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Review

Associations between the physical environment and park-based physical activity: A systematic review

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Abstract

Background: With an increase in the evidence for the associations between park-based physical activity (PA) and physical environments (especially park and neighborhood environments), researchers face an important challenge in interpreting and summarizing the evidence to develop environmental change interventions. An updated review is needed to better inform policymaking and environmental interventions. The current study aimed to systematically review the research on the associations of park-based PA with park and neighborhood environmental characteristics.
Methods: We targeted English peer-reviewed articles from 5 electronic databases using keywords related to park-based PA, park environments, and neighborhood environments. Of the 4071 identified papers, 25 studies published between 2008 and 2016 met all the eligibility criteria and were included in this review.
Results: The characteristics of physical environment that received consistent support included paths/trails, lighting, and incivilities (e.g., broken glasses and litter). Mixed findings were revealed for 6 park environmental factors (unspecified active facilities, playgrounds and skating areas, fitness stations, picnic areas, greenness, and park size) and 2 neighborhood environmental factors (park density and park proximity).
Conclusion: It can be concluded that paths/trails, lighting, and incivilities are 3 key physical environmental attributes of park-based PA. Given the inconsistent findings on park and neighborhood environmental factors, more robust designs such as prospective investigation are required.

Keywords: Neighborhood; Park-based physical activity; Park environment; Physical environment; Systematic review

1. Introduction

Providing free and accessible physical activity (PA) resources in natural sites is a promising strategy for increasing PA at the population level.[1] In particular, urban parks have been widely recognized as key environmental sites that can provide individuals with a variety of active recreation and health benefits.[2] Although experimental evidence has revealed that park-based PA leads to greater cardiovascular, blood glucose, and mental benefits than the same amount of activity in nongreen settings,[3,4] parks are still not well-used for PA by park visitors and those living in surrounding neighborhoods. Findings from park use research indicate that >50% of individuals do not visit parks for active or passive activities during a typical week.[5] It has also been reported that sedentary activities such as picnicking, sitting, and social interaction with families or friends are very common in parks.[6] Additionally, it has been reported that less than one-third of those who were surveyed or observed as park visitors engaged in park-based PA.[7]

Promoting park-based PA requires a clear understanding of the underlying factors that influence active behaviors in parks. Based on the social ecological approach, PA can be understood as people's interactions with their sociocultural and physical environments.[2,8] Physical environments refer to the perceived and objective characteristics of the physical contexts in which behaviors are engaged and people live.[2] Identifying the environmental attributes of PA is needed to develop effective interventions to promote park-based PA at a population level.[1] An increasing amount of cross-sectional and experimental evidence indicates that park environmental factors, such as the presence and condition of parks, aesthetics (e.g., greenness and park size), and crime-related safety, may influence park-based PA.[9,10] The neighborhood environment may

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also play a role in increasing residents' park-based PA, because people have to pass through their neighborhoods on the way to these parks. Several neighborhood environmental factors, such as street intersections, density and proximity of parks, and crime and traffic safety issues, have generally been identified to be associated with park-based PA.[11,12]

With an increase in the evidence of the associations between park-based PA and physical environments (especially park and neighborhood environments), researchers face an important challenge in interpreting and summarizing these findings when developing environmental change interventions to promote park-based PA. It is currently accepted practice to rely on literature reviews that have synthesized the empirical findings of previous studies to guide evidence-based research needs.[13] Although the literature on the density of and proximity to parks in relation to PA has been synthesized, this review focused on total PA instead of context-specific PA in parks.[14] Two reviews to date have summarized the environmental attributes of park-based PA.[15,16] One review[15] of qualitative studies found that park safety, aesthetics, supporting amenities, maintenance of features, and proximity to parks were important environmental factors associated with park-based PA. Another review[16] of experimental studies revealed that conducting PA programs and renovation of park environments could promote PA in green spaces. However, these 2 reviews did not synthesize the cross-sectional or longitudinal findings from the literature on the associations between the neighborhood environment and park-based PA.

To address these limitations, the present study aimed to systematically review the research on the relationships between park-based PA and park and neighborhood environment characteristics. Specifically, this review addressed some limitations of previous reviews by combining park and neighborhood environment characteristics in relation to park-based PA and synthesizing the cross-sectional and longitudinal results. A clear picture of the current evidence on physical environmental attributes of park-based PA may help to develop interventions for improving park-based PA via changing physical environments.

2. Methods

Steps described in these sections were undertaken in accordance with the recommendations from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[17]

2.1. Eligibility criteria

The identified studies from databases and hand-searching were eligible if they (a) were published in English peer-reviewed journals, (b) investigated park-based PA (i.e., any form of PA that were specifically engaged in parks), and (c) examined associations between park-based PA and ≥1 physical environment characteristic. Mixed-methods research, including quantitative analysis, was also taken into account. Articles were excluded from consideration if they (a) provided only descriptive findings, (b) were qualitative studies, reviews, experimental studies, or reports, (c) combined several environmental attributes as a composite score, or (d) focused on walking trails or open/green spaces that were not located within parks.

2.2. Information sources and search strategy

A literature search for the studies on associations between park-based PA and physical environments was conducted in the first week of December 2016. Five electronic databases (Medline, Embase, PsycINFO, SPORTDiscus, and Web of Science) were searched for English peer-reviewed articles published by December 2016. Keyword searches within titles and abstracts were undertaken for the following phrases: "park-based PA", "park environment", and "neighborhood environment" (Supplementary Table 1). Reference lists from the identified literature and previously published reviews were also searched by hand. Corresponding authors were contacted if there was any missing information within published papers (e.g., research methods).

2.3. Study selection

We managed study selection using Clarivate Analytics EndNote X7.7 (Clarivate Analytics Corp., Philadelphia, PA, USA) and have presented a flow chart of the selection processes in Fig. 1. After removing duplicate articles identified via EndNote and hand searching, the first author of this study retrieved abstracts according to the inclusion criteria. Screening and exclusion of full-text articles was conducted by the first author and rechecked by the second author. Disagreements between researchers were resolved by group discussion. Findings of the remaining studies were organized for further analyses.

