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# 1 The relationship between neighbourhood walkability and 2 cardiovascular risk factors in northern France

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5  
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10

11

## 12 Abstract

13 **Background.** Although walkability is known to be associated with obesity and hypertension through  
14 increased physical activity; data on cardiovascular risk factors (especially in the Europe) are scarce.  
15 We assessed the relationship between neighbourhood walkability and cardiometabolic factors  
16 (including obesity, hypertension, the blood lipid profile, and serum glycated haemoglobin (HbA1c)  
17 levels) among adults living in northern France.

18 **Methods.** Data were extracted from the ELISABET study database (2011-2013). The participants  
19 (aged between 40 and 65) resided in or around the cities of Lille and Dunkirk. For each residential  
20 address, we determined a neighbourhood walkability index (using a geographic information system)  
21 and the Walk Score<sup>®</sup>. Multilevel linear and logistic models were used to assess the relationships  
22 between neighbourhood walkability on one hand and body mass index (BMI), obesity, blood

23 pressure, hypertension, serum HDL-C, LDL-C, triglyceride and HbA1c levels, and physical activity level  
24 on the other.

25 **Results.** 3218 participants were included. After adjusting for individual and neighbourhood variables,  
26 we found that a higher neighbourhood walkability index was associated with a lower BMI (-0.23  
27 kg.m<sup>-2</sup>; 95% confidence interval (CI) [-0.44;-0.01] for a one interquartile range (IQR) increment), a  
28 lower systolic blood pressure (-1.66 mmHg; 95% CI [-2.46;-0.85] per IQR), a lower prevalence of  
29 hypertension (% of increase : -7.12, 95% CI [-13.56;-0.52] per IQR), and a higher prevalence of  
30 moderate or high physical activity (% of increase = 6.9; 95% CI [1.2;12.72] per IQR). The walkability  
31 index was not significantly associated with other cardiovascular risk factors. Similar results were  
32 observed for the Walk Score®.

33 **Conclusion.** Our results showed that residence in a more walkable neighbourhood was associated  
34 with a lower prevalence of vascular risk factors. Promoting neighbourhood walkability might help to  
35 improve the population's cardiovascular health.

36 Keywords: walkability; built environment; vascular risk factor; obesity; physical activity

37

38 Highlights :

- 39 • Walkability is a composite measure of how walking-friendly an environment is.
- 40 • We assessed associations between walkability and cardiovascular risk factors.
- 41 • We studied data (n=3218) from a cross-sectional health survey in northern France.
- 42 • Walkability was associated with higher physical activity, and lower blood pressure and BMI.
- 43 • Modifying the built environment might improve cardiovascular health.

44

45 **I. Introduction**

46 Cardiovascular disease (CVD) is the leading cause of death worldwide and remains a  
47 significant public health problem in industrialized countries(1). In France, cardiovascular disease is  
48 the second-leading cause of death after cancer; in 2017, almost 65,000 deaths were due to CVD (1).  
49 Worldwide, more than 70% of CVD cases can be attributed to modifiable risk factors, such as diet and  
50 lifestyle (2). The French ESTEBAN study found prevalences of 17% for obesity (3), 30.6% for  
51 hypertension (4) and 5% for treated diabetes (5). A sedentary lifestyle and unhealthy food choices  
52 are among the main causes of CVD and are often related to socioeconomic and environmental  
53 variables (6).

54 Cardiovascular disease and low levels of physical activity are interrelated (7–9). The World  
55 Health Organization (WHO) recommends doing at least 150 minutes of moderately intense physical  
56 activity or 75 minutes of vigorous physical activity per week (10). However, nearly 40% of the French  
57 population report that they do not follow these recommendations (3). A better understanding of the  
58 determinants of physical activity (including travel-related and leisure-time physical activities) might  
59 help to better promote healthier behaviour, with physical activity performed throughout the day and  
60 at low cost.

61 There is growing interest in environmental initiatives that might prevent CVD. Recent studies  
62 have shown that certain characteristics of the built environment (including walkability) are  
63 associated with greater levels of transport-related and leisure-time physical activity (11,12).  
64 Neighbourhood walkability is a composite measure of how friendly an environment is for walking; it  
65 comprises objectively measured parameter. The most frequently used are residential density, street  
66 connectivity, and land use diversity (13). A growing body of research suggests that walkability is  
67 related to cardiometabolic health outcomes (14); indeed, a recent meta-analysis found strong  
68 evidence for longitudinal relationships between neighbourhood walkability on one hand and obesity,  
69 hypertension, and type 2 diabetes on the other (15).Few examined the relationship with other  
70 cardiometabolic health outcomes (e.g. cholesterol and triglyceride (TG) levels)(16–18). However,

71 most of the studies were performed in North America and those associations have rarely been  
72 assessed in a European context. Indeed, effect of walkability on health may be impacted by different  
73 pattern of urbanism in Europe and America. Historically, the medieval European city was developed  
74 radiating out from the centre. Conversely, American cities were planned with essential role given to  
75 cars and with low density. Europe is characterized by the relative importance of large and medium-  
76 sized cities and by a marked proximity between cities(19). Cars are most frequently used for  
77 transportation in US cities than in European cities(20). The European cities are characterized by  
78 higher structural variability, than American and some Asian cities, and by a decreasing uniform  
79 concave density gradient from the centre to the periphery, compared to a relative increase in density  
80 at the periphery of American cities .(21)

81         Although the European results appears to be consistent with the North American results for  
82 hypertension (22,23), they rather indicate a lack of association with type 2 diabetes and obesity  
83 (24,25). This is probably due to specific features of European urban settings and dietary patterns. To  
84 the best of our knowledge, only one French study has assessed the relationship between walkability  
85 and cardiometabolic factors (body mass index (BMI) and blood pressure) (23). It was performed in  
86 the Paris metropolitan area - a highly dense urban setting – and used the Walk Score® (a commercial  
87 instrument that is not yet supported by its developer in France, meaning that it is available but the  
88 developer doesn't guaranty the validity in France) as the environmental indicator.

89

90         Given the differences in urban settings and behavioural patterns between Europe and  
91 America, additional evidence is needed in each European country (26).

92         Hence, we analyzed data from the *Enquête Littorale Souffle Air Biologie Environnement*  
93 (ELISABET) survey of a representative sample of the population living in and around the cities of Lille  
94 and Dunkirk in northern France. The study's primary objective was to describe the association  
95 between neighbourhood walkability and cardiovascular risk factors among French adults. To this end,

96 we assessed a walkability index (WI), calculated using a geographic information system (GIS)) and the  
97 Walk Score® (WS) as environmental indicators.

98

## 99 **II. Methods**

100

### 101 *1. Study population and area*

102

103 Our analysis was based on the cross-sectional ELISABET survey of a random sample for the  
104 electoral roll of men and women aged between 40 and 65 who have lived for at least on year in the  
105 Lille or Dunkirk urban areas, between January 2011 and November 2013. The ELISABET study's  
106 methodology has been described in detail elsewhere (27–29).

