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Does Perceived Behavioral Control Mediate the Association Between Perceptions of Neighborhood Walkability and Moderate- and Vigorous-Intensity Leisure-Time Physical Activity?

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Background: Research regarding the pathways via which the environment influences physical activity is limited. This study examined the role of perceived behavioral control (PBC) in mediating the relationship between perceptions of neighborhood walkability and frequency of moderate (MODPA) and vigorous physical activity (VIGPA). ***Methods:*** Data were collected through a province-wide survey of physical activity. Telephone-interviews were conducted with 1207 adults and captured information about perceptions of neighborhood walkability, physical activity, PBC and demographics. Gender-stratified regression analyses were conducted to test PBC mediation of the built environment-physical activity association. ***Results:*** Among women easy access to places for physical activity was positively associated with MODPA and VIGPA. Having many shops and places within walking distance of homes was also positively associated with MODPA among women however; reporting sidewalks on most neighborhood streets, and crime rate in the neighborhood were negatively correlated with MODPA. Among men, easy access to places for physical activity was positively associated and crime rate in the neighborhood negatively associated, with VIGPA. After adjusting for PBC, the association between easy access to places for physical activity and VIGPA and MODPA attenuated for men and women suggesting mediation of this association by PBC. ***Conclusions:*** PBC mediated the relationship between easy access to places for physical activity and physical activity, but not for other perceived environmental attributes.

Keywords: built environment, self-report environment, theory of planned behavior, exercise

Background

Current levels of physical activity in most developed countries are unsatisfactory.[1,2] Though research suggests that the built environment is potentially an important determinant of physical activity,[3–6] explanatory models of physical activity have generally focused on biological, psychological, and sociological determinants, largely ignoring the physical environment.[7,8] However, social cognitive models of behavior such as social cognitive theory[9] and the theory of planned behavior[10] recognize the role of the environment as it is perceived by the individual.[11] According to these models, the built environment may influence physical activity but it will do so by influencing the cognitions of individuals. For instance, constructs such as perceived behavioral control (PBC) and self-efficacy[9,10] capture the influence of perceived internal and external opportunities and barriers that are associated with behavior. PBC reflects confidence to overcome internal (eg, motivation and ability) and external constraints (eg, availability of resources or opportunities).[12,13] PBC may therefore, mediate associations between the built environment and physical activity.

Exploring the associations between the built environment and cognitions could be important for understanding mechanisms underlying the built environment–physical

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activity relationship and for identifying potential interventions.[14–16] Interventions could be designed to change a person's perceptions about the walkability of their neighborhood which in turn might result in more positive cognitions and increased physical activity. For example, making a person more aware of the physical activity facilities that exist within walking distance of their home might result in more positive beliefs regarding their ability to walk to these facilities. Recent studies have begun to examine the role of cognitions in the relationship between the built environment and physical activity.[17–23] In a study of children, attitudes, PBC, and intentions mediated the association between perceived aesthetics and proximity to opportunities and physical activity.[17] McNeill et al[21] found that perceived neighborhood quality and the availability of facilities were indirectly associated with physical activity via intrinsic motivation and self-efficacy, while a prospective study by Rhodes et al[23] showed that attitude mediated the relationship between retail land use mix, neighborhood aesthetics, infrastructure quality, and walking.

Limited research also suggests that the mediating role of psychological variables in the relationship between the built environment and physical activity might be gender-specific[24] Understanding how gender moderates this relationship could explain why associations between the built environment and physical activity often differ for men and women.[24–28] Moreover, certain built environmental attributes may be associated with different types of physical activity behavior,[3,5] that is, some physical activity behaviors are context-specific.[29] It is possible that the mediating role of cognitions, such as PBC, in the built environment-physical activity relationship is dependent on the type of physical activity and environmental variables examined. Studies exploring this issue are lacking. The dearth of literature to date means that more research examining mediation of the environment-physical activity relationship is needed and additional exploration of this relationship with regard to gender differences and influence of different types of physical activity required.