2.4. Data collection process and data items

To organize findings of the eligible articles, a data extraction form was developed and piloted on a sample of the included studies ($n = 10$). Data collection was conducted by the first author and rechecked by the second author. For any inconsistencies, the authors had a discussion to reach a consensus. Two tables (Table 1 and Supplementary Table 2) were created by recording and coding the following data for each eligible article: (a) first author, publication year, and reference number, (b) sample characteristics, including country of origin, sample size of parks and participants, and participants' gender and age, (c) study designs and measurements, and (d) main findings of physical environment characteristics. The direction of associations was coded as significant positive "+", significant negative "−", or nonsignificant "n.s.". Superscript numbers and text fonts were added to distinguish between studies conducted with differences in age, gender, and measurements.

In line with the rules from a previous review,[13] records in the detailed table were further summarized and tabulated. Specifically, factors were not shown in the summarized tables unless ≥3 records were available. Furthermore, similar factors such as paths and trails were combined during data analyses. Additionally, a more general factor, such as "unspecified active facilities" was created if the characteristic lacked specificity. Based on the classification of physical environmental factors in previous studies,[18,19] variables in Supplementary Table 3 were

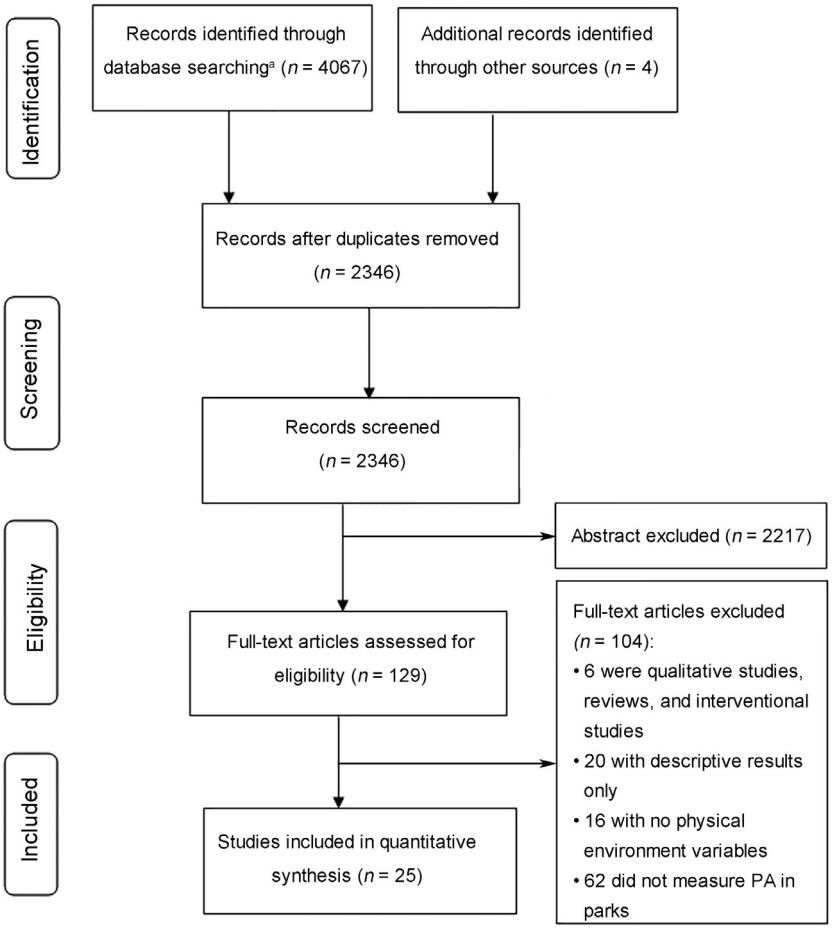

Fig. 1. Flow chart of the systematic literature search. [a] In the 4067 publications, 1054 were identified from Ovid MEDLINE, 858 from Ovid Embase, 399 from PsycINFO, 227 from SPORTDiscus, and 1529 from Web of Science. PA = physical activity.

classified into 4 park environmental categories, including (a) park features (active facilities and supporting amenities), (b) park condition (feature maintenance and incivilities), (c) park aesthetics (attractiveness, greenness, park size, and amount of shade), and (d) park safety (crime-related safety in parks). In addition, we coded 3 categories of neighborhood environmental factors, including (a) walkability (park density and street connectivity), (b) park proximity (distance from residential homes to parks), and (c) neighborhood safety (traffic- and crime-related safety in the neighborhood). Although crime and traffic safety are not characteristics of the physical environment, they were included in the present study because safety issues have intimate links with some physical environment characteristics such as lighting and incivilities (e.g., broken glasses and litter)[5,20] and these factors can affect a specific site's reputation as safe or unsafe. The definition for each of the physical environment variables is presented in Supplementary Table 3. Strength of evidence for the associations with park-based PA was assessed based on the criteria adopted from Sallis et al.[13]

2.5. Risk of bias in individual studies

The risk of bias for each eligible article was evaluated by adopting a formal assessment scale that was developed for assessing the quality of cross-sectional and longitudinal studies.[21] This scale has 5 items (Supplementary Table 4), with a value of either 0 (absent or inadequately described) or 1 (explicitly described and present). Articles were assessed by 2 independent authors as having a score of a low (5), moderate (3−4), or high (0−2) risk of bias, depending on the accumulated scores of the 5 items. Inter-rater agreement was assessed. To synthesize a whole picture of evidence from the eligible studies, Plotnikoff et al.[21] suggested that all the articles, including those with a high risk of bias, would be included in the analyses.

3. Results

3.1. Study selection

As shown in Fig. 1, a total of 4071 articles were identified in the study selection (databases, $n = 4067$; and hand searching, $n = 4$). Among the 2346 unique articles, 2217 of which were discarded after evaluation of the abstracts, the full texts of the remaining 129 articles were examined for eligibility. Finally, 25 articles were selected and extracted (Table 1).