107

108 The ELISABET data were collected at home or in some case (10%) at the convenience of the  
109 volunteer in a health care establishment; a trained, registered nurse administered a detailed  
110 questionnaire, collected a blood sample and recorded anthropomorphic data. The study protocol  
111 was approved by the local investigational review board (*CPP Nord Ouest IV*, Lille, France; reference:  
112 2010-A00065-34; ClinicalTrials.gov identifier: NCT02490553) in compliance with the French  
113 legislation on biomedical research. All participants provided their written, informed consent to  
114 participation in the study. Sampling frame and participation rate is described more extensively in  
115 supplemental data

116 According to French census data, the Lille and Dunkirk urban areas respectively comprised  
117 1,154,103 and 203,770 inhabitants in 2014 (French National Institute Statistics and Economics  
118 Studies (*Institut National de la Statistique et des Études Économiques (INSEE)*)(30). Each urban area  
119 comprises an old city centre surrounded by agglomerated cities and non-agglomerated cities  
120 separated by rural areas. leading to a wide range of walkability levels. Lille and Dunkirk both have a  
121 dense public transport network, and traffic levels vary from low to high across each urban area.

122

## 123 2. *Definition of cardiovascular risk factors*

124

### 125 2.1 *Physical activity and walking*

126

127 Physical activity was evaluated using the International Physical Activity Questionnaire (31).  
128 Three indicators were used to quantify physical activity: the intensity, and the frequency (per week)  
129 and average duration (per day) for each intensity level. We defined three levels of physical activity,  
130 according to the International Physical Activity Questionnaire results: high, moderate and low (see  
131 supplemental material for the definition of the categories). We also analysed self-reported daily  
132 walking time above 30 minutes as a binary variable (yes/no). For physical activity, we analysed the  
133 prevalence of moderate or high physical activity vs low and the prevalence of high activity versus low  
134 or moderate.

135

### 136 2.2 *Obesity*

137

138 We used the WHO definition of BMI, i.e. by the person's weight in kilograms divided by the  
139 square of his/her height in meters ( $\text{kg}/\text{m}^2$ ). Overweight corresponds to a BMI  $\geq 25 \text{ kg}/\text{m}^2$  and  $< 30$   
140  $\text{kg}/\text{m}^2$ , and obesity corresponds to a BMI equal to or greater than  $30 \text{ kg}/\text{m}^2$ . Height and weight were  
141 measured by a trained registered nurse during examination

142

### 143 2.3 *Blood pressure*

144

145 Two consecutive measurements of systolic blood pressure (SBP) and diastolic blood pressure  
146 (DBP) were made with participants in the sitting position, after 5 minutes of rest. Examination was  
147 done in the morning, subject should be fasting for the appointment. When available, the blood

148 pressure was the mean of two measurement. A second blood pressure measurement was taken  
149 systematically only during the last third of the study period (28) Hypertension was defined as an SBP  
150  $\geq 140$  mmHg, a DBP  $\geq 90$  mmHg, or ongoing treatment with antihypertensive medication. To account  
151 for the effect of antihypertensive medication in our blood pressure analyses, we added 10 mmHg  
152 and 5 mmHg to the observed SBP and DBP values, respectively (32).

#### 153 *2.4 Blood lipid profile and glycated haemoglobin (HbA1c) levels*

154 The laboratory measurements of blood markers have been described previously (26). The fasting  
155 HbA1c level in whole blood was measured using high performance liquid chromatography (VARIANT  
156 II, Bio-Rad, Hercules, CA, USA). Serum cholesterol and TG levels were measured using enzymatic  
157 assays. The level of high-density lipoprotein (HDL) cholesterol (HDL-C) was determined after the  
158 precipitation of apolipoproteins B with phosphotungstate/magnesium chloride. The level of LDL-C  
159 was calculated according to the Friedewald equation ( $\text{LDL-C} = \text{Total Cholesterol} - \text{HDL-C} - \text{TG}/5$  in g/L).  
160 Assay samples were collected after a 10-hour fast. Throughout the project, the quality of each  
161 analysis was monitored in an internal quality control program (with the use of calibration standards,  
162 laboratory blanks, and reference materials (Seronorm™ Trace Elements Whole Blood, SERO,  
163 Billingstad, Norway)) and an external quality control program (an interlab comparison program  
164 established by the Quebec Toxicology Centre, Quebec National Institute of Public Health, Quebec,  
165 Canada). All the samples in a given batch were analysed at the same time with the same calibration  
166 standard. All biological samples were tested in the same laboratory.

167

#### 168 *3. Exposure data*

169

170 Two frequently employed walkability measures (a WI and the WS) were used to assess  
171 neighbourhood walkability for each participant.

172



173 *3.1 Walkability index*

174

175 The WI used here was based on the index developed by Frank and al(13, 27), as a function of  
176 net residential density, street connectivity, and land use diversity. To approximate walkable areas, a  
177 500 m radius buffer zone was created around each participant's home address, using ArcGIS  
178 software (Esri, Redlands, CA, USA) and a 500m walkable distance from the address by the network  
179 for the second. These buffer zones were then used to collect data on the built environment  
180 accessible by foot for each participant. The main analysis was made with a 500 meters Euclidean  
181 buffer. Sensitivity analysis with a 500m network buffer were realised.

182 The net residential density corresponded to the number of residential dwellings (houses and  
183 apartments) divided by the residential land surface within a participant's buffer zone. We used the  
184 2010 population census data provided by the INSEE.

185 Street connectivity was obtained by calculating the intersection density. We used the 2013  
186 road data from the French National Institute for Geographic and Forest Information (Institut National  
187 de l'Information Géographique et Forestière, BDTOPO® database). The ArcGIS software was first used  
188 to identify intersections of three or more walkable road segments. We excluded intersections on  
189 limited-access roads (e.g. motorways and flyovers). The intersection density was calculated by  
190 dividing the number of pedestrian-accessible street intersections in the buffer zone by the total area  
191 of the buffer zone.

192 Land use diversity corresponded to the types of destination that a participant could reach on  
193 foot in his/her neighbourhood. We considered retail facilities, institutions, amenities (e.g banks, post  
194 offices, hospitals, churches, etc.), recreational facilities, and residential facilities. To determine the  
195 number of destinations of each type within the buffer zone, we used data from the INSEE's 2016  
196 Permanent Facilities Database (Base Permanente des Équipements). An entropy index was then  
197 calculated for each participant's buffer zone, using the following equation.

198 Entropy index of a buffer zone  $j = \frac{-\sum p_{ij} \times \ln p_{ij}}{\ln N_i}$  (34)

199 where  $p_{ij}$  is the fraction of destinations of type  $i$  within the buffer zone  $j$ , and  $N_i$  is the number of  
200 different destination types (five, in the present analysis). The values range from 0 (a low diversity of  
201 destinations) to 1 (high diversity).

202 Lastly, each indicator was standardized as a z-score, and the neighbourhood WI was obtained  
203 by summing the z-scores. The WI was considered as both a continuous variable (per one interquartile  
204 range (IQR) increment) and as a categorical variable (in tertiles).

205

206

### 207 *3.2 The WS*

208

209 The WS was created by Front Seat Management LLC (Seattle, WA, USA). The algorithm  
210 calculates neighbourhood walkability by assigning a one-mile radius (1.6 km – a 30 min walk) buffer  
211 zone around the participant's residential address. Facilities present in the buffer zone are split into  
212 seven categories, including dining & drinking facilities, grocery shops, other shops, places for errands,  
213 parks, schools, and culture & entertainment. Based on the distance from the residential address (a  
214 distance decay function), points are assigned for each destination in every category. No points are  
215 given for destinations more than 1 mile away. The various (equally weighted) categories are summed  
216 and normalized as a score ranging from 0 ("Car Dependent") to 100 ("Walker's Paradise"). The WS  
217 also measures pedestrian friendliness by analysing the population density and road metrics such as  
218 block length and intersection density. The WS's data sources include Google, education.com,  
219 OpenStreetMap and places added by the WS user community.

