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

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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[®]. 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⁻²; 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 (kg/m^2). Overweight corresponds to a BMI $\geq 25 \text{ kg}/\text{m}^2$ and < 30
140 kg/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 ≥ 140 mmHg, a DBP ≥ 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 ($LDL-C = Total\ Cholesterol - HDL-C - TG/5$ 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 PM₁₀ 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, Chi² 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 PM₁₀ 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/m²) 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 PM₁₀ or NO₂ 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 PM₁₀ Or NO₂.

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 β coefficient [95% CI] for BMI = -0.010 kg/m² [-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 PM₁₀ or NO₂. 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 ≥ 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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541 [Expert report on the location of the swimming pool in the Saint Sauveur station development
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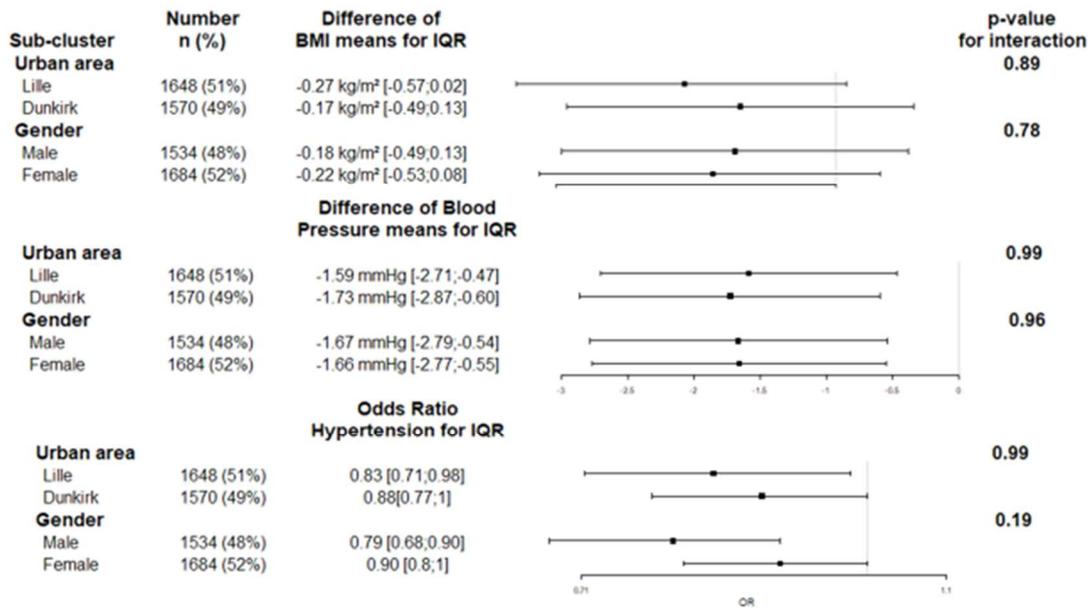
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737 Figure 1. Association with main outcomes for an IQR increment in the WI



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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 ^a	Dunkirk			P-Value ^a
	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 ⁻⁴				<10 ⁻⁴
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 ⁻⁴				<10 ⁻⁴
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(%) ^b				<10 ⁻⁴				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 ²), 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 ⁻⁴				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) ^c	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) ^d	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(%) ^d	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 ^e (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 ^e (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 ^f (%), mean (SD)	5.58(0.6)	5.65(0.6)	5.74(0.7)	<10 ⁻⁴	5.75(0.67)	5.78(0.76)	5.78(0.76)	0.772
Environmental variables								
Walk Score®, mean (SD)	39.2(22.7)	60.4(18.7)	79.7(13)	<10 ⁻⁴	33.7(24.2)	58.2(22.2)	76.8(20.8)	<10 ⁻⁴
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 ⁻⁴	17 [16.4-20]	16.7[15.5-18.9]	18.1[14.1-20]	<10 ⁻⁴
IRIS density (1000 hab/km ²), median [IQR]	1.6[0.6-3.3]	4.0[1.8-5.1]	8.5[6.0-11.3]	<10 ⁻⁴	0.9[0.4-2.5]	4.1[2.3-6.3]	6.9[4.5-9.1]	<10 ⁻⁴
PM10 (µg/m ³), mean(sd)	25.9(1.8)	26.9(1.8)	28.15(1.6)	<10 ⁻⁴	26.2(1.1)	26.63(0.8)	25.19(0.6)	<10 ⁻⁴
NO ₂ (µg/m ³), mean(sd)	23.2(4.9)	25.9(4.7)	28.72(4.8)	<10 ⁻⁴	19.055(2.18)	20.222(2.2)	20.826(1.72)	<10 ^{-3*}