3.2. Characteristics of eligible studies

A summary of study characteristics is shown in Supplementary Table 5. More than one-half of the identified studies ($n = 16$) were undertaken in the United States, with the remaining studies

Table 1
Sample characteristics and methods of eligible studies.

First author (year)	Sample characteristics					Methods		
	Country	No. of parks	No. of participants	Female (%)	Age (year)	Data types	Measures of park-based PA	Measures of environments
Babey (2015)[11]	US	—	3638	51.1	12–17	CD, S	SI	SI
Bai (2013)[5]	US	—	893	60.7	18–64	CD, S	SI	SI
Bocarro (2015)[41]	US	20	—	—	—	DO	SOPARC	EAPRS
Cohen (2010)[6]	US	30	4257	—	—	CD, DO, OA, S	SOPARC	SI
Cohen (2012)[42]	US	50	—	—	—	DO, OA	SOPARC	SOPARC
Coughenour(2014)[43]	US	10	—	—	—	CD, DO, OA	SOPLAY	GIS, PARA
Dunton (2014)[26]	US	—	135	—	8–14	OA, S	Accelerometer, GPS	GIS, Gmaps, NDVI, NEWS,
Edwards (2014)[44]	AU	—	1304	—	12–15	OA, S	APARQ	Aerial imagery, GIS
Edwards (2015)[9]	AU	58	1304	—	12–15	OA, S	SI	GIS, NDVI, POSDAT
Esteban-Cornejo (2016)[34]	US	—	928	—	12–16	CD, OA, S	SI	GIS, NEWS
Floyd (2011)[29]	US	20	—	—	0–18	DO, OA	SOPARC	EAPRS
French (2017)[22]	US	—	534[a]	—	—	DO, OA, S	SI	PIN3, SI
Kaczynski (2008)[27]	CA	33	380	63.8	18–88	DO, OA	PA log booklet	EAPRS
Kaczynski (2009)[28]	CA	—	384	62.8	18–88	OA, S	PA log booklet	GIS
Kaczynski (2010)[45]	CA	32	384	—	18–88	DO, OA, S	PA log booklet	EAPRS, GIS, NEWS
Kaczynski (2014)[10]	US	146	893	60.8	18–98	DO, OA, S	PA-PS	CPAT, GIS
Kaczynski (2014)[32]	US	146	893	60.8	18–98	OA, S	PA-PS	GIS
Lackey (2009)[33]	CA	54	574	55.4	18–88	DO, OA, S	PA log booklet	EAPRS, GIS, NEWS
Loukaitou-Sideris (2009)[30]	US	100	897	—	10–13	DO, OA	SOPLAY	GIS, SOPLAY
Parra (2010)[31]	CO	—	1966	—	60–98	OA, S	SI	GIS
Reis (2009)[20]	BR	—	1718	—	14–18	S	SI	SI
Ries (2009)[23]	US	—	329	59.0	—	OA, S	SI	GIS, SI
Rung (2011)[25]	US	37	—	—	—	DO, OA, S	SOPARC	BRAT-DO, GIS
Spengler (2011)[24]	US	28	—	—	0–10	CD, DO	SOPLAY	Audit tool
van Dyck (2013)[46]	BE, US	20	—	—	—	DO, OA	SOPARC	EAPRS, GIS

Note: — indicates not relevant; [a] indicates parent–child dyads.
Abbreviations: PA = physical activity. Country: AU = Australia; BE = Belgium; BR = Brazil; CA = Canada; CO = Colombia; US = United States.
Data types: CD = census data; DO = direct observation; OA = objective approach (e.g., accelerometer, Google maps), S = survey.
Measures: APARQ = Adolescent Physical Activity Recall Questionnaire[47]; BRAT-DO = the Bedimo-Rung Assessment Tools[48]; CPAT = the Community Park Audit Tool[49]; EAPRS = the Environmental Assessment for Public Recreation Spaces instrument[50]; GIS = Geographic Information System; Gmaps = Google maps; GPS = Global Positioning System; NEWS = Neighborhood Environment Walkability Survey; NDVI = Normalized Difference Vegetation Index; PA log booklet = 7-day physical activity log booklet; PA-PS = the Physical Activity in Park Settings questionnaire[52]; PARA = the Physical Activity Resource Assessment[53]; PIN3 = the 3rd Pregnancy, Infection, and Nutrition (PIN3) neighborhood audit instrument[55]; POSDAT = Public Open Space Desktop Auditing Tool[51]; SI = the survey instrument was based on previous studies or developed by the authors; SOPARC = System for Observing Play and Recreation in Communities[54]; SOPLAY = the System for Observing Play and Leisure Among Youth[55].

being conducted in Canada ($n = 4$), Australia ($n = 2$), Brazil ($n = 1$), and Colombia ($n = 1$). A single study took place in the United States and Belgium. A total of 2 studies stratified their results by age, 10 studies reported 1 age subgroup, and 13 studies reported a combined age. A total of 6 studies showed findings stratified by gender, and the other 19 studies combined genders. All the eligible studies used cross-sectional designs. A total of 15 studies measured self-reported park-based PA and 10 studies measured PA with direct observation instruments. Self-reported measures were used in 4 studies to assess physical environment characteristics, 16 studies used objective tools, and 5 studies used both perceived and objective measures. Park environmental factors in relation to park-based PA were examined in 8 studies, neighborhood environmental factors were examined in 7 studies, and both park and neighborhood environmental factors were examined in 10 studies. Most of the studies were analyzed at the unit of the individual and adjusted for >2 types of covariates.

3.3. Risk of bias assessment

Two authors of the present study independently assessed the selected studies for bias (inter-rater agreement = 92%; Supplementary Table 4). The majority of studies (18 of 25) had a moderate risk of bias (i.e., scores of 3 and 4), 6 studies received a score of 5, equating with a low risk of bias, and only 1 study had a score of 2. One-half of the studies ($n = 13$) adopted a randomization method in their sampling selection. Most of the studies presented supporting evidence for the validity or reliability of the measures of park-based PA (n =15) and environmental factors ($n = 19$). All the studies included power calculation details.