220 In France, the WS is available but the score "is not yet supported in France", according to its  
221 developer; Front Seat Management LLC states that it does not have enough data to ensure an  
222 accurate score. However, a study of the Ile-de-France region (including Paris) found a strong  
223 association between objective walking time (measured with a GPS device and an accelerometer) and  
224 the neighbourhood WS (35). In the present study, each participants' residential address was

225 attributed with a WS corresponding to the nearest point on a 100 m grid extracted from the WS  
226 website in January 2019.

227

#### 228 4. *Covariates*

229

230 In the present analysis, we selected participants who had lived at their current address for at  
231 least one year. Participants with a non-localizable place of residence were excluded. The following  
232 variables were recorded: age, sex, urban area (Lille or Dunkirk), educational level, professional status,  
233 smoking status, marital status, and the identity of the nurse investigator having collected the study  
234 data.

235 The median income and population density for each neighbourhood were extracted from  
236 data provided by the French National Institute for Statistics and Economic Studies (INSEE). The  
237 geographical unit for a neighbourhood corresponded to the French “regrouped statistical  
238 information block” (IRIS) unit, as defined by the INSEE. The IRIS unit is the smallest census unit  
239 available in France(36) . We also recorded the annual mean residential PM<sub>10</sub> concentration, as  
240 estimated by the ATMO Hauts-de-France monitoring organization with a spatial resolution of 25×25  
241 m using an atmospheric dispersion modelling system. These methods have been described previously  
242 (29).

243 For each outcome, we only analysed participants with a full corresponding dataset.

244

#### 245 5. *Statistical analyses*

246

247 In order to describe the WI tertiles in each urban area, Chi<sup>2</sup> tests were used to compare  
248 proportions of qualitative variables. Quantitative variables were assessed with Student's test (when  
249 the data were normally distributed) or a Kruskal-Wallis test.

##### 250 5.1 *Regression analyses*

251 Geographical autocorrelation of quantitative outcome variables was estimated separately  
252 using Moran.I of the R package ape. All Moran indices were <0.02, therefore, auto-correlation were  
253 not addressed at the modelling stage.

254 To study the relationship between the outcomes (physical activity, BMI, blood pressure,  
255 blood lipid markers, and HbA1c) and neighbourhood walkability, we used multiple linear regression  
256 models for quantitative outcomes. We used Tobit regression model for blood lipids and HbA1c in  
257 order to account for treatment effect. We used logistic regression models and robust Poisson  
258 regression (glmrob of R Package robust) for binary outcomes. The WI and WS were used as  
259 explanatory variables. The main model was adjusted for age (as a continuous variable), sex (as a  
260 binary variable), urban area (Lille or Dunkirk), education level (primary education only, secondary  
261 education only, 2–4 years of higher education, or 5 or more years of higher education), smoking  
262 status (former smoker, never smoker, or current smoker), marital status (single, married or similar,  
263 divorced, widower, or other), work activity (full-time work, part-time work, or unemployment/no  
264 occupation), mobility limitation defined as answer yes to “Do you have difficulty to walk ?” or yes to  
265 “Are you breathless when you walk with other people of your age on flat ground ?”, investigator (a  
266 class variable, with 12 modalities for the 12 nurse investigators), inclusion season (winter, summer,  
267 fall and spring) and the median neighbourhood household income in the IRIS unit (as a continuous  
268 variable). The variables are described in supplemental table 1.

269 We estimated mean differences for quantitative outcomes or the odds ratio for binary  
270 outcomes per tertile of neighbourhood walkability (using the WI and the WS, with the lowest tertile  
271 as reference) and for an interquartile range of neighbourhood walkability. We also tested for  
272 potential interactions between our main outcomes (BMI, SBP, and hypertension) on one hand and  
273 sex and urban area on the other. We tested interaction for age (years) and education (less than 2  
274 years after high school / 2 years or more after high school) for the association between WI an

275 outcomes .For interaction, with  $p < 0.10$ , we presented stratified analysis (for the age the analysis  
276 were stratified by age superior or inferior to the median (53.5 years) )

277

## 278 *5.2 Sensitivity analyses*

279 We calculated a WI with the most recent data available (2015 for resident density, 2020 for  
280 street connectivity and 2016 for permanent facilities) and calculated spearman correlation between  
281 the two scores in order to evaluate stability of WI over time.

282 Anti-hypertensive therapy is very common and may bias the results, standard adjustment is  
283 not an accurate method for taking it in account. Many methods have been suggested to account the  
284 treatment effect for blood pressure (37) . Conversely, few methodologies for treatment of  
285 hyperlipemia or diabetes have been suggested. These various methodologies used for blood pressure  
286 have strength and weakness. In order to evaluate the accuracy of the model and sensitivity to the  
287 method, additional analyses were performed using three other methods. In the main model, we  
288 added 10 mmHg to the SBP and 5 mmHg to DBP for treated participants (32). The first additional  
289 method added a constant value to the participant's SBP and DBP, depending on the drug class and  
290 the drug combination. We used the constant described in the ATOM study ("blood pressure-lowering  
291 effects of antihypertensive drugs and combinations: meta-regression of published clinical trials")  
292 (38,39). In the second method, we performed censored normal regression (using a Tobit model) with  
293 right censoring on the observed blood pressure for a treated individual (37). Thirdly, we applied the  
294 non-parametric algorithm described by Levy and al. (40).

295 Furthermore, we adjusted our analyses for the residential  $PM_{10}$  and  $NO_2$  concentration (as a  
296 have high concentrations of traffic-related air pollutants, which may raise the cardiovascular disease  
297 risk (29,41). Lastly, we performed mediation analysis (42), studying the mediator effect of physical  
298 activity (define as dichotomous variable low versus moderate or high) and BMI in the association  
299 between WI and blood pressure variables (SBP, DBP, and hypertension). We studied association

300 between physical activity and BMI with blood pressure and studied the ratio of mediation using the  
301 function mediate of the R package. The confident interval was calculated by Bootstrap with 500  
302 simulation.

303 We did further adjustment for household income and ethnicity. Missing data for house  
304 income were code as category of income. Ethnicity (European or Other) were determined by cluster  
305 the analysis of genetics data is currently ongoing (methodology not publish yet)(42)

306 In a sensitivity analysis, we take into account the sampling frame, using svydesign of the package  
307 survey and the finite population correction to take all small town were not included in Lille city area.  
308 To account the different sampling frame in Dunkirk and Lille, we did separate analysis in Lille and  
309 Dunkerque and pooled the results using rma of the metaphor package. In this analysis, participants  
310 reporting the use of diabetes medication or cholesterol medication were excluded from this  
311 sensitivity analyses of the associations with HbA1c and the blood lipid profile, respectively.