Given the current state of knowledge and calls to investigate the mediating role of psychological variables in associations regarding the built environment and physical activity[14,30] this study had 2 objectives. First, we examined whether perceptions of the built environment were associated with participation in moderate (MODPA) and vigorous (VIGPA) physical activity among men and women. The second objective examined whether PBC mediated the association between perceptions of the built environment and MODPA and VIGPA among men and women.

Method

Design and Sample

A telephone-interview survey was conducted with 1207 adults from the Province of Alberta, Canada. Households were randomly sampled using random-digit dialing. One respondent 18 years and older was recruited from each household. In addition, respondents within households were sampled based on gender to recruit even proportions of men and women. After contacting households interviewers first attempted to recruit a male respondent, and if this was not possible then they attempted to recruit a female respondent. The response rate was 39.9%. Data regarding demographic information, physical activity behaviors, perceptions of neighborhood walkability, and physical activity-related cognitions were collected through interviews conducted between March and May 2006.

Self-Reported Environment Variables

Eight items from the International Physical Activity Prevalence Study's Environmental Survey Module[31] measured respondents' perceptions of the supportiveness of the built environment for physical activity. The items captured agreement on a 5-point Likert scale with higher scores representing more positive agreement (ie, 1 = strongly disagree to 5 = strongly agree). Respondents were asked whether they agreed, disagreed or were neutral about the following statements: 1) I have easy access to places to get physical activity; 2) Many shops, stores, and other places to buy things are within easy walking distance of home; 3) There are sidewalks on most of the streets in their neighborhood; 4) In and around my neighborhood, there are facilities for bicycling such as special bicycle lanes, bicycle paths and shared use trails for cyclists and pedestrians; 5) There are several free or low cost recreational facilities in my neighborhood; 6) The crime rate in my neighborhood makes it unsafe to go for walks at night; 7) There is so much traffic on the streets that it makes it difficult or unpleasant to walk in my neighborhood; and 8) There are many interesting things to look at while walking in my neighborhood. Ratings of these environmental variables have been shown to have acceptable test-retest reliability.[32]

Perceived Behavioral Control

PBC reflects an individual's belief in their control over a behavior taking into consideration actual constraints or supports that might influence the behavior.[33] A single item provided a direct measure of PBC. The item asked the respondent to indicate their agreement with the following statement—"If I wanted to, I could easily participate in regular physical activity". The item provides a general measure of PBC—capturing both internal and external constraints related to physical activity. Given the focus on perceptions of walkability (ie, external constraint) inclusion of an item or items measuring PBC related to the external environment might have been better suited to the current analysis. However, it should be noted that the objectives of the current study were not part of the primary area of investigation when the survey was originally developed. Agreement was captured on a 5-point Likert scale (ie, strongly disagree to strongly

agree). Similar worded items used elsewhere to capture PBC have shown acceptable levels of test-retest reliability.[34]

Physical Activity Variables

Physical activity was captured using items from the Godin Leisure-Time Exercise Questionnaire.[35] Respondents were asked to consider how many times a week, on average, they participated in physical activity for more than 15 minutes during their free time. Frequency was measured for strenuous (activity that causes the heart to beat rapidly such as running, jogging, team sports, and swimming), moderate (activity that is not exhausting such as fast walking, easy cycling, and swimming) and mild (activity that requires minimal effort and doesn't cause sweating such as easy walking and yoga) physical activity. Mild physical activity was not included in the current analysis after an initial examination of the results indicated limited associations between this behavior and environmental variables. The Godin Leisure-Time Exercise Questionnaire has been shown to provide reliable and valid estimates of physical activity in the Canadian context.[35,36]

Statistical Analysis

Descriptive statistics including means, medians, minima, and maxima were calculated for the 8 self-reported environmental variables, PBC, frequency of VIGPA and MODPA, age, and years of schooling. Data were examined for missing and extreme values and VIGPA and MODPA variables were log transformed to improve their distributions (ie, reduce positive skew). Of the 1207 respondents surveyed, 1045 provided complete environmental, PBC, and physical activity frequency data. Four additional respondents were excluded due to extreme reports of frequency in physical activity (ie, >30 bouts per week) resulting in a final sample consisting of 523 men and 518 women. Compared with respondents included in the analysis those excluded (13.8%) were older (52.47 vs. 44.17 years, $P < .001$), reported fewer years of schooling (14.10 vs. 15.04 years, $P < .001$), and reported fewer bouts of VIGPA (0.72 vs. 0.85 times/week, $P < .05$) and MODPA (1.10 vs. 1.29 times/week, $P < .05$).

