Multiple dimensions of residential environments, neighborhood experiences, and jogging behavior in the RECORD Study

Noëlla Karusisi [a,b,*], Kathy Bean [c], Jean-Michel Oppert [d], Bruno Pannier [c], Basile Chaix [a,b]

[a] Inserm, U707, Faculté de Médecine Saint-Antoine, 27 rue Chaligny, 75012 Paris, France
[b] Université Pierre et Marie Curie-Paris6, UMR-S 707, Faculté de Médecine Saint-Antoine, 27 rue Chaligny, 75012 Paris, France
[c] Centre d'Investigations Préventives et Cliniques, 6 rue La Pérouse, 75116 Paris, France
[d] Université Pierre et Marie Curie-Paris6, Service de Nutrition, Hôpital Pitié-Salpêtrière (AP-HP), Centre de Recherche en Nutrition Humaine Ile-de-France (CRNH IdF), 47-83 boulevard de l'Hôpital 75013 Paris, France

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ABSTRACT

Objective. The purpose of this study was to examine the associations between a broad range of environmental characteristics and jogging behavior while taking into account different complementary outcomes to describe the behavior.

Methods. Using the RECORD Cohort Study (7290 participants, 2007–2008, Paris region, France), multilevel models were used to investigate individual/neighborhood variables associated with the probability of jogging; the time spent jogging; and the location of the practice.

Results. The presence and quality of green and open spaces was associated both with a greater probability of jogging [risk ratio (RR) for the first *vs.* the fourth quartile = 1.22, 95% credible interval (CrI): 1.03–1.44] and with the practice of jogging within rather than outside the neighborhood (RR = 1.29; 95% CrI: 1.10–1.53). Moreover, a high social cohesion and the presence of enjoyable places were associated with a higher probability of jogging (RR = 1.15; 95% CrI: 1.00–1.31; RR = 1.22; 95% CrI: 1.03–1.44) while the presence of parks or a lake increased the probability of jogging inside rather than outside the neighborhood (RR = 1.29; 95% CrI: 1.10–1.53; RR = 1.14; 95% CrI: 1.03–1.26).

Conclusions. Paying attention to physical and social environments, related neighborhood experiences, and attitudes toward health may be an effective approach to promote outdoor physical activity.

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Introduction

Several studies have found relationships between geographic life environments and physical activity (Berke et al., 2007; Humpel et al., 2002).

While previous studies have related geographic life environments to outdoor physical activities (Ball et al., 2007; Owen et al., 2004; Suminski et al., 2008a), none has focused on jogging behavior as a separate and specific outcome and none of them has been conducted in France. Therefore, more knowledge regarding the association between objectively measured attributes of the built environment and jogging behavior is needed to improve the design of the environment and create physically active communities (Suminski et al., 2008b).

Using data from the French RECORD Study, the aim of this study was to investigate associations that may exist between, on one hand, characteristics of the residential environment, weather over the previous week, experiences made in the residential neighborhood, health attitudes, and psychological variables and, on the other hand, the jogging behavior over the previous week. To better account for the complexity of jogging activity, the present study focuses on different aspects of jogging behavior such as practicing jogging or not, the time spent jogging, and the location of jogging, *i.e.* jogging inside or outside the residential neighborhood. Moreover, we took into account numerous environmental factors related to the sociodemographic, physical, service, social–interactional, and symbolic environments.

Methods

Population

The RECORD Cohort Study (www.record-study.org) was used for the analyses. Between March 2007 and February 2008, 7290 participants were recruited (Chaix et al., 2012; Leal et al., 2011). Participants were recruited without *a priori* sampling during health checkups conducted by the Centre d'Investigations Préventives et Cliniques, located in the Paris metropolitan area. Eligibility criteria were as follows: age 30 to 79 years; ability to complete study questionnaires; and residence in one of the 10 (out of 20)

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* Corresponding author at: Inserm, U707, Faculté de Médecine Saint-Antoine, 27 rue Chaligny, 75012 Paris, France.
  E-mail address: karusisi@u707.jussieu.fr (N. Karusisi).

administrative divisions of Paris or 111 other municipalities of the metropolitan area selected *a priori*. Of the persons selected for participation, 83.6% accepted to participate and completed the data collection protocol.

All participants were geocoded with accuracy based on their residential address in 2007–2008. The study protocol was approved by the French Data Protection Authority.