312

313 The threshold for statistical significance was set to  $p < 0.05$ . Statistical analyses were performed  
314 using R software (version 3.5.1, R Core Team, 2018) (43)

315

### 316 **III. Results**

317

318 A total of 3276 participants had been included in the ELISABET survey, and one participant  
319 had been excluded after he withdrew his consent. The spatial distribution of the volunteers is  
320 presented in supplemental figure 1. In the present study, we excluded a further 43 participants  
321 because they had moved home within the previous year, 6 participants with missing data on their  
322 professional status, 4 with missing data on their marital status, 1 with missing data on his smoking  
323 status, and 1 who was unable to walk as the result of a known disease. Ultimately, 3218 participants  
324 were analyzed (1648 for Lille and 1570 for Dunkirk). Missing data meant that 125 participants were

325 excluded from the physical activity analysis, 28 were excluded from the SBP analysis, and 56 were  
326 excluded from the analyses of DBP and hypertension.

327           The study population's characteristics are summarized by urban area and by WI level in Table  
328 1. The participants' mean age was 53.3 yrs. In each urban area, participants living in the most  
329 walkable neighbourhood were significantly more likely to be current smokers, single, or divorced,  
330 and presented a higher educational level. In Lille, the most walkable neighbourhood had higher level  
331 of PM<sub>10</sub> and a lower annual residential income; in Dunkirk, the opposite was true. The WI and WS  
332 were closely correlated (Spearman's correlation coefficient = 0.77,  $p < 1 \times 10^{-15}$ ). The distribution of the  
333 participants' WS values is described in Table 2; most of the participants lived in a "somewhat  
334 walkable" or "very walkable" neighbourhood.

335

#### 336           *Associations between neighbourhood walkability and cardiovascular risk factors*

337

338           The results of the multivariable analyses for each of the walkability indices are summarized in  
339 Table 3. In the fully adjusted model, we observed a significant negative association between  
340 neighbourhood walkability (according to the WI or the WS) and the prevalence of moderate or high  
341 physical activity was increase by 12.3% [-0.1;26.2] in the high tertile of walkability. (OR for One IQR  
342 [95%CI] = 1.25[1.13;1.38] ) and at least 30 minutes of walking per day was increased by 12.1% IC95%  
343 [-2.2-28.5] ( OR 1.16[1.06;1.28] for a one IQR increment in WI). WS was associated to lower  
344 prevalence of High physical activity -15.0%[-30.0;2.6] in the highest tertile of WS and OR  
345 0.86[0.76;0.97] for one IQR. No significant association were observed with WI. There was a  
346 significant association between neighbourhood walkability and BMI; for a one IQR increment in the  
347 WI, we observed a significant difference (- 0.23 [-0.44;-0.01] kg/m<sup>2</sup>) in the mean BMI. However, we  
348 did not observe a significant association with obesity (OR 0.95[0.85;1.07] for WI). There were strong  
349 negative associations between neighbourhood walkability and blood pressure outcomes. For a one  
350 IQR increment in WI, there was a difference of - 1.66 [-2.46;-0.85] mmHg for the SBP and -0.79[-

351 1.31;-0.27] mmHg for the DBP. The prevalence of hypertension was -8.9%[-20.2;3.9] lower in the high  
352 tertile of walkability (OR for one IQR 0.87 [0.78;0.96]) . We did not find significant associations with  
353 the biomarkers of cardiovascular risk (i.e. serum HbA1c, LDL-C, HDL-C and TG levels). All associations  
354 found for WI were also observed for WS. The only difference between the two scores was observed  
355 for a high level of physical activity.

356

### 357 *Sensitivity analyses*

358 We studied the association using network buffer of 500 m instead of the Euclidian buffer.  
359 Result were similar than in the main analysis (supplemental table 2). The spearman correlation  
360 between WI use in the main analysis and a WI calculated with the most recent data available was  
361 0.95.

362 The results of the models for walkability and blood pressure after adjustment of the blood  
363 pressure values with four different approaches are summarized in Supplemental Tables 3a and 3b  
364 The associations with walkability and blood pressure were similar, although censored normal  
365 regression led to a slightly stronger association (-2.43 mmHg for the mean SBP for a one IQR  
366 increment in the WI).

367 The results of the models for neighbourhood walkability and cardiovascular risk factors  
368 after adjustment for the residential PM<sub>10</sub> or NO<sub>2</sub> concentration are summarized in Supplemental  
369 Table 3. The results were similar to those of the main model, except that the association was no  
370 longer significant for the BMI. No association between walkability index or Walkscore and Hbac1 was  
371 observed after adjustment for PM<sub>10</sub> Or NO<sub>2</sub>.

372 After adjustment for household income and divergent ancestry, results remain consistent  
373 (supplemental table 4). In the model taking into account the stratified sample, results were  
374 consistent except for the association of WS with physical activity and walking and WI with walking  
375 which were no more significant. Results were similar in the model taking into account the sampling



376 frame (Supplemental table 5) except for the association with physical activity which was only  
377 significant for WI and moderate or high physical activity .

#### 378 *Mediation analysis*

379 Moderate or high physical activity was associated to lower diastolic blood pressure  
380 compared to low physical activity (-0.98mmHG [-1.89; -0.08 mmHg]). No significant associations  
381 were observed between physical activity and blood systolic blood pressure or hypertension (both  
382  $p>0.6$ ). Accordingly, association ratios between WI and blood pressure explain by physical activity  
383 were small and non-significant (supplemental table 6). BMI was significantly associated to systolic  
384 blood pressure (coefficient for 1 unit of BMI 0.91 mmHg [0.77; 1.04]), diastolic blood pressure (  
385 coefficient for 1 unit of BMI 0.57 mmHg [0.49 ; 0.63] and hypertension percentage increase or  
386 prevalence 4.9% [3.9%; 5.9%]). Association ratios explained by BMI were significant and range from  
387 12.1%[0.4%;27%] for systolic blood pressure to 17.4%[2.1%; 45%] for diastolic blood pressure.

388

#### 389 *Interaction analysis*

390 No significant interactions with the urban area or with sex were observed for any of the main  
391 outcomes (figure 1). For other interactions, the only significant one with WI was for education and  
392 daily walking above 30 minutes ( $p=0.04$ ), the percentage increase in prevalence for one IQR of WI  
393 was 2.73 % [-5.04;11.62] in the lower education group and 9.42 % [0.19;20.16] in the higher  
394 education group. Interaction with  $p >0.10$  are presented in supplemental table 7

#### 395 **Discussion**

396 Our results showed that higher neighbourhood walkability was associated with a lower  
397 prevalence of low physical activity. Neighbourhood walkability had strong negative associations with  
398 blood pressure and BMI. However, we did not find a significant association with obesity or any of the  
399 blood markers.