Analyses were stratified by gender as a result of previous studies reporting differences between walkability and physical activity outcomes among men and women.[24–28,37] Independent *t* tests were used to compare gender differences for age, years of schooling, and frequency of VIGPA and MODPA. Mann-Whitney *U* tests were used to compare gender differences for self-reported environmental variables and PBC. A series of gender-stratified generalized linear regression models were conducted for each physical activity outcome (ie, VIGPA and MODPA) following procedures suggested by Baron and Kenny[38] for examining mediation. Firstly, PBC (the mediator) was regressed on the self-reported environmental variables (the independent variables). VIGPA and MODPA (the dependent variables) were then each regressed on the self-reported environmental variables. Finally, VIGPA and MODPA were each regressed on the self-reported environmental variables and PBC. All models were statistically adjusted for the self-reported environment, age, and years of schooling (education). For all regression models unstandardized and standardized beta coefficients and 95% confidence intervals were estimated. A mediation effect was established when the following 3 statistical criteria were met: the self-reported environment was significantly associated with PBC; the self-reported environment was significantly associated with VIGPA and/or MODPA; and PBC was significantly associated with VIGPA and/or MODPA when the self-reported environment was present in the same model.[38] *P*-values < 0.05 were considered statistically significant. All analysis were conducted using Statistical Package for Social Sciences (SPSS 15.0).

Results

The average age of men (43.7 ± 14.9 years) and women (44.6 ± 16.4 years) was similar; however, a statistically significant difference in years of schooling was observed (men: 15.3 ± 3.0 versus women: 14.8 ± 3.1years, $P < .01$; Table 1). Frequency of participation in VIGPA was higher among men versus women (0.98 ± 0.74 vs. 0.74 ± 0.73, $P < .001$), although no statistical difference in MODPA was observed. Compared with women, men more strongly agreed that they had access to free and low cost facilities in their neighborhood (3.87 ± 1.32 vs. 3.66 ± 1.45, $P < .05$) and could easily participate in regular physical activity if they wanted to (ie, PBC; 4.26 ± 1.08 vs. 4.09 ± 1.20, $P < .05$). Men rated "the crime rate in the neighborhood made it unsafe for walking at night" less negatively than women (men: 1.70 ± 1.14 and women: 2.20 ± 1.34, $P < .001$; ie, higher score for crime rate indicated a more negative rating). Men also rated "traffic in the neighborhood made walking difficult or unpleasant" less negatively than women (men: 1.82 ± 1.07 and women: 1.99 ± 1.20, $P < .05$).

Self-Reported Environmental Correlates of Perceived Behavioral Control

Having easy access to places for physical activity was positively associated with PBC among men (B = 0.40, $P < .001$) and women (B = 0.48, $P < .001$), after adjusting for age, education, and other self-reported environmental variables (Table 2 and 3). Among men, PBC was positively associated with having many shops, stores, or other places within walking distance (B = 0.10, $P < .01$) and having many interesting things to look at while walking in the neighborhood (B = 0.08, $P < .05$; Table 2). Moreover, for men a negative relation was found between traffic in the neighborhood made walking difficult or unpleasant and PBC (B=-0.10, $P < .05$). No other statistically significant associations between the

Table 1 Descriptive Statistics for the Self-Reported Environment, Perceived Behavioral Control (PBC), Frequency of Physical Activity, Age, and Education Among Men and Women