Measures

Jogging behavior

Three outcome variables were defined in the present study: (i) a binary variable indicating whether the individuals had jogged over the previous 7 days; overall jogging time in minutes over the previous 7 days (among joggers); and (iii) a binary variable defined among joggers indicating whether they had performed at least part of their jogging activity in their neighborhood rather than only out of their neighborhood.

Individual adjustment covariates

Several sociodemographic characteristics were considered: age (divided in 3 classes), sex, individual education (divided into 4 classes: no education, primary education and lower secondary education, higher secondary education and lower tertiary education, and upper tertiary education), marital status (coded in 2 classes: living alone or as a couple), occupation (coded into 4 categories: high white-collar workers, intermediate occupations, low white-collar workers, and blue-collar workers) and household income (divided into 4 categories). Two binary variables were determined: homeownership and perceived financial strain. We attributed to each individual the 2004 Human Development Index (HDI) of his/her country of birth (divided in 4 classes: born in low-development countries, in medium-development countries, in France, and in other high-development countries (Beckman et al., 2006)).

Moreover, we determined energy expenditure at work over the previous week by taking into account the reported time spent in moderate or vigorous occupational physical activities (divided in 4 classes: no work activity/no energy expenditure, low energy expenditure, lower middle energy expenditure, upper middle energy expenditure and high energy expenditure).

Weather variables

We used daily meteorological data provided by Meteo France for 2007–2008. Based on these data, we defined average weather variables (in quartiles) for each participant for the recruitment day and 7 previous days: minimum temperature; maximum temperature; average temperature; rainfall; atmospheric pressure; wind speed; time of sunshine; presence of fog or not; and presence of mist or not.

Neighborhood variables

Details on the neighborhood variables, related to the socioeconomic, physical, service related, social–interactional, and symbolic environments, are reported in Table 1.

Most variables were defined within 1 km radius circular buffers centered on each participant's residence. Other neighborhood variables were defined using the ecometric method through which individuals' perceptions were aggregated at the neighborhood level (TRIRIS geographic unit, see definition in Table 2) based on 3-level (perception items, individuals, area units) hierarchical modeling (Chaix et al., 2008; Mujahid et al., 2007). Neighborhood variables were analyzed as divided into 4 categories comprising a similar number of individuals.

Neighborhood experiences, psychological variables, and health attitudes

Six variables from the RECORD questionnaire allowed us to assess neighborhood experiences. Four separate variables indicated whether family members lived in the same neighborhood as the participants, whether participants had any close friends in their neighborhood, whether participants usually talked with neighbors, and whether participants at least knew some people by sight in their neighborhood. Moreover, two separate variables indicated whether living in the neighborhood was a source of stress for the participants or a source of depressive feelings.

Regarding psychological variables, we considered the 13-item QD2A depression scale of Pichot (Pichot et al., 1984) and the 4-item Perceived Stress Scale of Cohen (Cohen et al., 1983).

Regarding health attitudes, 5 variables related to general values or attitudes toward health were considered: priority given to health; attitude toward prevention of diseases; propensity to keep healthy resolutions;

Table 1
Operational definitions of neighborhood variables considered in the analyses, the RECORD Study, 2007–2008.