400 With regard to blood pressure, the associations observed in the present study were  
401 consistent with those reported previously in the United Kingdom(22) and in France (23). In the latter  
402 study, the effect size for the association between WS and SBP (beta coefficient [95% CI] = -0.030  
403 mmHg [-0.063;-0.0004] per unit increment in WS) was half that observed here (-0.064, [-0.095; -  
404 0.033]) (23). Our present results are also in agreement with data from North America(15,17,44) and  
405 Australia (45). Consistency is found in the Bradford Hill criteria, which reinforces the hypothesis of  
406 causality. Nevertheless these studies are mainly cross-sectional and further studies are needed to  
407 conclude on causal association . This association may be explained by increased physical activity. In  
408 the present study, neighbourhood walkability was negatively associated with a low physical activity  
409 prevalence. However, no increase of high physical activity prevalence was observed, on the contrary,  
410 a decrease in the prevalence with WS was observed. Walkability may increase moderate physical  
411 activity through walking for daily activities. High physical activity, which depends on vigorous activity  
412 (mainly accruing during sport practice), may be less impacted. Walkability may increase walking and  
413 then reduce low physical activity but may not be sufficient to achieve high physical activity.  
414 Consistently, sedentary behaviour is associated with high blood pressure (7), and moderate physical  
415 activity has a positive impact on blood pressure (46,47). The activity was not associated to blood  
416 pressure, accordingly, it does not explain the associations with SBP and DBP in the mediation  
417 analysis. One reason for this small impact might be the misclassification of self-reported physical  
418 activity and thus a lack of accuracy. Accordingly, previous studies did not clearly demonstrate  
419 mediation by physical activity of the association between walkability and changes in cardiometabolic  
420 outcomes (45,48,49). The small impact of physical activity on the association might also be due to  
421 one or more other mechanisms or cofounding factors acting alone or together. Future research  
422 should investigate additional mechanisms by which walkability is involved in cardiometabolic health  
423 outcomes.

424 With regard to weight status, we observed a significant association with BMI but not with  
425 obesity. The negative association with BMI was consistent with European studies (conducted in

426 Belgium (50) and France (23)) and American studies (51,52). The effect size reported in the French  
427 study (estimated  $\beta$  coefficient [95% CI] for BMI = -0.010 kg/m<sup>2</sup> [-0.019;-0.002] per unit increment in  
428 WS (23)) was similar to that observed here (-0.011 [-0.020; -0.002]). The earlier French study also  
429 found that living in a low-walkability (car-dependent) neighbourhood was associated with an  
430 elevated prevalence of obesity. Furthermore, longitudinal studies in North America found a strong,  
431 protective association between higher walkability and obesity (15). In contrast, we did not find a  
432 significant association with obesity in our study perhaps because of loss of power analysing a  
433 binomial variable (obesity) instead of a continuous variable (BMI).

434 Lastly, the associations between neighbourhood walkability and SBP and DBP were only  
435 partly explained in the mediation analysis by BMI. The effect of walkability on blood pressure  
436 through a lowering in BMI does not seem to be predominant - probably due to a small weight  
437 reduction. Even though weight reduction diminishes blood pressure (53), other mechanisms may be  
438 involved, previous studies suggest that physical activity may reduce blood pressure through  
439 physiological pathway other than body weight (54).

440 With regard to blood markers, we did not find an association with HbA1c and even a non-  
441 significant increase of HbA1c associated with high walkability in the main model was observed. A  
442 recent meta-analysis reported that neighbourhood walkability was associated with a lower  
443 risk/prevalence of diabetes (55). Two European studies did not find an association between  
444 walkability and type 2 diabetes. The effect of walkability might simply not be strong enough to have  
445 any observable effects on the HbA1c level. Furthermore, HbA1c has been linked to air pollution. As  
446 regards, one possible explanation for the lack of association of HbA1c with high walkability in the  
447 main model could be due to higher air pollution in area with high density. Accordingly, air pollution  
448 was higher in walkable neighbourhoods in Lille. The non-significant, unfavourable association  
449 between walkability and HbA1c disappeared after adjustment for PM<sub>10</sub> or NO<sub>2</sub>. Although it is not  
450 sufficient to confirm it this last result is consistent with the hypothesis of a confounding by air pollution.

451 In sedentary people, increased light- or moderate-intensity physical activity has a positive  
452 effect on blood lipid levels by increasing the HDL-C level and decreasing the LDL-C and triglyceride  
453 levels (56–58). However, we did not find an association between neighbourhood walkability and any  
454 of the blood lipid markers. Again, the influence of walkability on physical activity might not be strong  
455 enough to produce an observable effect on the blood lipid profile. Canadian studies have observed  
456 that higher HDL cholesterol was associated to Walkability(16,18). However, these results are  
457 inconsistent to the best of our knowledge, no European studies have been conducted, and an  
458 American study did not observe any association with HDL-C or LDL-C (17). Furthermore, a recent  
459 Dutch study did not find any evidence to suggest that population density (a walkability parameter) is  
460 associated with blood lipid levels (50). Therefore, there is limited evidence for an association  
461 between walkability and blood lipids.

462 We observed a higher prevalence of smoking in area with high walkability. This association  
463 has been observed previously in Ontario. Nevertheless, we didn't expected walkability to have  
464 unfavourable impact on smoking. The reasons for higher rate of smoking associated to walkability  
465 remain to be explained. One hypothesis may be the greater proximity to tobacco seller(16)

466 Our results were consistent across cities, gender, education groups and age. A significant  
467 interaction was observed only for walking  $\geq 30$  min/Day and education. It seems that walkability may  
468 be more associated to walking when education level is higher. This may be due to a possible increase  
469 in health consciousness among better educated people. It may also be due to chance due to the large  
470 number of interaction tests done.

471

472 Our study had some limitations. Firstly, its cross-sectional design prevented us from assessing  
473 the possible causal nature of the relationship between neighbourhood walkability and our outcomes.  
474 Reverse causation might be possible due to potential self-selection of neighborhood driven by  
475 physical activity preferences. Health-conscious participants may selected residential location that  
476 facilitated physical activity; in turn, that choice might lead to overestimation of the relationships

477 between walkability and health outcomes(59). In our study, however, residents living in more  
478 walkable areas reported smoking more (i.e. arguing against this hypothesis), and previous studies  
479 have shown that reverse causation is unlikely (60,61).

480 Secondly, there was a time interval between the collection of the ELISABET data (in 2011-2013) and  
481 the collection of geographical data (in 2019 for the WS and from 2013 to 2016 for the WI). It is  
482 possible that some neighbourhoods changed during this time, which might have led to  
483 misclassification of walkability measures. Nevertheless, any changes might have been marginal.  
484 Moreover, we did not account for fine features such as greenness, sidewalk conditions, or shade – all  
485 of which can influencing pedestrian behaviours like leisure-time walking (56) accordingly the  
486 correlation between the two WI calculated with different data periods were high. Thirdly, we could  
487 not incorporate more subjective variables, such as perceived security or aesthetics. Fourthly, the  
488 participant individual income measurement had weakness, there were lots of missing data and only  
489 household income was available. Residual confounding on socio economic level is therefore possible.  
490 Furthermore, we didn't have ethnicity information. Nevertheless, results were consistent after  
491 adjusting with a proxy of ethnicity by genetic cluster analysis which is not validated yet.

492 Filthy, This work has an analytic objective and representativeness of the sample is a less  
493 important issues(63). Nevertheless, we take into account the study sampling in a sensitivity analysis.  
494 The results on blood pressure remain significant. Association with physical activity were consistent  
495 but only significant for WI. The reduce number of significant results with physical activity may be  
496 explain by the lower power of this analysis. Indeed the number of degrees of freedom were increase  
497 by the stratification of the analysis by city areas. Lastly, our walkability index did not distinguish  
498 between establishments within each type of destination; for example, the retail category included  
499 supermarkets and small convenience stores. Nevertheless, this measurement error might have been  
500 non-differential and would have biased the association towards the null

501 This study had several strengths. Firstly, we used objective measures of cardiometabolic risk markers.  
502 Secondly, we use two different walkability indices - one of which was GIS-based. Thirdly, we studied

503 two different French cities with a wide range of urban settings and environmental features. The  
504 observed associations were similar in both cities. Furthermore, the observed associations were  
505 consistent with both walkability indices and all methods of adjusting the blood pressure analysis. This  
506 strengthens the level of confidence in our associations - especially for blood pressure and BMI, which  
507 do not appear to be explained by specific local features or methodological issues.