3.4. Physical environmental correlates

Table 2 presents a summary the of findings about the associations of park-based PA with park and neighborhood environment factors.

Table 2
Studies that investigated associations between physical environment and park-based PA.

Physical environmental factors[a]	The relationships to park-based PA, record counts			+%	Summary codes[b]	Reference number
	Significantly positive	Not statistically significant	Significantly negative			
Park environment						
(1) Park features						
Unspecified active facilities	4	5	0	44	?	5, 9, 27, 29, 30, 41, 42,
Sport courts and fields	10	30	0	25	00	9, 10, 25, 27, 29, 41
Paths/trails	5	2	0	71	+	9, 10, 27
Playgrounds and skating areas	6	7	0	46	?	9, 10, 25, 27
Fitness stations	2	3	0	40	?	9, 10
Swimming pools	0	5	0	0	0	10, 27
Unspecified supporting amenities	2	5	0	29	00	27, 29, 30, 41, 43
Lighting	3	2	0	60	+	9, 20, 46
Picnic areas	5	5	2	42	?	9, 25, 29, 41
Water features	1	5	0	17	0	9, 10, 27
Restrooms	1	2	0	33	0	9, 25
(2) Park condition						
Feature maintenance	1	7	1	11	0	5, 25
Incivilities	3	2	0	60	++	5, 22, 24, 43
(3) Park aesthetics						
Attractiveness	1	2	0	33	0	5, 30
Greenness	6	5	0	55	?	9, 10, 25, 26, 27
Park size	8	8	0	50	?	9, 10, 26, 27, 28, 29, 30,46
Amount of shade	0	4	1	0	0	9, 24
(4) Crime-related safety	1	3	1	20	00	5, 6, 11, 30
Neighborhood environment						
(1) Walkability						
Park density	5	6	0	45	?	10, 23, 26, 28, 31
Street connectivity	2	2	2	33	0	9, 31, 32, 45
(2) Park proximity	6	11	0	35	?	10,11,20,23,26,27,28,33,44
(3) Neighborhood safety						
Traffic-related safety	1	4	1	17	00	20, 22, 32, 34, 43
Crime-related safety	0	6	1	14	00	22, 23, 30, 34

Notes: [a] Factors are not be shown in the summarized tables unless ≥3 records were available; [b] The criteria for summary coding of the evidence was adopted from Sallis et al.[13]; +% indicates the number of records supporting the expected positive association divided by total number of records; + indicates positive association (60%−100% of records supporting the positive association); 0 indicates nonsignificant association (0%−33% of records supporting the positive association); ? indicates inconsistent association (34%−59% of records supporting the positive association); when associations were examined in at least 4 studies, double signed summary codes (00 or ++) were applied.
Abbreviation: PA= physical activity.

3.4.1. Park environmental correlates of park-based PA

Of the 17 studies that examined the associations between park-based PA and park environments, 18 park environmental factors related to features, conditions, aesthetics, and safety were identified and appeared in ≥3 records. Most of the park features (10 of 11) had an unrelated or inconsistent association with park-based PA. In contrast with these unexpected findings, paths/trails and lighting were consistently positive attributes of park-based PA. Trails and paths received greatest support (71% positive) for promoting park-based PA, regardless of age and gender. The presence of artificial lighting (or light poles) that allowed the use of parks at night was also important. Two studies [9,20] found that the presence of lighting was positively related to increases in park-based PA for teens, especially for female teens.

For park condition, a significant relationship with park-based PA was only found for incivilities, but not for feature maintenance. Three of 5 records identified a positive association for incivilities.[5,22,43] In addition to an observational study that found positive evidence for incivilities[43] another 2 studies[5,22] revealed that adults' perceived park use for PA was positively related to self-reported or objectively measured park incivilities, whereas the relationship was not significant for children.[24] Unexpected findings, however, were found for maintenance of park features. Most of the records (7 of 9) indicated that a lack of maintenance was not an important issue hindering park-based PA. In particular, the condition of sport fields, playgrounds, and basketball counts was unrelated to park-based PA.[25]

The effects of greenness and park size on park-based PA may differ by age. The presence of greenness was found to be positively related to active park use in 2 adolescent samples.[9,26] By contrast, green vegetation in parks did not yield significant evidence in increasing park-based PA in adults and older people.[10,27] Moreover, Kaczynski et al.[27,28] revealed that most findings related to park size were positively associated

with adults' park-based PA. In contrast, 3 independent studies did not show evidence that park size plays an important role in higher levels of park-based PA among children or teens.[9,26,29]

Evidence from 4 studies demonstrated a nonsignificant relationship between park-based PA and crime-related safety in parks. Although 1 study of American adolescents revealed a positive association between perceived safety in parks and self-reported park-based PA,[11] the association was not significant in a sample of American adults.[5] Likewise, another study reported no relationship for objectively measured park safety in American boys and girls.[30] In contrast, a negative correlation was found between observed park-based PA and perceived park safety in American adults.[6]

3.4.2. Neighborhood environmental correlates of park-based PA

Findings related to 5 neighborhood environment factors including walkability (i.e., park density and street connectivity), park proximity, and neighborhood safety (i.e., traffic- and crime-related safety) are summarized in Table 2. Inconsistent evidence was found in relation to park density and street connectivity and their association with park-based PA. Despite 1 study that found a positive relationship between park density (parks with a 500-m buffer) and perceived park-based PA in Colombian seniors,[31] a nonsignificant association was found in the same buffer distance in a sample of American teens.[26] Inconsistent evidence was also revealed in 2 independent studies conducted by Kaczynski et al.[10,28] Kaczynski et al.[28] found that the density of parks within an 800-m range of neighborhoods was positively related to increased reports of park-based PA in Canadian females, adults, and seniors, but not in males. Another study by Kaczynski et al.[10] revealed that the relationship between park density within 1 mile of homes and perceived park-based PA was significant in American adults but not in females, males, or older adults. Furthermore, unexpected evidence was revealed in street connectivity. A single record found a positive relationship between street connectivity and park-based PA.[31,32] In contrast, Parra et al.[31] revealed a negative relationship between objective street connectivity and perceived park-based PA in Colombian seniors. Two specific characteristics of street connectivity—the presence of minor roads and the number of lots—were unrelated to park-based PA among a sample of Australian children.[9]