Environmental dimension	Variable	Definition, data source (year)
Socio-demographic	Education level[a]	Proportion of residents aged > 15 years with an upper tertiary education, Census (2006)
	Household income[a]	Median household income per consumption unit, Tax Registry of General Directorate of Taxation (2006)
	Real estate prices[a]	Mean value of dwellings sold in 2003–2007, Paris-Notaries (2003–2007)
	Population density[a]	Population density in the neighborhood, Census (2006)
Physical	Proportion of built surface[a]	Proportion of the neighborhood covered with buildings, 3-dimensional data from IGN on buildings' ground shapes and heights (2008)
	Mean building height[a]	Mean building height weighted by each building ground size, 3-dimensional data from IGN on buildings' ground shapes and heights (2008)
	Density of street intersections[a]	Density of intersections with at least 4 ways, data on road network from IGN (2008)
	Average block length[a]	Average length of street blocks, data on road network from IGN (2008)
	Connected node ratio[a]	Number of street intersections with at least 3 ways divided by the number of intersections plus cul-de-sacs within circular areas, data on road network from IGN (2008)
	Proportion of the area with parks or green spaces[a]	Proportion of the area covered with parks or green spaces, linear and polygonal data from IAU-IdF (2008)
	Proportion of the area covered by water[a]	Proportion of the area covered by water, linear and polygonal data from IAU-IdF (2008)
	Presence and quality of green and open spaces[b]	Ecometric variable, 3 items from the RECORD questionnaire (2007–2008)
	Maintenance of the physical environment[b]	Ecometric variable, 4 items from the RECORD questionnaire (2007–2008)
Service-related	Density of destinations[a]	Number of destinations close to the dwelling including supermarkets, other shops, administrative services, health services, entertainment services, data from INSEE (2008)
	Presence of monuments and enjoyable places[a]	Count of monuments (historical or other), data from IAU-IdF (2005)
	Number of transportation lines[a]	Number of transportation lines near the dwelling, data from the STIF (2008)
	Presence of a mall nearby[a]	Presence of a shopping mall near the dwelling, data from IAU-IdF (2008)
Social interactional	Social cohesion[b]	Ecometric variable, 4 items from the RECORD questionnaire (2007–2008)
	Collective feeling of insecurity[b]	Ecometric variable, 1 item from the RECORD questionnaire (2007–2008)
	Deteriorated social interactions[b]	Ecometric variable, 5 items from the RECORD questionnaire (2007–2008)
	Hostility and distrust within the neighborhood[b]	Ecometric variable, 3 items from the RECORD questionnaire (2007–2008)
Symbolic	Stigmatization of the neighborhood[b]	Ecometric variable, 3 items from the RECORD questionnaire (2007–2008)

IAU-IdF, Institute of Urban Planning of region Ile-de-France; IGN, National Geographic Institute; Insee, National Institute of Statistics and Economic Studies; STIF, the Ile-de-France Transportation Authority.
  [a] The variable was measured in circular areas of 1000 m of radius centered on each participant's residence.
  [b] The variable was measured at the TRIRIS neighborhood level (fixed boundaries not centered on participants' residences, roughly equivalent to census tracts in the US).

Table 2
Descriptive information on the population size and surface of neighborhoods and areas considered in the study, the RECORD Study, 2007–2008.

Type of neighborhood or area	Utilization	Characteristics			
		Number of area units	Area (km²), median (interdecile range)	Population, median (interdecile range)	Number of participants, median (interdecile range)
IRIS	Multilevel model	1914	0.160 (0.0502–0.652)	2425 (1836–3534)	3 (1–7)
TRIRIS	Construction of ecometric variables	662	0.663 (0.184–2.996)	7978 (6174–10,434)	10 (4–19)
Municipality	Multilevel model	116	5.797 (2.715–12.562)	30,671 (8924–97,875)	6 (2–28)
1 km radius buffers	Measurement of neighborhood factors	One per participant	3.14	10,859 (3573–30,314)	–
Perceived[a] neighborhood	Outcomes variable and experiences in the neighborhood	–	–	–	–

[a] Participants were asked to answer to the survey questions related to their neighborhood based on their own definition of their neighborhood.

health-related internal locus of control (belief that the risk of disease depends on individual health behavior); and health-related external locus of control (belief that one's health depends on external forces such as God or fate).

Statistical analysis

First, to analyze associations between individual and neighborhood variables and the probability of jogging, we estimated a multilevel log binomial model at the IRIS neighborhood level (see definition in Table 2). Second, we modeled the 4-category ordinal variable for the time spent jogging over the previous 7 days with a logit ordinal multilevel regression model. Finally, we modeled the binary variable indicating whether individuals had made at least part of their jogging in their residential neighborhood with a log binomial multilevel regression model at the municipality level (see Table 2). The second and third models were estimated among joggers. We first estimated models including only age and sex to assess between-neighborhood variability in jogging behavior. Second, we included individual adjustment covariates and weather variables. Third, we used these basic models to test one by one the

Table 3
Descriptive information on the RECORD participants stratified by sex, Paris Metropolitan Area, 2007–2008.