508

509

## 510 **Conclusion**

511

512 Overall, our results evidenced favourable associations between neighbourhood walkability on one  
513 hand and blood pressure and BMI on the other. However, no association was found for other  
514 cardiovascular health outcomes (HbA1c and blood lipid markers) in the French context. Greater  
515 neighbourhood walkability might improve health at the population level. Further research in Europe  
516 is required for a better understanding of the mechanisms involved - especially for blood markers.

517

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535

536 **Competing interest**

537 AC, FO, PA, AM declare that they have no conflicts of interest.

538

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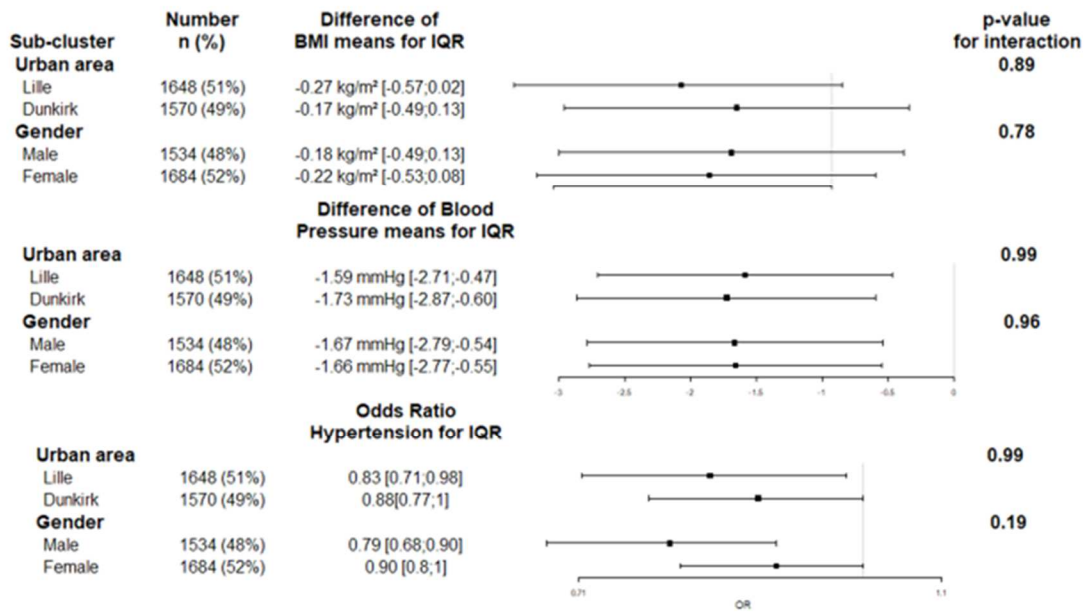
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737 Figure 1. Association with main outcomes for an IQR increment in the WI



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**Table 1 : Participants included in the analysis and neighborhood characteristics, by urban area and level of walkability**

Individual Variables	Lille			P-Value <sup>a</sup>	Dunkirk			P-Value <sup>a</sup>
	Low WI	Medium WI	High WI		Low WI	Medium WI	High WI	
Number n(%)	495(30.0)	592(35.9)	561(34.0)		584(37.2)	483(30.8)	503(32.0)	
Sex (Men), n(%)	240(48.5)	275(46.5)	255(45.5)	0.61	282(48.3)	246(50.9)	236(46.9)	0.44
Age, mean (SD)	53.2(6.9)	53.5(7.2)	52.6(7.4)	0.11	53.4(7.3)	53.4(7.4)	53.3(7.2)	0.942
Educational level, n(%)				<10 <sup>-4</sup>				<10 <sup>-4</sup>
5 years or more after high school	99(20)	135(22.8)	153(27.3)		58(9.9)	50(10.3)	91(18.1)	
2 years to 4 years after high school	118(23.8)	131(22.1)	114(20.3)		87(14.9)	65(13.5)	75(14.9)	
secondary education	242(48.8)	277(46.7)	239(42.6)		373(63.9)	299(61.9)	275(54.7)	
primary education	36(7.2)	49(8.3)	55(9.8)		66(11.3)	69(14.3)	62(12.3)	
Marital status, n(%)				<10 <sup>-4</sup>				<10 <sup>-4</sup>
single	25(5.0)	47(7.9)	93(16.6)		12(2.0)	24(5)	40(7.9)	
married or similar	405(81.8)	449(75.84)	363(64.7)		526(90.1)	393(81.4)	373(74.1)	
divorced	49(9.9)	70(11.82)	91(16.2)		34(5.8)	53(11)	71(14.1)	
widowed	12(2.4)	22(3.7)	10(1.8)		12(2.0)	13(2.7)	18(3.6)	
other	4(0.8)	4(0.7)	4(0.7)		0(0)	0(0)	1(0.2)	
Work activity, n(%)				0.733				0.164
no occupation/unemployed	154(31.1)	188(31.8)	178(31.7)		236(40.4)	215(44.5)	185(36.8)	
part-time work	56(11.3)	78(13.2)	78(13.9)		61(10.5)	47(9.7)	61(12.1)	
full-time work	285(57.6)	326(55.1)	305(54.4)		287(49.1)	221(45.8)	257(51.1)	
Smoking status, n(%)				0.01				0.186
Nonsmokers	582(53.6)	556(49.6)	517(49)		320(54.8)	246(50.9)	241(47.9)	
Current smokers	169(15.6)	217(19.4)	226(21.4)		97(16.6)	90(18.6)	107(21.3)	
Former smokers	335(30.8)	347(31)	312(29.6)		167(28.6)	147(30.4)	155(30.8)	
Physical activity level, n(%) <sup>b</sup>				<10 <sup>-4</sup>				0.003
Low	144(29.7)	149(25.9)	156(28.1)		301(51.4)	217(54.4)	203(42.5)	
Moderate	142(29.3)	249(43.3)	241(44.1)		165(28.2)	159(29.8)	192(40.1)	
High	198(41)	177(30.7)	150(27.4)		87(14.1)	80(15.7)	83(17.4)	
Daily walking >30 min, n(%)	210(42.42)	222(37.5)	251(44.74)	0.036	223(38.18)	193(39.96)	221(43.94)	0.141
BMI (kg/m <sup>2</sup> ), mean (SD)	26.9(4.7)	26.6(5.2)	26.6(5.3)	0.553	27.5(5.1)	28(5.2)	27.1(5.2)	0.039
Weight status, n(%)				<10 <sup>-4</sup>				0.025
BMI<25	202(41)	247(41.7)	239(42.6)		205(35.1)	142(29.4)	184(36.6)	
25<BMI<25	178(36)	233(39.3)	205(36.5)		236(40.4)	187(38.7)	195(38.8)	
BMI>30	115(23)	112(19)	117(20.9)		143(24.5)	154(31.9)	124(24.6)	
SBP (mmHg), mean (SD) <sup>c</sup>	129.2 (19.3)	126.5 (19)	126.5 (18.2)	0.035	132.1(19.3)	130 (19)	128.2(20)	0.039
DBP (mmHg), mean (SD) <sup>d</sup>	83.2(11.6)	81.8(11.5)	82.5(11.5)	0.158	83.7(12.3)	83.7(12.1)	81.9(12.2)	0.022
HBP, n(%) <sup>d</sup>	231(46.7)	253(42.7)	237(42.2)	.306	290(49.7)	235(48.6)	220(43.7)	0.132
Antihypertensive medication, n(%)	119(24)	142(24)	129(23)	0.899	145(24.8)	119(24.6)	118(23.5)	0.856
LDL-C <sup>e</sup> (g/L), mean (SD)	1.41(0.32)	1.37(0.36)	1.4(0.36)	0.151	1.41(0.3)	1.40(0.35)	1.42(0.34)	0.811
HDL-C <sup>e</sup> (g/L), mean (SD)	0.6(0.1)	0.59(0.1)	0.58(0.1)	0.17	0.58(0.14)	0.56(0.14)	0.57(0.15)	0.08
HbA1c <sup>f</sup> (%), mean (SD)	5.58(0.6)	5.65(0.6)	5.74(0.7)	<10 <sup>-4</sup>	5.75(0.67)	5.78(0.76)	5.78(0.76)	0.772
<b>Environmental variables</b>								
Walk Score <sup>g</sup> , mean (SD)	39.2(22.7)	60.4(18.7)	79.7(13)	<10 <sup>-4</sup>	33.7(24.2)	58.2(22.2)	76.8(20.8)	<10 <sup>-4</sup>
IRIS median income (×1000 euros), median [IQR]	21.1 [19.8-22.4]	20.6[18.1-21.5]	17.2[13.4-21.6]	<10 <sup>-4</sup>	17 [16.4-20]	16.7[15.5-18.9]	18.1[14.1-20]	<10 <sup>-4</sup>
IRIS density (1000 hab/km <sup>2</sup> ), median [IQR]	1.6[0.6-3.3]	4.0[1.8-5.1]	8.5[6.0-11.3]	<10 <sup>-4</sup>	0.9[0.4-2.5]	4.1[2.3-6.3]	6.9[4.5-9.1]	<10 <sup>-4</sup>
PM10 (µg/m <sup>3</sup> ), mean(sd)	25.9(1.8)	26.9(1.8)	28.15(1.6)	<10 <sup>-4</sup>	26.2(1.1)	26.63(0.8)	25.19(0.6)	<10 <sup>-4</sup>
NO <sub>2</sub> (µg/m <sup>3</sup> ), mean(sd)	23.2(4.9)	25.9(4.7)	28.72(4.8)	<10 <sup>-4</sup>	19.055(2.18)	20.222(2.2)	20.826(1.72)	<10 <sup>-3*</sup>