	Men (n = 523)			Women (n = 518)		
	Mean (SD)	Median	Min, max	Mean (SD)	Median	Min, max
Age (years)	43.73 (14.93)	44	18, 88	44.58 (16.44)	44	18, 90
Education (years of school)	15.34 (2.97)[b]	15	7, 25	14.75 (3.12)[b]	14	5, 25
Physical activity						
Frequency vigorous-intensity	2.42 (2.56)[c]	2.00	0, 24	1.74 (2.00)[c]	1.00	0, 7
Log frequency vigorous-intensity	0.98 (0.74)[c]	1.10	0, 3.22	0.74 (0.73)[c]	0.69	0, 2.08
Frequency moderate-intensity	3.66 (3.02)	3.00	0, 21	3.41 (2.60)	3.00	0, 15
Log frequency moderate-intensity	1.33 (0.72)	1.39	0, 3.71	1.26 (0.73)	1.39	0, 2.77
Self-reported environment						
Easy access to places for physical activity	4.42 (0.92)	5	1,5	4.32 (1.13)	5	1,5
Many shops, stores, or other places within walking distance of home	3.29 (1.58)	3	1,5	3.36 (1.66)	4	1,5
Sidewalks on most streets in my neighborhood	4.36 (1.23)	5	1,5	4.18 (1.41)	5	1,5
Facilities for bicycling in or around my neighborhood	3.58 (1.53)	4	1,5	3.34 (1.66)	4	1,5
Access to free or low cost recreational facilities in neighborhood	3.87 (1.32)[a]	4	1,5	3.66 (1.45)[a]	4	1,5
Crime rate in my neighborhood makes it unsafe to walk at night	1.70 (1.14)[c]	1	1,5	2.20 (1.34)[c]	2	1,5
Traffic in neighborhood makes walking difficult or unpleasant	1.82 (1.07)[a]	1	1,5	1.99 (1.20)[a]	2	1,5
Many interesting things to look at while walking in my neighborhood	3.34 (1.31)	3	1,5	3.45 (1.38)	4	1,5
Perceived behavioral control						
If I wanted to I could easily participate in regular physical activity	4.26 (1.08)[a]	5.00	1,5	4.09 (1.20)[a]	5	1,5

Note. Self-reported environment and PBC scored as 1 = strongly disagree, to 5 = strongly agree. Mean ranks for the self-reported environment and PBC for men and women compared using the Mann-Whitney Test. Means for physical activity, age and education compared using independent *t* tests.

[a] $P < .05$.

[b] $P < .01$.

[c] $P < .001$ for significant differences between men and women.

self-reported environment and PBC among men or women were found.

Self-Reported Environmental Correlates of Vigorous and Moderate-Intensity Physical Activity

Easy access to places for physical activity was positively associated with frequency of VIGPA regardless of gender (men: B = 0.14, $P < .001$ and women: B = 0.11, $P < .001$), after adjusting for age, education, and other self-reported environmental variables (Tables 2 and 3). Men reporting that the crime rate in their neighborhood makes it unsafe to walk at night was negatively, albeit weakly, associated with participation in VIGPA (B = –0.06, $P < .05$), adjusting for age, education, and other self-reported environmental variables. No other significant associations between the self-reported environment and VIGPA were found for either gender.

Table 2 Linear Regression Models Showing the Mediation Affect of Perceived Behavioral Control (PBC) on the Association Between Self-Reported Environmental Characteristics and Log-Transformed Frequency of Vigorous (VIGPA) and Moderate-Intensity Physical Activity (MODPA) Participation Among Men (N = 523)