Variables	Men (%)	Women (%)
Age (years)		
30–44	36.43	33.61
45–59	43.28	38.54
60–79	20.29	27.84
Individual education		
No education	7.06	9.11
Medium–low education	22.68	27.57
Medium–high education	26.97	33.89
High education	42.67	28.32
Marital status		
Living alone	24.27	40.57
Living as a couple	69.58	54.81
Occupation		
High white-collar workers	46.90	24.70
Intermediate occupations	5.86	5.01
Low white-collar workers	30.59	53.02
Blue-collar workers	13.92	5.97
Homeownership		
Owners	55.59	51.35
Nonowners	44.33	48.41
Household income		
Low income	24.08	29.59
Medium–low income	23.60	25.30
Medium–high income	23.24	20.92
High income	28.62	23.51
Perceived financial strain	14.74	20.53
Human Development Index of country of birth		
Low	5.00	4.77
Medium	15.64	15.67
France	71.40	67.94
High (other than France)	7.96	11.61

different contextual variables, using 1 km radius circular areas when applicable (a 1 km radius was found to be relevant for the jogging behavior investigated). Fourth, we progressively combined into one model the environmental variables that were associated with each outcome. Fifth, we added simultaneously the variables for neighborhood experiences, psychological status, and health attitudes to estimate their association with jogging behavior. At each step, we only retained those variables that remained associated with the outcomes.

All models were estimated with Markov chain Monte Carlo simulation using WinBUGS 1.4.3.21 (Chu and Cole, 2010; Spiegelhalter et al., 2002).

Results

Descriptive information on the study sample is provided in Table 3.

The probability of jogging

Overall, 14.6% of the participants reported to have jogged over the previous 7 days.

A multilevel model adjusted for age and sex revealed that there were no between-neighborhood variations in the practice of jogging (variance = 9.98E−4; 95% credible interval: 1.332E−4–0.05616).

The individual and neighborhood variables that were associated with jogging after mutual adjustment are shown in Table 4. The probability of jogging increased with individual education level, and was higher among participants who owned their dwelling and reported no financial strain. The probability of jogging was lower among blue collar workers than among high white collar workers.

Regarding neighborhood influences, the probability of jogging showed a pattern of dose–response associations with the presence and quality of green and open spaces, with the degree of social cohesion in the neighborhood, and with the presence of monuments and enjoyable places near the dwelling. After controlling for individual covariates, the probability of jogging increased with the presence and quality of green and open spaces and with the degree of social cohesion in the neighborhood.

Neighborhood experiences associated with a lower probability of jogging were a high neighborhood-related stress and not having friends in one's neighborhood. Moreover, the propensity to keep healthy resolutions was associated with a much higher probability of jogging. The association between the presence and quality of green and open spaces and the probability of jogging was only slightly reduced after adjustment for neighborhood experiences and the propensity to keep healthy resolutions.

Time spent jogging

Among joggers, the average jogging time over the previous 7 days was 108 min (interquartile range = 55 min; 120 min). Among the individual and neighborhood variables tested, only few individual variables were associated with the outcome (results not shown in a

Table 4
Associations between individual/environmental characteristics and the probability of jogging.

Individual/environmental variables	Model 1[a]	Model 2[b]
	Rate ratio (95% credible interval)	Rate ratio (95% credible interval)
Age (years)		
30–39	1.00	1.00
40–59	0.74 (0.66–0.83)	0.71 (0.64–0.80)
60–79	0.39 (0.32–0.46)	0.33 (0.28–0.40)
Men (*vs.* women)	2.02 (1.74–2.35)	1.98 (1.72–2.30)
Individual education level		
No education	1.00	1.00
Primary and lower secondary	1.50 (1.08–2.17)	1.64 (1.21–2.28)
Higher secondary and lower tertiary	1.69 (1.22–2.45)	1.62 (1.18–2.31)
Upper tertiary	1.91 (1.37–2.78)	1.81 (1.32–2.52)
Occupation		
High white-collar	1.00	1.00
Intermediate	0.92 (0.71–1.17)	0.93 (0.73–1.17)
Low white-collar	0.93 (0.80–1.07)	0.92 (0.80–1.06)
Blue-collar	0.78 (0.61–1.00)	0.77 (0.61–0.98)
Nonownership of dwelling (*vs.* owner)	0.82 (0.72–0.93)	0.88 (0.78–0.99)
No financial strain	1.24 (1.03–1.50)	1.11 (0.94–1.35)
Time of sunshine		
Low	1.00	1.00
Mid-low	1.13 (0.97–1.31)	1.15 (0.99–1.34)
Mid-high	1.09 (0.93–1.27)	1.08 (0.93–1.26)
High	1.16 (1.00–1.36)	1.13 (0.97–1.31)
Presence and quality of green and open spaces		
Low	1.00	1.00
Mid-low	1.12 (0.95–1.32)	1.11 (0.95–1.31)
Mid-high	1.24 (1.05–1.46)	1.21 (1.03–1.41)
High	1.22 (1.03–1.44)	1.15 (0.98–1.36)
Neighborhood social cohesion		
Low	1.00	1.00
Mid-low	1.15 (0.98–1.35)	1.14 (0.98–1.33)
Mid-high	1.14 (0.97–1.35)	1.13 (0.96–1.32)
High	1.22 (1.03–1.44)	1.20 (1.03–1.41)
Presence of monuments and enjoyable places		
Low	1.00	1.00
Medium	1.13 (0.99–1.29)	1.11 (0.98–1.27)
High	1.15 (1.00–1.31)	1.16 (0.99–1.29)
No friends in the neighborhood	–	0.85 (0.76–0.95)
Neighborhood related stress	–	0.67 (0.53–0.83)
Propensity to keep healthy resolutions		
Low	–	1.00
Medium	–	2.29 (1.86–2.85)
High	–	3.78 (3.10–4.70)