WI: walkability index; n: number; SD: standard deviation.

<sup>a</sup>Student's t-test for quantitative variables( Kruskal-Wallis test for skewed quantitative variables), or a chi<sup>2</sup> test for qualitative variables<sup>b</sup>: 125 missing data, <sup>c</sup> : 28 missing data; <sup>d</sup> : 56 missing data

**Table 1 (continuing) : Participants included in the analysis and neighborhood characteristics, by urban area and level of walkability**

Individual Variables	Lille			P-Value <sup>a</sup>	Dunkirk			P-Value <sup>a</sup>
	Low WI	Medium WI	High WI		Low WI	Medium WI	High WI	
<b>Genotype clusters ,n(%)</b>								<b>0.317</b>
European	444(89.7)	539(91.05)	464(82.71)	<10 <sup>-4</sup>	532(91.1)	427(88.41)	448(89.07)	
Others	51(10.3)	53(8.95)	97(17.29)		52(8.9)	56(11.59)	55(10.93)	
<b>Inclusion season ,n(%)</b>				0.726				<b>0.622</b>
Autumn	111(22.42)	137(23.14)	141(25.13)		150(25.68)	141(29.19)	123(24.45)	
Summer	104(21.01)	140(23.65)	122(21.75)		128(21.92)	104(21.53)	110(21.87)	
Winter	129(26.06)	132(22.3)	132(23.53)		134(22.95)	110(22.77)	112(22.27)	
Spring	151(30.51)	183(30.91)	166(29.59)		172(29.45)	128(26.5)	158(31.41)	
<b>MET,median [IQR]</b>	<b>2235[887.1-5040]</b>	<b>1806[856.5-3724]</b>	<b>1626[792-3360]</b>	<10 <sup>-4</sup>	<b>996[330-2346]</b>	<b>1039.5[280.1-2529.75]</b>	<b>1227.8[462-2362.75]</b>	<b>0.111</b>
<b>Annual Household income (euros),n(%)</b>				<10 <sup>-4</sup>				<b>0.036</b>
<7000	124(25.05)	165(27.87)	158(28.16)		96(16.44)	99(20.5)	94(18.69)	
7000-15 000	4(0.81)	3(0.51)	13(2.32)		1(0.17)	1(0.21)	3(0.6)	
15 000-30 000	21(4.24)	42(7.09)	71(12.66)		15(2.57)	26(5.38)	28(5.57)	
30 000-45 000	142(28.69)	168(28.38)	154(27.45)		116(19.86)	69(14.29)	73(14.51)	
45 000-60 000	101(20.4)	109(18.41)	67(11.94)		47(8.05)	45(9.32)	41(8.15)	0.164
60 000	54(10.91)	57(9.63)	51(9.09)		29(4.97)	25(5.18)	32(6.36)	
Didn't answer the question.	49(9.9)	48(8.11)	47(8.38)		280(47.95)	218(45.13)	232(46.12)	
<b>Mobility limitations, n(%)</b>	<b>36(7.27)</b>	<b>39(6.59)</b>	<b>57(10.16)</b>	<b>0.064</b>	<b>72(12.33)</b>	<b>60(12.42)</b>	<b>52(10.34)</b>	<b>0.505</b>

MET: Metabolic Equivalent of Task

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**Table 2 : Distribution of the Walk Score® by urban area**

Walk Score®	Lille		Dunkirk	
	<i>n</i> (%)	Mean	<i>n</i> (%)	Mean
Overall	1648	60.6	1570	55,1
Very car-dependent (0-24)	201(12.2)	14.7	373(23,8)	11.1
Car dependent (25-49)	215(13.0)	34.1	159(10,1)	40.6
Somewhat walkable (50 -69)	504(30.6)	60.2	418(26,6)	59.0
Very walkable (70 -89)	605(36,7)	78.8	459(29,2)	78.6
Walker's paradise (90 -100)	123(7,5)	95.1	161(10,3)	93.8

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**Table.3 : Association between neighborhood walkability (defined as a walkability index (WI) or the Walk Score® (WS)) and cardiovascular risk factors**