	PBC regressed onto self-reported environment		VIGPA regressed onto self-reported environment		VIGPA regressed onto self-reported environment and PBC		MODPA regressed onto self-reported environment		MODPA regressed onto self-reported environment and PBC	
	B	95% CI	B	95% CI	B	95% CI	B	95% CI	B	95% CI
Self-reported environment										
Easy access to places for physical activity	0.40 (0.34)	0.30–0.50[c]	0.14 (0.17)	0.07–0.21[c]	0.06 (0.07)	−0.01–0.13	0.03 (0.04)	−0.04–0.10	−0.02 (–0.03)	−0.10–0.05
Many shops, stores, or other places within walking distance of home	0.10 (0.14)	0.03–0.16[b]	0.04 (0.08)	−0.01–0.08	0.02 (0.04)	−0.02–0.06	0.02 (0.04)	−0.03–0.06	0.00 (0.01)	−0.04–0.05
Sidewalks on most streets in my neighborhood	−0.02 (–0.02)	−0.10–0.07	−0.06 (-0.09)	−0.12–0.00	−0.05 (–0.09)	−0.11–0.01	−0.03 (–0.06)	−0.09–0.03	−0.03 (–0.05)	−0.09–0.03
Facilities for bicycling in or around my neighborhood	0.00 (0.00)	−0.07–0.07	0.04 (0.09)	−0.01–0.09	0.04 (0.09)	−0.00–0.09	0.02 (0.04)	−0.03–0.07	0.02 (0.04)	−0.03–0.07
Access to free or low cost recreational facilities in neighborhood	−0.07 (–0.09)	−0.16–0.02	−0.05 (-0.10)	−0.12–0.01	−0.04 (–0.07)	−0.10–0.02	−0.02 (–0.04)	−0.08–0.05	0.01 (0.01)	−0.07–0.06
Crime rate in my neighborhood makes it unsafe to walk at night	−0.04 (-0.04)	−0.12–0.05	−0.06 (-0.10)	−0.12–0.00[a]	−0.05 (–0.08)	−0.11–0.00	−0.04 (–0.06)	−0.09–0.02	−0.03 (–0.05)	−0.09–0.03
Traffic in neighborhood makes walking difficult or unpleasant	−0.10 (–0.10)	−0.19–0.01[a]	−0.03 (-0.04)	−0.09–0.03	−0.01 (–0.01)	−0.07–0.05	−0.02 (–0.03)	−0.08–0.04	−0.01 (–0.01)	−0.07–0.05
Many interesting things to look at while walking in my neighborhood	0.08 (0.09)	0.01–0.15[a]	0.02 (0.03)	−0.03–0.07	0.00 (0.01)	−0.05–0.05	0.04 (0.08)	−0.01–0.09	0.03 (0.06)	−0.02–0.08
Perceived behavioral control										
If I wanted to I could easily participate in regular physical activity					0.20 (0.30)	0.15–0.26[c]			0.13 (0.20)	0.07–0.19[c]

Note. Self-reported environment and PBC scored as 1 = strongly disagree, to 5 = strongly agree. All models adjusted for self-reported environment, age, and education (years of schooling). Standardized coefficients in parentheses.

[a] $P < .05$

[b] $P < .01$

[c] $P < .001$

Table 3 Linear Regression Models Showing the Mediation Affect of Perceived Behavioral Control (PBC) on the Association Between Self-Reported Environmental Characteristics and Log-Transformed Frequency of Vigorous (VIGPA) and Moderate-Intensity Physical Activity (MODPA) Participation Among Women (N = 518)