Park proximity played a greater role in promoting active park use among children and adolescents compared with adults and older people. Having more accessible parks in neighborhoods could promote adolescents' active park use. The current review revealed that both perceived and objectively measured park proximity received consistent support in relation to park-based PA among young people.[11,20,26] In contrast with the supportive evidence for teens, all of the records involving adults and older people found that park proximity has a limited association with park-based PA. Findings from 2 American samples (age range: 18−98 years) indicated that there was a nonsignificant association between objectively measured park proximity and self-reported park-based PA[10,28] Consistent evidence was found for adult and older adult samples in Canada.[33]

For neighborhood safety, traffic- and crime-related safety were not significant in relation to park-based PA in >34% of the records. Although 1 study found a positive association between perceived traffic-related safety and increases in perceived park-based PA among Brazilian male teens,[20] the same study found a nonsignificant association among female teens. In 3 additional studies, traffic-related safety was a nonsignificant factor.[22,32,34] Most of evidence on crime-related safety also revealed a nonsignificant relationship, except for 1 study in which perceived crime-related safety in the neighborhood was negatively related to American teens' reports of park-based PA.[34]

4. Discussion

4.1. Summary of evidence

The present systematic review extends prior knowledge by summarizing studies on the associations between park-based PA and park and neighborhood environment characteristics. A key finding was that paths/trails, lighting, and incivilities were consistently associated with park-based PA and that several park environmental factors were identified as inconsistent (6 of 18) or nonsignificant (9 of 18) correlates of park-based PA. For the neighborhood environment, we found that the density and proximity of parks demonstrated an inconsistent relationship with park-based PA, whereas street connectivity and the traffic- and crime-related safety within the neighborhood were nonsignificant factors.

Parks containing a large variety of features may support a range of visitors' activity needs. The current review has demonstrated consistent evidence for the positive influence of paths/trails and lighting on increases of park-based PA. The findings regarding trails/paths are consistent with 2 other reviews of the qualitative and experimental research.[15,16] The link between trails/paths and park-based PA suggests that people are more likely to engage in walking, jogging, and cycling in parks when trails/paths are available. We also found that several park features, including playing and skating areas, fitness stations, and picnic areas, have the potential for increasing park-based PA, although the evidence was mixed. These findings are not consistent with the qualitative review,[15] in which a variety of features such as playgrounds, structured activities, barbecues, and seating in parks were found to be important for generating activities among people using parks. The lack of consistency in findings is likely due to measurement error in objectively assessing park features.[13] Most available objective measures of the park environment can be considered first-generation measures, which have well-documented limitations in reliability and validity.[35] Future research is needed to improve the quality of measures by refining their use in various social-ecological contexts.

In contrast with our expectations, incivilities were positively related to park-based PA. This result is inconsistent with the qualitative evidence that clean parks might promote park use.[15] However, the positive association between incivilities and PA was revealed by Ding et al.,[36] who found that individuals with higher perceptions of environment disorders such as

broken glasses and litter were more likely to engage in PA. These findings can be understood that those who spend a greater amount of time in parks are more cognizant of park incivilities. Another possible explanation is that more frequent park use could contribute to less park cleanliness.[5] Although park incivilities such as the presence of broken glass and overgrown grass suggest that the park has a low level of aesthetics and safety,[18] it is difficult to maintain a clean and aesthetic park environment if the park is visited by a large number of people.

Park size and greenness have been studied extensively, but their relationships with park-based PA received inconsistent support. The present review found that park size had no relationship with park-based PA among children or teenagers, and the association was mixed for adult and senior samples. These findings demonstrate that the acreage of park space has limited influence on young people's park-based PA. One possible reason is that children and adolescents may pay greater attention to park facilities such as playgrounds and sports courts compared with park size. We also found that the relationship between greenness and park-based PA was mixed in adults and older adults, but was positive in children and adolescents. This finding for children and adolescents is similar to previous reviews in which the green environment is suggested to influence an increase in total PA[12,36] and PA in green spaces.[16] One possible mechanism proposed for the contribution of greenness to PA is that experiencing "green" spaces plays a key role in psychological benefits such as reduced negative emotions and increased energy.[37]

Although crime-related safety in parks has been studied extensively in the retrieved studies, we found limited support for its associations with park-based PA. The nonsignificant findings from the present review suggest that people engaging in park-based PA may pay more attention to park features, but not to crime-related safety issues.[5] In contrast, 1 review of qualitative research[15] found that crime-related safety was positively associated with park-based PA among children and the elderly. A possible reason for the mixed evidence could be that crime-related safety concerns such as the presence of drug users and presence of lighting at night are more important for certain age and gender subgroups. The moderating effects of age and gender on the relationships between safety and total PA were reported in 2 of the reviewed studies.[20,30] Differences in the measurements of safety across studies is another possible explanation for the inconsistent evidence. Further consideration is the necessity for developing adequate measures of perceptions of safety in parks.[38]

Considering neighborhood environments, park density received inconsistent support for a positive association with park-based PA. One possible explanation for the mixed findings across studies is that the association between park density and park-based PA is likely to differ in buffer sizes and be influenced by confounding variables. It is possible that residents prefer parks within smaller buffers around their homes than those further away. The current review demonstrated that enhancing park-based PA was more likely as the number of parks within a small buffer of homes (e.g., 500 m) increased, but not for the density of parks within a 1-mile buffer. This finding is in line with a systematic review by Bancroft et al.,[14] in which smaller (compared with larger) buffer sizes had a greater link to objectively measured overall PA.