Variables	Score	% of increase				Odds ratio		Difference of Mean					
		Low (ref)	Medium [95% CI]	High [95% CI]	Linear trend for an interquartile range increment in walkability [95%CI] p-Value	Linear trend for an interquartile	p-Value	Low (ref)	Medium [95% CI]	High [95% CI]	Linear trend for an interquartile range increment in walkability [95% p-Value		
<b>Physical activity</b>													
Moderate or High activity <sup>b</sup>	WI	-	9.49[-2.16;22.52]	12.26[-0.12;26.16]	6.9[1.2;12.72]	0.01744	1.25[1.13;1.38]	0.00001					
	WS	-	4.49[-6.78;17.12]	9.49[-2.49;22.94]	5.14[-1.06;11.36]	0.10413	1.17[1.06;1.3]	0.00258					
High activity <sup>b</sup>	WI	-	-1.11[-25.24;5.69]	-12.67[-27.62;5.37]	-5.29[-14.52;4.28]	0.27489	0.94[0.83;1.05]	0.26169					
	WS	-	-7.12[-22.03;10.65]	-15.02[-29.59;2.56]	-10.8[-20.25;-1.31]	0.02572	0.86[0.76;0.97]	0.01087					
Daily Walking ≥ 30 min	WI	-	-4.34[-16.5;9.6]	12.1[-2.22;28.51]	7.91[1.07;14.92]	0.02306	1.16[1.06;1.28]	0.00131					
	WS	-	-1.82[-14.36;12.56]	8.59[-5.36;24.59]	4.79[-2.6;12.2]	0.20438	1.1[0.99;1.21]	0.07125					
MET(%)	WI	-							-	-15.84[-32.58;5.06]	11.73[-21.1;58.21]	11.51[1.99;21.37]	0.01748
	WS	-							-	-11.52[-27.27;7.66]	-7.32[-28.11;19.49]	4.37[-5.54;14.32]	0.38826
<b>Weight status</b>													
BMI (kg/m <sup>2</sup> )	WI	-							-	-0.03[-0.44;0.39]	-0.3[-0.73;0.13]	-0.23[-0.44;-0.01]	0.03723
	WS	-							-	-0.19[-0.61;0.23]	-0.32[-0.75;0.1]	-0.26[-0.48;-0.03]	0.02593
Obese	WI	-	5.04[-11.91;25.26]	-5.38[-21.7;14.35]	-3.5[-12.73;6.07]	0.4687	0.95[0.85;1.07]	0.40163					
	WS	-	2.68[-13.92;22.49]	-11.64[-26.97;6.91]	-5.87[-15.72;4.01]	0.24367	0.92[0.82;1.03]	0.15616					
<b>Blood pressure</b>													
SBP (mmHg) <sup>c</sup>	WI	-							-	-2.81[-4.39;-1.24]	-2.7[-4.33;-1.07]	-1.66[-2.46;-0.85]	0.00006
	WS	-							-	-2.09[-3.69;-0.5]	-2.28[-3.91;-0.65]	-1.52[-2.38;-0.66]	0.00054
DBP (mmHg) <sup>d</sup>	WI	-							-	-0.92[-1.94;0.1]	-1.1[-2.15;-0.04]	-0.79[-1.31;-0.27]	0.0031
	WS	-							-	-0.77[-1.81;0.26]	-0.89[-1.95;0.16]	-0.69[-1.25;-0.14]	0.01461
Hypertension <sup>d</sup>	WI	-	-6.98[-17.95;5.46]	-9.42[-20.64;3.39]	-7.12[-13.56;-0.52]	0.03461	0.86[0.78;0.95]	0.00225					
	WS	-	-5.93[-17.18;6.85]	-8.9[-20.16;3.94]	-6.69[-13.56;0.2]	0.05719	0.87[0.78;0.96]	0.00635					
Current smoker	WI	-	2.93[-16.88;27.47]	19.51[-3.41;47.88]	12.48[1.91;23.46]	0.02026	1.2[1.07;1.35]	0.00201					
	WS	-	24[-0.35;54.3]	40.22[12.78;74.33]	21[8.86;33.2]	0.00068	1.3[1.14;1.49]	0.0001					
Hba1c (%)	WI	-							-	0.03[-0.03;0.08]	0.07[0.01;0.13]	0.02[-0.01;0.05]	0.15841
	WS	-							-	0.02[-0.04;0.08]	0.05[-0.01;0.11]	0[-0.03;0.04]	0.79696
<b>Lipidemia</b>													
LDL(g/L)	WI	-							-	-0.01[-0.02;0.01]	0[-0.02;0.01]	0[-0.01;0.01]	0.82986
	WS	-							-	-0.01[-0.02;0.01]	0[-0.02;0.01]	-0.01[-0.01;0]	0.10571
HDL(g/L)	WI	-							-	-0.01[-0.04;0.02]	0[-0.03;0.03]	-0.01[-0.02;0.01]	0.43311
	WS	-							-	-0.03[-0.06;0]	-0.02[-0.05;0.01]	-0.01[-0.03;0.01]	0.29618
TG (g/L) <sup>f</sup>	WI	-							-	-0.02[-0.06;0.01]	-0.01[-0.04;0.03]	-0.01[-0.02;0.01]	0.45793
	WS	-							-	-0.04[-0.08;-0.01]	-0.03[-0.07;0.01]	-0.01[-0.03;0.01]	0.16389

CI: confidence interval; IQR: interquartile range; MET: Metabolic Equivalent of Task

main model adjusted for sex, age, urban area, educational level, smoking status, inclusion season, marital status, work activity, mobility limitation and residential median income

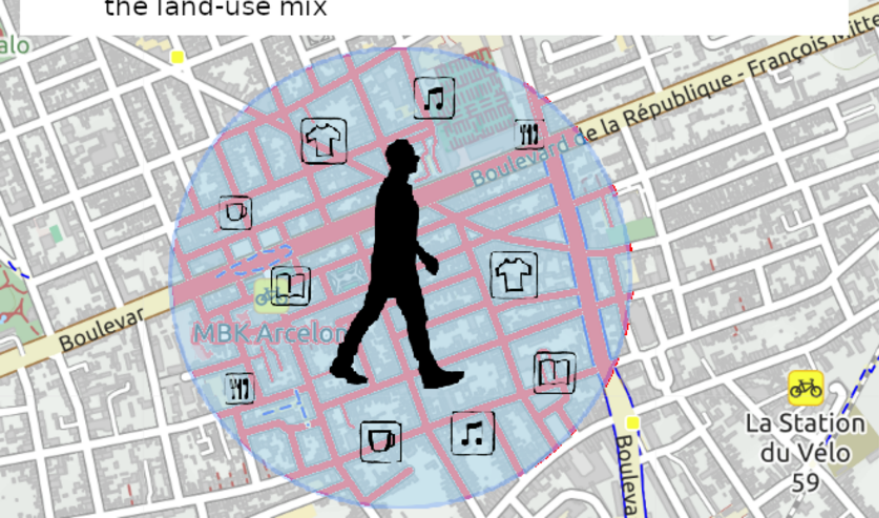
b: 125 missing data, c: 28 missing data; d: 56 missing data

Multiple linear regression for difference of mean; poisson regression for % of increase; logistic regression for odds ratio

Walkability can be defined as the extent to which the built environment supports and encourages walking trips

We defined walkability using three parameters:

- household density
- street connectivity
- the land-use mix



We analyzed associations between walkability and cardiovascular risk factor

For a one interquartile increment in walkability :



the % of prevalence increase was 5,8% for daily walking above 30 minutes



the BMI fell by 0.23 kg.m<sup>-2</sup>



the systolic blood pressure fell by 1.66 mmHg