use the motorbike, but not the car	0.92 (0.86, 0.98)	0.01	—	—
Walk but use other modes of transport except public transport	1.32 (1.23, 1.42)	<0.001	—	—
Use public transport and the bicycle (but do not walk)	0.79 (0.72, 0.87)	<0.001	—	—

Note: Model A includes all factors; Model B excludes "transport habits." City was included as a random effect. See Table 4 for the description of each principal component. [See Table S19 for factor loadings (built environment); the first factor "High-density residential and work/study areas" (B1 in Table S19) describes participants with built characteristics related to "high density" in both the residential and the work/study addresses, whereas the second factor "Low-density residential, but high work/study areas" (B2 in Table S19) describes participants with "low-density residential" areas and "high work/study areas."] —, Not applicable; CI, confidence interval; IRR, incidence rate ratio; PCs, principal components.

[a]No: no degree, primary school or secondary school, Yes: education above secondary school.

different walkability indexes, which commonly include the built environment indicators associated with walking in the present study (Duncan et al. 2011; Frank et al. 2010). We also observed that increasing levels of NO_2 were associated with increased minutes of walking per week, whereas the opposite was true for surrounding greenness (i.e., NDVI). These two associations are also indicators of urban dense areas given that higher levels of air pollution and lower availability of green spaces are typical characteristics of these areas. For instance, in our study, the correlation between street-length density and NO_2 was 0.64, and the correlation with surrounding greenness was −0.70. Some researchers suggest that greener cities have higher rates of all-cause mortality than less-green cities because the former tend to be more spread out, requiring greater car use and leading to unhealthy lifestyles (de Nazelle et al. 2011; Marquet et al. 2018). However, a large number of studies have shown the health benefits of exposure to green spaces through mechanisms beyond the promotion of physical activity (de Keijzer et al. 2016; WHO Regional Office for Europe 2016), which highlights the necessity to pursue strategies to integrate more vegetation in the urban environment without penalizing its walkability. Similarly, air pollution has been proven to be a major health problem in cities worldwide (Giles-Corti et al. 2016; WHO 2014). Our study showed that urban dense areas are not only associated with more walking but also with higher levels of air pollution. In order to maximize the benefits of walking, and because motorized vehicles are the major source of exposure to air pollution in cities, it is urgent to reduce the use of these vehicles, and thereby air pollution and noise exposure, and move toward sustainable and active modes of transport. Moreover, reducing cars and motorbikes in cities could also be a way, and an opportunity, to increase greenness in public spaces and improve traffic safety (Giles-Corti et al. 2016; Nieuwenhuijsen and Khreis 2019).

In the present study, we observed that reporting to live in a "walk-friendly social environment" was associated with increased minutes of walking per week, and in fact, this principal component was moderately correlated with having a very good opinion about walking for travel ($r = 0.24$) and living in a built environment (high-density urban area, $r = 0.22$) that supports such activity (see Table S15). However, because our study design was cross-sectional, we cannot discard reverse causality due to self-selection. An Australian longitudinal study evaluated the association between built environment neighborhood characteristics (1,600-m buffer) and transport-related walking (Knuiman et al. 2014). In that study, over 1,800 participants moving to new housing developments were followed-up for 7 y; the design allowed controlling for self-selection. The results were in line with those observed in the present study: street connectivity, residential density, and land-use mix were associated with increasing transport-related walking (Knuiman et al. 2014). Indeed, even if participants of the present study would have moved to areas with these desired characteristics so that they could easily walk to and from places, the results of the present study might be suggesting that these built environment characteristics in a neighborhood facilitate walking for travel (otherwise people prone to walk would also live in places without these characteristics).

Although results pointed toward the same direction, fewer work/study built environment indicators were associated with minutes of walking per week, as compared with the number of residential built environment indicators associated with the outcome variable of interest (i.e., minutes of walking per week for travel). However, in line with recent research (Marquet et al. 2018), when both the residential and the work/study built environments are considered, results of the present study suggest that a high-density residential area is essential to facilitate or promote walking for travel, whereas a high-density work/study area might help but is not as strongly associated. These results somehow make sense: Where people work or study can be an area where people go for only one single purpose (i.e., to work or to study) but not to do other activities that can significantly contribute to the total minutes of walking per week due to transport (e.g., getting groceries, going to organized activities, visiting friends, going to a restaurant, walking the dog). In fact, in the city of Barcelona, 80% of all proximity trips have a personal purpose other than work (Marquet and Miralles-Guasch 2015), which highlights the need for exploring the role of the built environment characteristics of nonresidential places visited, besides work (Chaix et al. 2017).