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

^aStudent's t-test for quantitative variables(Kruskal-Wallis test for skewed quantitative variables), or a chi² test for qualitative variables

b: 125 missing data, c : 28 missing data; d : 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 ^a	Dunkirk			P-Value ^a
	Low WI	Medium WI	High WI		Low WI	Medium WI	High WI	
Genotype clusters ,n(%)								0.317
European	444(89.7)	539(91.05)	464(82.71)	<10 ⁻⁴	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)	
Inclusion season ,n(%)				0.726				0.622
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)	
MET,median [IQR]	2235[887.1-5040]	1806[856.5-3724]	1626[792-3360]	<10 ⁻⁴	996[330-2346]	1039.5[280.1-2529.75]	1227.8[462-2362.75]	0.111
Annual Household income (euros),n(%)				<10 ⁻⁴				0.036
<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)	
Mobility limitations, n(%)	36(7.27)	39(6.59)	57(10.16)	0.064	72(12.33)	60(12.42)	52(10.34)	0.505

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		
Physical activity													
Moderate or High activity ^b	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 ^b	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
Weight status													
BMI (kg/m ²)	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					
Blood pressure													
SBP (mmHg) ^c	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) ^d	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 ^d	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
Lipidemia													
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) ^f	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

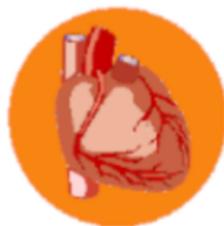
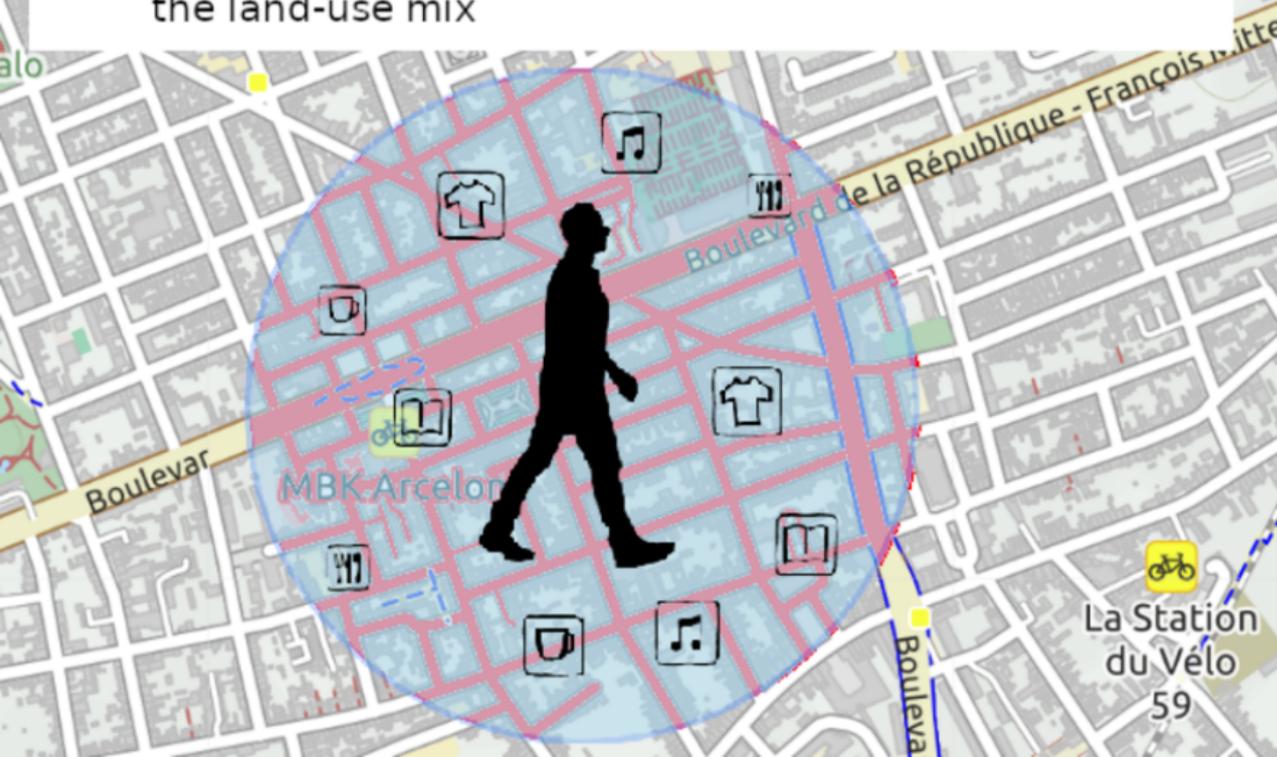
b: 125 missing data, c: 28 missing data; d: 56 missing data

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

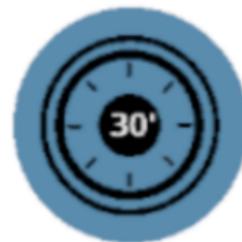
We defined walkability using three parameters:

- 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⁻²



the systolic blood pressure fell by 1.66 mmHg