[a] Model 1 included all individual sociodemographic, weather, and environmental variables associated with the outcome.
[b] Model 2 further included neighborhood experiences and health attitudes associated with the outcome.

Table 5
Associations between individual/environmental characteristics and jogging within rather than outside the neighborhood.

Individual/environmental variables	Model 1[a]	Model 2[b]
	Rate ratio (95% credible interval)	Rate ratio (95% credible interval)
Age (years)		
30–39	1.00	1.00
40–59	0.95 (0.87–1.03)	0.94 (0.85–1.07)
60–79	1.00 (0.87–1.13)	1.01 (0.88–1.17)
Men (*vs.* women)	0.94 (0.85–1.04)	0.92 (0.82–1.02)
Individual education level		
No education	1.00	1.00
Primary and lower secondary	1.03 (0.81–1.42)	1.04 (0.80–2.31)
Higher secondary and lower tertiary	1.07 (0.85–1.46)	1.07 (0.83–2.54)
Upper tertiary	1.15 (0.92–1.57)	1.16 (0.91–3.01)
Minimum temperature		
Low	1.00	1.00
Mid-low	0.95 (0.84–1.06)	0.95 (0.84–1.11)
Mid-high	1.00 (0.90–1.11)	0.98 (0.88–1.14)
High	0.93 (0.83–1.04)	0.93 (0.82–1.06)
Proportion of area covered with water	1.14 (1.03–1.26)	1.15 (1.03–1.36)
Proportion of area covered with parks		
Low	1.00	1.00
Mid-low	1.05 (0.91–1.22)	1.06 (0.91–1.43)
Mid-high	1.13 (0.99–1.30)	1.19 (1.02–1.73)
High	1.15 (1.00–1.34)	1.17 (1.00–2.22)
Presence and quality of green and open spaces		
Low	1.00	1.00
Mid-low	1.27 (1.10–1.49)	1.31 (1.03–1.95)
Mid-high	1.18 (1.01–1.38)	1.12 (0.93–1.34)
High	1.29 (1.10–1.53)	1.27 (1.06–1.91)
Attachment to the neighborhood		
Low	–	1.00
Medium	–	1.13 (1.00–1.48)
High	–	1.24 (1.00–1.69)

[a] Model 1 included all individual sociodemographic, weather, and environmental variables associated with the outcome.
[b] Model 2 further included neighborhood experiences and health attitudes associated with the outcome.

Adding neighborhood experiences into the model indicated that a high attachment to one's residential neighborhood was associated with jogging inside rather than outside one's neighborhood. Attachment to the neighborhood only mediated a modest part of the relationship between the presence and quality of green and open spaces and the likelihood to jog in one's neighborhood (Table 5).

Discussion

The main findings of this study are the following: (i) there were particularly strong disparities in jogging behavior according to the individual level of education; (Inoue et al., 2009) the presence and quality of green and open spaces played an important role in predicting both the probability of jogging behavior and the location of jogging, but aspects of the social environment also appeared to influence such behavior; and (iii) neighborhood experiences and health attitudes only mediated a very modest part of the relationships between residential environment characteristics and jogging behavior.

Study limitations and strengths

To the best of our knowledge, no previous study has exclusively focused on jogging as a separate outcome.

Strengths of the study include the large sample accurately geocoded over the Paris Ile-de-France region, the complementary

table). The time spent jogging was higher among blue-collar workers and low white-collar workers than among high white-collar workers. However, no environmental variable was related to the outcome.