Participants who walked more for travel had different priorities when traveling as compared with those who walked less. Valuing safety (traffic and crime), privacy, low exposure to air pollution, and to a lesser extent, low environmental impact and health benefits was associated with increased minutes of walking per week, whereas those valuing short travel, predictability, and flexibility walked less, independent of whether they cared about health and the environment. Lower travel cost did not seem to be an important criterion for either walkers or non-walkers because we did not find associations, either when evaluating the criteria alone or when including it in a principal factor. However, we observed a moderate correlation between the principal components "cost and short travel" and transport habit "walk and public transport" ($r = 0.21$), suggesting that cost might be an important aspect for those who use public transport. On the other hand, even if participants had a negative opinion about walking, it did not seem to be important for walking for travel. Furthermore, when we conducted the PCA for opinion about walking when traveling, we found three principal components, all of which were positively associated with minutes of walking per week. One of the principal components described people who were very positive about walking [which moderately correlated with reporting a "walk-friendly social environment" ($r = 0.24$)], whereas the other two principal components described people who had a negative opinion about walking regarding certain aspects, but who also positively valued other aspects of this activity. We could not determine a principal component capturing a very negative opinion about walking. Our results might indicate that opinion about walking is important but not the main driver when choosing (or not choosing) walking as a mode of transport. In this sense, in a study evaluating car, bicycle, and public transport choices, Kroesen et al. (2017) suggested that, in terms of transport choice, behavior (transport habits) influences much more the attitude (importance of criteria and opinion about modes of transport) than the other way around. In fact, in our study, when introducing all the correlates in the model, principal components of transport habits had a stronger (and more consistent) association with minutes of walking per week than values and attitude toward walking. Finally, we observed that considering walking to be unpleasant due to high levels of air pollution was associated with more minutes of walking per week; these results may indicate that those who walk more are also more annoyed by the pollution emitted by the nearby motorized vehicles than those who, for example, drive these vehicles. These results are in accordance with the association observed between urban density and NO_2 levels and more walking because exposure to air pollution (and therefore annoyance by it) is more intense in dense urban areas. In fact, in a previous PASTA study, researchers already observed that increasing NO_2 levels at the home address was associated with concerns over the health effects of air pollution (Dons et al. 2018). These findings support the necessity to reduce motorized vehicles in cities.

We observed that having access to a bicycle, and that the principal component describing those who combine public transport and the bicycle, were associated with less walking. However, these are expected results (substitution of walking for biking) and, in terms of pursuing policies to increase the levels of physical activity among the general population, this is not bad news. Similarly, those who mostly used a motorbike also walked fewer minutes per week on average. We identified a transport habit profile of people who combine the use of the motorbike (r with the profile $= 0.53$) and the car ($r = 0.38$), but do not walk ($r = -0.15$) and definitely do not use a bicycle ($r = -0.73$) (profile "PC2" in Table S14). People in this profile, moreover, had a poor opinion of walking for travel ($r = -0.19$) (see Table S15). We observed, however, a positive association between belonging to this profile and minutes walked per week, which was an unexpected result, or at least counterintuitive. However, associations between walking and other profiles were consistent with expectation. In addition, although walking for travel does not seem to be a common option for people with moderate motorbike/car use, when they do walk, they do it for longer periods than those who never use the motorbike or the car or, on the contrary, use them daily. For instance, we observed that as compared with those who never use the motorbike (179.4 min walking per week), those who reported using it less than once a month (234.7 min/week), 1–3 d/month (176.3 min/week), or 1–3 d/week (183.0 min/week) walked similar or more minutes per week. As expected, those who reported daily use of the motorbike walked less (140.0 min/week). In any case, our results require further insight into this profile of people in future research to better understand the implications of their transport habits in relation to walking.

Another finding of our study is that the use of public transport and living near public transport stations appear to promote walking. Several results support these conclusions. As already discussed, a higher density of public transport stations, and living nearer to them, was associated with increased minutes of walking per week. In addition, we identified a profile of people who combine walk and public transport, which is associated with more walking as well. In fact, a natural intervention study conducted in the United States in Salt Lake City observed that the extension of the light rail service increased the number of new light rail users as well as the amount of physical activity among the study participants that started using this service after the intervention (Brown et al. 2015; Miller et al. 2015; Werner et al. 2016). Therefore, promoting public transport is also a way to promote walking and reach the recommended levels of physical activity. In this sense, it is important to note that in our study valuing flexibility and predictability when traveling was negatively associated with walking. However, among those valuing flexibility and predictability, there was this profile of people who also valued low exposure to air pollution and health benefits. Therefore, if the public transport service improved in terms of providing more flexibility and predictability, and if the health benefits of using public transport were promoted, people with this type of profile may increase walking for travel.