	PBC regressed onto self-reported environment		VIGPA regressed onto self-reported environment		VIGPA regressed onto self-reported environment and PBC		MODPA regressed onto self-reported environment		MODPA regressed onto self-reported environment and PBC	
	B	95%CI	B	95%CI	B	95%CI	B	95%CI	B	95%CI
Self-reported environment										
Easy access to places for physical activity	0.48 (0.45)	0.40–0.57[c]	0.11 (0.17)	0.06–0.17[c]	0.04 (0.06)	–0.02–0.10	0.10 (0.16)	0.05–0.16[c]	0.02 (0.03)	–0.04–0.08
Many shops, stores, or other places within walking distance of home	0.04 (0.06)	–0.02–0.11	0.02 (0.05)	–0.02–0.06	0.02 (0.04)	–0.03–0.06	0.05 (0.10)	0.00–0.09[a]	0.04 (0.09)	–0.01–0.08
Sidewalks on most streets in my neighborhood	–0.02 (–0.02)	–0.10–0.06	–0.04 (–0.07)	–0.09–0.02	–0.03 (–0.06)	–0.09–0.02	–0.07 (–0.14)	–0.13–0.02[b]	–0.07 (–0.14)	–0.12–0.02[b]
Facilities for bicycling in or around my neighborhood	0.04 (0.06)	–0.04–0.12	0.03 (0.06)	–0.02–0.08	0.02 (0.05)	–0.03–0.07	0.03 (0.07)	–0.02–0.09	0.03 (0.06)	–0.03–0.08
Access to free or low cost recreational facilities in neighborhood	–0.07 (–0.08)	–0.16–0.03	–0.04 (–0.08)	–0.10–0.02	–0.03 (–0.06)	–0.09–0.03	–0.04 (–0.08)	–0.10–0.02	–0.03 (–0.06)	–0.09–0.03
Crime rate in my neighborhood makes it unsafe to walk at night	0.01 (0.01)	–0.06–0.09	–0.03 (–0.06)	–0.08–0.02	–0.03 (–0.06)	–0.08–0.02	–0.08 (–0.15)	–0.13–0.03[b]	–0.08 (–0.15)	–0.13–0.04[b]
Traffic in neighborhood makes walking difficult or unpleasant	–0.05 (–0.05)	–0.14–0.03	–0.01 (–0.01)	–0.06–0.05	0.00 (0.00)	–0.07–0.05	0.04 (0.06)	–0.02–0.09	0.05 (0.08)	–0.01–0.10
Many interesting things to look at while walking in my neighborhood	0.03 (0.03)	–0.05–0.10	0.04 (0.08)	–0.01–0.09	0.04 (0.07)	–0.01–0.09	0.04 (0.07)	–0.01–0.09	0.03 (0.06)	–0.01–0.08
Perceived behavioral control										
If I wanted to I could easily participate in regular physical activity					0.15 (0.24)	0.09–0.20[c]			0.18 (0.30)	0.13–0.23[c]

Note. Self-reported environment and PBC scored as 1 = strongly disagree, to 5 = strongly agree. All models adjusted for self-reported environment, age, and education (years of schooling). Standardized coefficients in parentheses.

[a] $P < .05$

[b] $P < .01$

[c] $P < .001$

For men no statistically significant associations were found between the self-reported environment and MODPA (Table 2). For women, however, having easy access to places for physical activity (B = 0.10, $P < .001$) and many shops or places with walking distance (B = 0.05, $P < .05$) were positively associated with frequency of MODPA after adjusting for age, education, and the self-reported environment (Table 3). Contrary to expectations, among women agreement that sidewalks existed on most streets in the neighborhood (B=-0.07, $P < .01$) was negatively associated with frequency of MODPA while the relationship between crime rate in the neighborhood making it unsafe to walk at night and MODPA (B=-0.08, $P < .01$) was as expected (Table 3).

Mediating Role of Perceived Behavioral Control in the Relation Between the Self-Reported Environment and Vigorous and Moderate-Intensity Physical Activity

Overall, the regression results suggest that PBC mediated the relationship between: 1) easy access to places for physical activity and VIGPA for men and women (Tables 2 and 3); and 2) easy access to places for physical activity and MODPA for women only (Table 3).

PBC was moderately associated with frequency of VIGPA for men (B = 0.20, $P < .001$) and women (B = 0.15, $P < .001$; Table 2 and 3). Inclusion of PBC in the model attenuated the association between easy access to places for physical activity frequency of VIGPA for men (ie, PBC not included: B = 0.14, $P < .01$ and PBC included in the model: B = 0.06, $P > .05$) or women (PBC not included: B = 0.11, $P < .001$ and PBC included in the model B = 0.04, $P > .05$; Table 2 and 3) suggesting mediation by PBC. For men PBC did not mediate the association between crime rate in the neighborhood making it unsafe to walk at night and frequency of VIGPA (PBC not included B=-0.06, $P < .05$ and PBC included in model B=-0.05, $P > .05$; Table 2).