Mixed findings were also identified in the association between park proximity and park-based PA. Thus, there is no conclusive evidence for the proposition that parks close to residents' living places could encourage people to be active in those parks. Despite qualitative evidence from 1 review suggesting that distance to parks is an important factor that can encourage residents, especially children and older adults, to use parks for PA,[15] the current review suggests that having an accessible park in neighborhoods is not always linked to using parks for PA. Similar mixed evidence also has been identified in 2 other reviews involving the influence of proximity to PA services.[38,39] For example, Van Cauwenberg et al.[38] found mixed evidence for a positive relationship between recreational or transport-related PA in older adults and increasing access to services. One possible explanation for the unexpected evidence is safety concerns in parks or neighborhoods. Some studies have revealed that crime-related safety issues in parks, such as insufficient lighting, sexual assault, and theft, could limit park-based visits or PA.[6,15]

Methodological issues, such as sample characteristics, potential covariates and moderators, and measure types (perceived and objective measures), are likely to increase the prevalence of inconsistent findings across studies.[13] The extent to which the environmental attributes of park-based PA are generalizable across cultural contexts remains unexplored. Considering that most of the eligible studies were undertaken in Western countries, future studies outside North America, Australia, and Europe are needed to test the generalization of the associations. Moreover, the findings regarding sociodemographic differences in the associations between physical environments and park-based PA remain inconsistent. Some studies found that the associations varied by age and gender,[10,29] whereas others showed that sociodemographic factors did not moderate the relationship between PA and parks.[40] The inconsistency in these findings is likely to be explained by self-selection bias, differences in measurement tools, and/or cultural influences.[40] How sociodemographic factors play a role (e.g., as covariates or moderators) in the relationship between the park environment and park-based PA requires further testing in future research.

Furthermore, the discrepancy in results is likely to be explained by the differences between perceived and objective measures. The low agreement between perceived and objectively measured park environmental characteristics (proximity to parks) may stem from the integration of objective environmental conditions captured via personal sociodemographic factors and social cognition.[31,40] The potential moderating effect of the perception of the physical environment on the relationship between objective environmental characteristics and PA is an additional explanation for the mixed and null results. For example, 1 study found that the associations of objective street interaction and land use mix with PA were moderated via perceived pedestrian infrastructure.[40] Thus, investigating how social cognitive and perceived

environmental factors can be integrated into the objectively measured physical environment in the prediction of park-based PA is warranted in future research.

4.2. Limitations and strengths

The present study needs to be considered within the context of its limitations. First, the present study retrieved only English peer-reviewed articles and thus may contain biased findings. Articles published in non-English journals may have yielded different physical environment attributes of park-based PA. Second, the current review did not stratify the results by socio-demographic factors or measure types (perceived and objective measures) owing to the limited number of eligible studies in the subgroups. Finally, this review did not systematize the intrapersonal and interpersonal factors or environment-level socioeconomic status in relation to park-based PA. This is because the purpose of this study was focused only on the modifiable components of the physical environment. Including other factors could provide policymakers with multiple strategies for enhancing park-based PA.

A primary strength of the current review is the context specificity of environment−PA associations. This review systematized studies on the environmental correlates of PA undertaken in parks. Information on such environment−PA relationships could guide researchers in developing ecological models of park-based PA and further improve the design of environmental change interventions. A second strength is that the study included a comprehensive search strategy across various databases. Finally, the current review comprehensively examined various study designs through which physical environments and park-based PA were measured, including both perceived and objectively measured findings.

5. Conclusion

It can be concluded that the evidence for the associations between park-based PA and physical environments is limited. The environmental characteristics that were found to be consistently related to park-based PA were paths/trails, lighting, and incivilities. The causal influence of these factors on park-based PA should be a focus of future studies. In contrast, the current review identified several mixed physical environment attributes of park-based PA, which may be due to differences in sample characteristics or methodologies. The inconsistent environmental factors included unspecified active facilities, playgrounds and skating areas, fitness stations, picnic areas, greenness, park size, park density, and park proximity.

Given the unanswered questions about the associations between physical environments and park-based PA, this review provides some recommendations for future studies. First, prospective and intervention studies are of importance to assess any causality for the relationships between park-based PA and environmental factors. Moreover, the inconsistent findings suggest that future studies should more rigorously explore the relationship between physical environmental factors and park-based PA by using standardized measures with satisfactory reliability and validity and by considering potential moderating and confounding factors. Such an approach could improve the development of a conceptual model that better describes the associations between physical environment and park-based PA. Further, future studies should pay greater attention to how the neighborhood environment facilitates park-based PA as we found that neighborhood environment attributes of park-based PA were less likely to be examined compared with the park built environment. A final consideration is to evaluate the magnitude of these associations via meta-analysis. Overall, this review provides a guide for future research that aims to increase park-based PA through the modification of physical environments.

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Authors' contributions

RZ did the literature review, review update, and data extraction, and wrote the first draft of the manuscript; YD, HW, and PW revised the manuscript. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

The authors declare that they have no competing interests.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jshs.2018.11.002.

References

1. Giles-Corti B, Timperio A, Bull F, Pikora T. Understanding physical activity environmental correlates: increased specificity for ecological models. *Exerc Sport Sci Rev* 2005;**33**:175–81.
2. Sallis JF, Floyd MF, Rodríguez DA, Saelens BE. Role of built environments in physical activity, obesity, and cardiovascular disease. *Circulation* 2012;**125**:729–37.
3. Song C, Ikei H, Igarashi M, Miwa M, Takagaki M, Miyazaki Y. Physiological and psychological responses of young males during spring-time walks in urban parks. *J Physiol Anthropol* 2014;**33**:8. doi:10.1186/1880-6805-33-8.
4. Thompson Coon J, Boddy K, Stein K, Whear R, Barton J, Depledge MH. Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. *Environ Sci Technol* 2011;**45**:1761–72.
5. Bai H, Wilhelm Stanis SA, Kaczynski AT, Besenyi GM. Perceptions of neighborhood park quality: associations with physical activity and body mass index. *Ann Behav Med* 2013;**45**(Suppl. 1):S39–48.
6. Cohen DA, Marsh T, Williamson S, Derose KP, Martinez H, Setodji C, et al. Parks and physical activity: why are some parks used more than others. *Prev Med* 2010;**50**(Suppl. 1):S9–12.