Jogging within the neighborhood

Overall, 32.4% of the joggers reported to have performed at least part of their jogging in their neighborhood over the previous 7 days.

Among joggers, age, sex and individual education were associated with the probability of jogging within one's residential neighborhood before adjustment for contextual variables.

Regarding environmental variables, the probability of jogging within the neighborhood increased with the proportion of area covered with water in the neighborhood, with the proportion of area covered with parks, and with the presence and quality of green and open spaces (Table 5).

outcome variables that were used to describe jogging, and the multiple neighborhood/social indicators that were employed to investigate factors contributing to the associations between environmental characteristics and jogging behavior.

However, analyses were based on cross-sectional data, not allowing us to investigate whether it is the environment that influenced jogging behavior or the usual physical activity habits of the participants to practice jogging that led them to live in particular neighborhoods that permit this activity. Moreover, we did not objectively assess the perceived boundaries of each participant's neighborhood. We simply asked the participants to answer to the survey questions related to their neighborhood based on their own definition of their neighborhood. Thus, the assessment of whether jogging was practiced inside or outside the neighborhood was based on areas that may vary in size across respondents.

Associations between environmental factors and jogging behavior

In our study, the presence and quality of green and open spaces was associated both with the probability of jogging and with the practice of jogging within rather than outside one's residential neighborhood. The presence and quality of green and open spaces was assessed with the ecometric technique (Chaix, 2009; Mujahid et al., 2007) by taking into account evaluations of the participants on 3 different environmental aspects including the lack of green spaces near the dwelling, the lack of space for outdoor sports, and the unpleasantness of the walking environment (Gauvin et al., 2008). Of particular interest, this variable was a stronger correlate than the objective area of parks or green spaces. The objective area of parks was associated with the probability of jogging before accounting for the presence/quality of green/open spaces but not after. Moreover, the practice of jogging within the neighborhood rather than outside was associated with the objective area of parks, but less strongly than with the presence/quality of green/open spaces. A hypothesis is that the presence and quality of green and open spaces was strongly associated with the probability and location of jogging because it takes into consideration the quality and the esthetic of parks and green spaces.

Furthermore, the presence of monuments and other enjoyable sites was associated with a higher probability of jogging and the likelihood to practice jogging in one's residential neighborhood rather than outside was higher when there was a lake in the neighborhood. These two findings suggest that such features of the neighborhood contribute to the attractive appearance and agreeableness of the environment effectively promote active living and physical activity in residential contexts.

In addition to the physical environment, an aspect of neighborhood social interactions, social cohesion, also influenced jogging behavior. Social cohesion was assessed as an ecometric variable based on 4 items of the RECORD questionnaire including helpfulness and exchanging services among neighbors, sense of community in the neighborhood, the attitude of solving neighborhood problems together, and feeling of connectedness among neighbors. Our finding suggests that, apart from the physical environment, cohesive social interactions may encourage participants to spend time in their outdoor environment, thereby promoting the practice of jogging.

Associations between neighborhood experiences or health attitudes and jogging behavior

Regarding neighborhood experiences, we found that people reporting a high level of neighborhood related stress and people reporting a low number of friends in their neighborhood had a lower probability to jog. Moreover, a low attachment to one's residential neighborhood increased the odds of jogging out of one's residential environment. In coherence with the effect of neighborhood social

cohesion, these findings suggest that, apart from the physical environment or environmental esthetics (Ball et al., 2001), social relationships in the neighborhood and related well-being may contribute to influence the jogging behavior (Diez Roux, 2003).

However, it should be noted that our cross-sectional data do not allow us to demonstrate that the relationships between neighborhood experiences and jogging are attributable to a causal effect of such experiences on the jogging behavior. Another possibility, perhaps slightly less plausible though, is that the jogging behavior promotes contacts with the environment, thereby generating favorable experiences in the neighborhood (*e.g.*, meeting people, familiarity with the neighborhood, etc.).

Implications

Our study focused on a specific recreational physical activity suggests that it is important to take into account features of the environment in which people live to promote regular physical activity.

The result that the presence and quality of green and open spaces was associated with both the likelihood of jogging and the fact of jogging within one's residential neighborhood indicates that creating pleasant environments with green spaces of high quality and other attractive features such as waterways or lakes may effectively promote outdoor physical activity. The study also suggests that local policymakers should pay attention to the social relationships among neighbors to promote the practice of a sport as jogging.

Conflict of interest

The authors declare that they have no competing interests.

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