PBC was associated with frequency of MODPA among men (B = 0.13, $P < .001$) and women (B = 0.18, $P < .001$; Table 2 and 3). After adjusting for PBC, associations between the self-reported environment and frequency of MODPA remained nonsignificant among men indicating a lack of mediation by PBC (Table 2). For women, adjusting for PBC noticeably attenuated the association between having easy access to places for physical activity and frequency of MODPA (ie, B = 0.10, $P < .001$ to B = 0.02, $P > .05$) indicating mediation (Table 3).

Discussion

The objectives of this study were to determine (a) if perceptions of the built environment were associated with physical activity among men and women, and (b) whether this association was mediated by PBC. Consistent with previous evidence, we did find that perceptions of the built environment were associated with both MODPA and VIGPA. Evidence for mediation of this association by PBC for men and women was also found.

Perceived easy access to facilities was associated with participation in VIGPA and MODPA among women and VIGPA among men. Men might be more likely to visit facilities for VIGPA but not for MODPA, while women will visit facilities for either VIGPA or MODPA. This may reflect preferences for particular settings where VIGPA and MODPA are undertaken by men. The association between perceived access to facilities and physical activity has received consistent support in research undertaken to date.[3,5,6,39] This consistent relationship may be a result of the type of environmental attribute that this item captures. "Easy access to facilities or places for physical activity" likely reflects attributes related to both connectivity and proximity of destinations or facilities. Studies have found limited associations between availability of sidewalks and MODPA among women or men, although associations with other types of physical activity (ie, VIGPA and walking) are reported.[40] Noteworthy was our finding that the perceived presence of sidewalks was negatively associated with MODPA behavior among women. Other studies have reported counter-intuitive findings such as higher levels of physical activity participation among those reporting the presence of heavy or bothersome traffic,[41–44] and unattended dogs.[45] However, individuals who are more active in their neighborhood may be more aware of, and or more accurately evaluate, their neighborhood surroundings compared with those who are less active. Another explanation could be that MODPA in this study captures activities—some requiring the use of sidewalks (eg, walking) and others that do not (eg, cycling). Although speculative, it is possible that neighborhoods that have fewer sidewalks also have more attributes that facilitate or support other types of MODPA.

Though we report that PBC may mediate the relationship between perceived access to places for physical activity and MODPA and VIGPA, a recent prospective study found that perceptions of the built environment did not influence walking behavior through PBC, although affective and instrumental attitudes did play a mediating role.[23] The same study found that proximity to retail land use, infrastructure quality, and neighborhood aesthetics were not associated with PBC. The difference between this and our study might suggest that mediation in the environment-physical activity relationship depends on the cognitions and the type of physical activity examined. Moreover, in the presence of other cognitions, the mediating role of PBC in the environment-physical activity relationship may be attenuated, although this requires clarification in future studies.

Similar to findings of our study, PBC has been shown to mediate associations between perceptions of the built environment and physical activity;[17] however, this study included children while our study included

adults, thus making comparisons difficult. One study found no association between perceptions of built environment (including traffic flow, presence of sidewalks, street lighting, unattended dogs, and crime) and self-efficacy among African-American women[46] while another found that perceived neighborhood quality and the availability of facilities were indirectly associated with physical activity via intrinsic motivation and self-efficacy.[21] Direct comparison with these studies are difficult because of differences in study design, and the cognitive and physical activity variables examined. Nevertheless our results support the majority of findings to date that show the association between perceptions of the built environment and physical activity to be mediated by cognitions. Moreover, our results add to this literature by finding that gender and the intensity of physical activity may influence the level of mediation present.

We found that perceiving traffic as a problem, easy access to places for physical activity, having many interesting things to look at in the neighborhood while walking and having many shops, stores or other places within walking distance of home to be weakly associated with PBC. For women, only easy access to places for physical activity was associated with PBC, suggesting that men and women may consider different aspects of the built environment as important when forming a motivation to be physically active. Gender-specific associations between perceptions of walkability and physical activity have been found elsewhere.[24–28,37] Also, gender differences in associations related to perceptions of crime and personal safety and physical activity in particular have been reported.[25–27,37] In the current study both men and women disagreed that the crime rate made it unsafe to walk at night; however, men tended to disagree more with this statement. Perception of the crime rate making the neighborhood unsafe to walk in at night was negatively, albeit weakly, associated with frequency of VIGPA among men and frequency of MODPA among women. Bennett et al[37] found fewer pedometer-determined steps for women, but not men, who perceived their neighborhood less safe to walk in at night. Foster et al[27] found that women, but not men, who reported less safety for walking during the day were less likely to walk for at least 15 minutes/day compared with those who reported the environment as safe; however, perceptions of safety of walking at night was not associated with walking behavior. Our findings support current evidence showing associations between perceived personal safety and physical activity.