7. Cohen DA, Han B, Isacoff J, Williamson S, Marsh T, McKenzie TL, et al. Impact of park renovations on park use and park-based physical activity. *J Phys Act Health* 2015;**12**:289–95.
8. Sallis JF, Cerin E, Conway TL, Adams MA, Frank LD, Pratt M, et al. Physical activity in relation to urban environments in 14 cities worldwide: a cross-sectional study. *The Lancet* 2016;**387**:2207–17.
9. Edwards N, Hooper P, Knuiman M, Foster S, Giles-Corti B. Associations between park features and adolescent park use for physical activity. *Int J Behav Nutr Phys Act* 2015;**12**:21. doi:10.1186/s12966-015-0178-4.
10. Kaczynski AT, Besenyi GM, Stanis SAW, Koohsari MJ, Oestman KB, Bergstrom R, et al. Are park proximity and park features related to park use and park-based physical activity among adults? Variations by multiple socio-demographic characteristics. *Int J Behav Nutr Phys Act* 2014;**11**:146. doi:10.1186/s12966-014-0146-4.
11. Babey SH, Tan D, Wolstein J, Diamant AL. Neighborhood, family and individual characteristics related to adolescent park-based physical activity. *Prev Med* 2015;**76**:31–6.
12. Moran M, van Cauwenberg J, Hercky-Linnewiel R, Cerin E, Deforche B, Plaut P. Understanding the relationships between the physical environment and physical activity in older adults: a systematic review of qualitative studies. *Int J Behav Nutr Phys Act* 2014;**11**:79. doi:10.1186/1479-5868-11-79.
13. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. *Med Sci Sports Exerc* 2000;**32**:963–75.
14. Bancroft C, Joshi S, Rundle A, Hutson M, Chong C, Weiss CC, et al. Association of proximity and density of parks and objectively measured physical activity in the United States: a systematic review. *Soc Sci Med* 2015;**138**:22–30.
15. McCormack GR, Rock M, Toohey AM, Hignell D. Characteristics of urban parks associated with park use and physical activity: a review of qualitative research. *Health Place* 2010;**16**:712–26.
16. Hunter RF, Christian H, Veitch J, Astell-Burt T, Hipp JA, Schipperijn J. The impact of interventions to promote physical activity in urban green space: a systematic review and recommendations for future research. *Soc Sci Med* 2015;**124**:246–56.
17. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst Rev* 2015;**4**:1. doi:10.1186/2046-4053-4-1.
18. Bedimo-Rung AL, Mowen AJ, Cohen DA. The significance of parks to physical activity and public health. *Am J Prev Med* 2005;**28**:159–68.
19. Saelens BE, Sallis JF, Black JB, Chen D. Neighborhood-based differences in physical activity: an environment scale evaluation. *Am J Public Health* 2003;**93**:1552–8.
20. Reis RS, Hino AA, Florindo AA, Añez CR, Domingues MR. Association between physical activity in parks and perceived environment: a study with adolescents. *J Phys Act Health* 2009;**6**:503–9.
21. Plotnikoff RC, Costigan SA, Karunamuni N, Lubans DR. Social cognitive theories used to explain physical activity behavior in adolescents: a systematic review and meta-analysis. *Prev Med* 2013;**56**:245–53.
22. French SA, Sherwood NE, Mitchell NR, Fan Y. Park use is associated with less sedentary time among low-income parents and their preschool child: the NET-Works study. *Prev Med Rep* 2017;**5**:7–12.
23. Ries AV, Voorhees CC, Roche KM, Gittelsohn J, Yan AF, Astone NM. A quantitative examination of park characteristics related to park use and physical activity among urban youth. *J Adolesc Health* 2009;**45**(Suppl. 3):S64–70.
24. Spengler JO, Floyd MF, Maddock JE, Gobster PH, Suau LJ, Norman GJ. Correlates of park-based physical activity among children in diverse communities: results from an observational study in two cities. *Am J Health Promot* 2011;**25**:e1–9.
25. Rung AL, Mowen AJ, Broyles ST, Gustat J. The role of park conditions and features on park visitation and physical activity. *J Phys Act Health* 2011;**8**(Suppl. 2):S178–87.
26. Dunton GF, Almanza E, Jerrett M, Wolch J, Pentz MA. Neighborhood park use by children: use of accelerometry and global positioning systems. *Am J Prev Med* 2014;**46**:136–42.
27. Kaczynski AT, Potwarka LR, Saelens BE. Association of park size, distance, and features with physical activity in neighborhood parks. *Am J Public Health* 2008;**98**:1451–6.
28. Kaczynski AT, Potwarka LR, Smale BJA, Havitz ME. Association of parkland proximity with neighborhood and park-based physical activity: variations by gender and age. *Leisure Sci* 2009;**31**:174–91.
29. Floyd MF, Bocarro JN, Smith WR, Baran PK, Moore RC, Cosco NG, et al. Park-based physical activity among children and adolescents. *Am J Prev Med* 2011;**41**:258–65.
30. Loukaitou-Sideris A, Sideris A. What brings children to the park? Analysis and measurement of the variables affecting children's use of parks. *J Am Plann Assoc* 2009;**76**:89–107.
31. Parra DC, McKenzie TL, Ribeiro IC, Ferreira Hino AA, Dreisinger M, Coniglio K, et al. Assessing physical activity in public parks in Brazil using systematic observation. *Am J Public Health* 2010;**100**:1420–6.
32. Kaczynski AT, Koohsari MJ, Stanis SAW, Bergstrom R, Sugiyama T. Association of street connectivity and road traffic speed with park usage and park-based physical activity. *Am J Health Promot* 2014;**28**:197–203.
33. Lackey KJ, Kaczynski AT. Correspondence of perceived *vs*. objective proximity to parks and their relationship to park-based physical activity. *Int J Behav Nutr Phys Act* 2009;**6**:53. doi:10.1186/1479-5868-6-53.
34. Esteban-Cornejo I, Carlson JA, Conway TL, Cain KL, Saelens BE, Frank LD, et al. Parental and adolescent perceptions of neighborhood safety related to adolescents' physical activity in their neighborhood. *Res Q Exerc Sport* 2016;**87**:191–9.
35. Floyd MF, Taylor WC, Whitt-Glover M. Measurement of park and recreation environments that support physical activity in low-income communities of color: highlights of challenges and recommendations. *Am J Prev Med* 2009;**36**(Suppl. 4):S156–60.
36. Ding D, Sallis JF, Kerr J, Lee S, Rosenberg DE. Neighborhood environment and physical activity among youth: a review. *Am J Prev Med* 2011;**41**:442–55.
37. Triguero-Mas M, Dadvand P, Cirach M, Martínez D, Medina A, Mompart A, et al. Natural outdoor environments and mental and physical health: relationships and mechanisms. *Environ Int* 2015;**77**:35–41.
38. Van Cauwenberg J, De Bourdeaudhuij I, De Meester F, Van Dyck D, Salmon J, Clarys P, et al. Relationship between the physical environment and physical activity in older adults: a systematic review. *Health Place* 2011;**17**:458–69.
39. Van Holle V, Deforche B, Van Cauwenberg J, Goubert L, Maes L, Van de Weghe N, et al. Relationship between the physical environment and different domains of physical activity in European adults: a systematic review. *BMC Public Health* 2012;**12**:807. doi:10.1186/1471-2458-12-807.
40. Cerin E, Conway TL, Adams MA, Barnett A, Cain KL, Owen N, et al. Objectively-assessed neighbourhood destination accessibility and physical activity in adults from 10 countries: an analysis of moderators and perceptions as mediators. *Soc Sci Med* 2018;**211**:282–93.
41. Bocarro JN, Floyd MF, Smith WR, Edwards MB, Schultz CL, Baran P, et al. Social and environmental factors related to boys' and girls' park-based physical activity. *Prev Chronic Dis* 2015;**12**:E97. doi:10.5888/pcd12.140532.
42. Cohen DA, Han B, Derose KP, Williamson S, Marsh T, Rudick J, et al. Neighborhood poverty, park use, and park-based physical activity in a Southern California city. *Soc Sci Med* 2012;**75**:2317–25.
43. Coughenour C, Coker L, Bungum TJ. Environmental and social determinants of youth physical activity intensity levels at neighborhood parks in Las Vegas, NV. *J Community Health* 2014;**39**:1092–6.
44. Edwards NJ, Giles-Corti B, Larson A, Beesley B. The effect of proximity on park and beach use and physical activity among rural adolescents. *J Phys Act Health* 2014;**11**:977–84.
45. Kaczynski AT, Johnson AJ, Saelens BE. Neighborhood land use diversity and physical activity in adjacent parks. *Health Place* 2010;**16**:413–5.
46. van Dyck D, Sallis JF, Cardon G, Deforche B, Adams MA, Geremia C, et al. Associations of neighborhood characteristics with active park use: an observational study in two cities in the USA and Belgium. *Int J Health Geogr* 2013;**12**:26. doi:10.1186/1476-072X-12-26.
47. Booth ML, Okely AD, Chey TN, Bauman A. The reliability and validity of the Adolescent Physical Activity Recall Questionnaire. *Med Sci Sports Exerc* 2002;**34**:1986–95.