In our study, we observed that working (full- or part-time) or studying was associated with fewer minutes of walking per week, as compared with not working. However, when looking at the descriptive analysis we observed that, for example, full-time workers were, on a daily basis, less prone to walk (71.1%) but more prone to use a bicycle (45.1%) as compared with nonworkers (82.3% and 29.3%, respectively). This means that different profiles of people use different modes of transport and that full-time workers seem to substitute walking for biking. These results are good news in the sense that workers are physically active by using the bicycle and that those who are not working are physically active in their everyday life through walking. In further studies it would be interesting to evaluate to what extent physical activity levels are interchanged between both modes of transport. Higher education was also associated with less walking but, again, this could be due to the substitution of walking for biking in the highly educated group. In fact, 43.2% of the participants in this group reported daily use of the bicycle, whereas this percentage dropped to 32.3% among less educated people (there was a difference of 47 min walking per week between both groups).

Regarding limitations of the present study, the first is the cross-sectional design of the study and the risk of self-selection, with implications discussed above. Second, we used self-reported (and not objectively measured) information to quantify the amount of physical activity and particularly the amount of minutes of walking for travel among participants. According to a study by Herrmann et al. (2013), the short-term reliability for travel of the GPAQ is 0.83, whereas the long-term reliability is 0.54. However, the GPAQ, and the protocol to discard nonvalid answers, is a validated and common questionnaire used in many research studies on physical activity. Furthermore, it is one of the tools used to track the evolution of levels of physical activity worldwide (Guthold et al. 2018). Third, we could not include information on access to a motorbike in the models because this information was not collected; however, use of motorbike was captured by the transport habits data. Fourth, for the reasons explained in the "Materials and Methods" section, we used a buffer of 300 m. In other countries, with different urban designs (e.g., Australia or the United States), this distance might not be determinant given that it might be too small (James et al. 2014; Knuiman et al. 2014; Sugiyama et al. 2012), or in other contexts, smaller buffers would be more relevant (e.g., 100 m). However, our study showed similar results when using a buffer of 500 m. In addition, due to the limited resources we had to conduct all the analyses, we could not apply network buffers. However, previous research indicates that results are similar to those obtained applying other buffer techniques (Forsyth et al. 2012). Fifth, in our study, we conducted a factor analysis that included the individual characteristics of both the residential and the work/study environments. Our aim was to obtain factors that would consider both aspects; however, further in-depth analyses would be ideal to assess differences in the specific role of residential versus work/study addresses. Although certainly of great value, such added complexity in the analysis is beyond the scope of this publication. Sixth, because the main purpose of the study was to identify generalizable insights for planning measures, and given the complexity of the present work, we did not run city-specific analysis. To address the concerns of potential city-specific effects on our results, we conducted sensitivity analyses in which we excluded each city one by one. Although, encouragingly, effect estimates were similar to those obtained in the main analyses, we recognize that the possibility of bias due to effect modification by city cannot be discarded. Finally, and probably one of the most important limitations, compared with the cities census data, the composition of the PASTA participants is broadly representative in terms of gender distribution and, therefore, it includes younger and better educated participants (Gaupp-Berghausen et al. 2019). This is not representative of the general population from the sociodemographic point of view, and probably also not from the behavioral point of view. Indeed, our analyses showed that the level of education is strongly associated with walking for travel, although the reduction observed is probably due to a substitution of walking for biking in the highly educated group. It is interesting that our findings are different from those observed in a study conducted in Australia, in which the authors reported that having a higher education was associated with more walking for travel (Bentley et al. 2018). The authors hypothesized that possibly this reflected the influence of health promotion, which could be the same motivation in our study to move toward biking in European cities, in addition to environmental concerns.

Conclusions

Walking in our everyday life for travel purposes is a way to achieve the recommended daily levels of physical activity, and therefore strategies to promote it should be pursued.

The present study supports findings from previous research regarding the role of the built environment in the promotion of walking for travel and provides new findings to help in achieving sustainable, healthy, livable, and walkable cities, in accordance with the Sustainable Development Goals for cities and communities (United Nations 2017). These strategies include the improvement of the nearby residential (and also the work/study) built environment by promoting the typical characteristics of dense urban areas, with a good and balanced street-length density and connectivity, as well as building-area density, a good public transport service, and a diverse options of facilities.

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