The relationship between the built environment, PBC and duration of physical activity were not examined in this study. Evidence for dose-response relationships between the perceptions of the built environment, PBC and physical activity are therefore limited. However, frequency of physical activity reflects initiation of an episode of behavior, which might be under less volitional control (ie, more likely to be constrained by external and internal barriers) compared with duration and intensity which might be determined or changed once physical activity is initiated.[47] The built environment in particular might therefore be more important in the initiation of physical activity than in its maintenance. Easy access to places, having many shops or places within walking distance, a low crime rate in the neighborhood and having many interesting things to look at while walking in the neighborhood could facilitate or support initiation of physical activity participation. It was noteworthy that these attributes were differentially associated with MODPA and VIGPA. However, 6 of the 8 items referred to environmental attributes related to walking, which might explain why we found associations between some of these items and MODPA among women. The item related to easy access to places was not activity specific which might explain why this was associated with both MODPA and VIGPA. Having convenient and accessible places to be physically active appears to be important for facilitating different types of physical activity behaviors.[40]

A major strength of this study includes the integration of cognitive, built environment, and behavioral variables into a single explanatory model. The separate examination of MODPA and VIGPA and inclusion of gender-specific analyses are other positive contributions. Different environmental attributes are likely associated with different types of physical activity behavior.[29,48] Moreover, different intensities of physical activity behavior may require different levels of PBC.[49] For example, higher levels of PBC might be needed to undertake structured or vigorous-intensity activities than for unstructured or moderate-intensity activities because of more resources required to undertake the former type of activity (eg, costs of using facilities, special equipment needed, access to suitable facilities). In the current study, the association was stronger between PBC and VIGPA compared with PBC and MODPA among men.

However, this study is not without several limitations. First, intention to be physically active was not considered. The theory of planned behavior[10] proposes both a direct relationship between PBC and behavior and an indirect relationship between PBC and behavior via behavioral intention. Therefore, associations between PBC and physical activity measured in this study may reflect both direct and indirect (ie, mediated by intention) pathways of this relationship and should be interpreted with caution. Second, the noninclusion of intention, attitude, and subjective norm limits understanding regarding the mediating role of the theory of planned behavior between the perceived environment and physical activity. Third, PBC was measured using a single item, capturing a specific belief regarding the ease of participating in regular physical activity. However, Rhodes et al[50] suggest that specific beliefs may uniquely contribute to physical activity but are obscured by aggregation of multiple beliefs. Therefore, the use of a single-item measure of PBC may not have been a limitation in our study. Fourth, the item regarding easy

access to places for physical activity should be considered to be general, as it does not address the mode in which respondents traveled to reach physical activity facilities or whether these facilities were located inside the neighborhood. Fifth, the cross-sectional design used in this study limits the assessment of temporal causality. For instance, it is possible that perceptions of the built environment are influenced by other beliefs, and people who are more active evaluate their neighborhoods more positively. Finally, the response rate of 40% could be of concern because participants were volunteers who may have been more motivated to participate and therefore have characteristics that differ from nonparticipants (eg, physical activity). Such limitations should be taken into account in future studies.

In summary, there is mounting evidence of an association between the built environment and physical activity,[3,5] but a limited understanding exists about the mechanisms that explain these associations. Our study found some support for the mediating role of cognitions in the relationship between the built environment and physical activity.[17,19–22] Perceptions of the built environment likely influence cognitions responsible for forming intentions to be physically active. Therefore creating walkable environments that are positively evaluated may have direct and indirect influence on physical activity participation.

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