48. Bedimo-Rung AL, Gustat J, Tompkins BJ, Rice J, Thomson J. Development of a direct observation instrument to measure environmental characteristics of parks for physical activity. *J Phys Act Health* 2006;**3**(Suppl. 1): S176–89.
49. Kaczynski AT, Stanis SAW, Besenyi GM. Development and testing of a community stakeholder park audit tool. *Am J Prev Med* 2012;**42**:242–9.
50. Saelens BE, Frank LD, Auffrey C, Whitaker RC, Burdette HL, Colabianchi N. Measuring physical environments of parks and playgrounds: EAPRS instrument development and inter-rater reliability. *J Phys Act Health* 2006;**3**(Suppl. 1):S190–207.
51. Edwards N, Hooper P, Trapp GS, Bull F, Boruff B, Giles-Corti B. Development of a public open space desktop auditing tool (POSDAT): a remote sensing approach. *Appl Geogr* 2013;**38**:22–30.
52. Walker JT, Mowen AJ, Hendricks WW, Kruger J, Morrow JR, Bricker K. Physical Activity in the Park Setting (PA-PS) Questionnaire: reliability in a California statewide sample. *J Phys Act Health* 2009;**6**(Suppl. 1):S97–104.
53. Lee RE, Booth KM, Reese-Smith JY, Regan G, Howard HH. The Physical Activity Resource Assessment (PARA) instrument: evaluating features, amenities and incivilities of physical activity resources in urban neighborhoods. *Int J Behav Nutr Phys Act* 2005;**2**:13. doi:10.1186/1479-5868-2-13.
54. McKenzie TL, Cohen DA, Sehgal A, Williamson S, Golinelli D. System for Observing Play and Recreation in Communities (SOPARC): reliability and feasibility measures. *J Phys Act Health* 2006;**3**(Suppl. 1): S208–22.
55. McKenzie TL, Marshall SJ, Sallis JF, Conway TL. Leisure-time physical activity in school environments: an observational study using SOPLAY. *Prev Med* 2000;**30**:70–7.
56. Evenson KR, Sotres-Alvarez D, Herring AH, Messer L, Laraia BA, Rodríguez DA. Assessing urban and rural neighborhood characteristics using audit and GIS data: derivation and reliability of constructs. *Int J Behav Nutr Phys Act* 2009;**6**:44. doi:10.1186/1479-5868-6-44.