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The Impact of Interventions to Promote Physical Activity in Urban Green Space: A Systematic Review and Recommendations for Future Research

Abstract

Evidence is mounting on the association between the built environment and physical activity with a call for intervention research. A broader approach which recognizes the role of supportive environments that can make healthy choices easier is required. A systematic review was undertaken to assess the effectiveness of interventions to encourage physical activity in urban green space. Five databases were searched independently by two reviewers using search terms relating to 'physical activity', 'urban green space' and 'intervention' in July 2014. Eligibility criteria included: (i) intervention to encourage physical activity in urban green space which involved either a physical change to the urban green space or a physical activity intervention to promote use of urban green space or a combination of both; and (ii) primary outcome of physical activity. Of the 2405 studies identified, 12 were included. There was some evidence (4/9 studies showed positive effect) to support built environment only interventions for encouraging use and increasing physical activity in urban green space. There was more promising evidence (3/3 studies showed positive effect) to support physical activity programs or physical activity programs combined with a physical change to the built environment, for increasing urban green space use and physical activity of users. Recommendations for future research include the need for longer term follow-up post-intervention, adequate control groups, sufficiently powered studies, and consideration of the social environment, which was identified as a significantly under-utilized resource in this area. Interventions that involve the use of PA programs combined with a physical change to the built environment are likely to have a positive effect on physical activity. Robust evaluations of such interventions are urgently required. The findings provide a platform to

inform the design, implementation and evaluation of future urban green space and physical activity intervention research.

Keywords: Built environment; physical activity; behavior change; systematic review; interventions; social environment; public health

Introduction

Prevalence of physical inactivity and its associated health conditions are rising, and the inexorable slide to a more inactive lifestyle has worrying implications for future levels of obesity, morbidity and mortality (Lee et al, 2012). A broader approach which recognizes the role of supportive environments that can make healthy choices easier is required. However, physical activity (PA) is a complex behavior that is often discouraged in modern built and social environments (Khan et al, 2011). Considerable evidence is mounting on the association between PA and the built environment in which an individual lives (O Ferdinand et al, 2012). Accordingly, the potential of the built environment as a determinant of PA, and its ability to influence community and population levels of PA is becoming more widely recognized (DoH, 2007; WHO, 2010).

In particular, urban green space (UGS) has an important contribution to make to public health with potential physical, psychological, social, economic and environmental benefits (Bedimo-Rung, 2005; Bowler et al, 2010; Lee and Maheswaran, 2010; Lachowycz and Jones, 2011). UGS is defined as all publicly owned and publicly accessible open space with a high degree of cover by vegetation, e.g., parks, woodlands, nature areas, and other green space within the city boundary area (Schipperijn et al, 2013). Cross-sectional evidence highlights the association between UGS and PA. The availability and accessibility of UGS, particularly across the socio-economic spectrum, offers the opportunity for recreation and active travel for little or no cost to the individual. Physical activity has been shown to have positive associations with proximity, access, size and quality of UGS (Giles-Corti et al, 2005; Mowen et al, 2007; Kaczynski et al, 2011). Attributes of UGS that might stimulate and encourage PA include walking/cycling paths, wooded areas, open spaces, water features, lighting, pleasant views, bike racks, parking lots, and playgrounds (Schipperijn et al, 2013). However, to date

much of the research in this area has been observational and shows that many UGS are underutilized (Floyd et al, 2008; Cohen et al, 2010; Floyd et al, 2011; Kaczynski et al, 2011).

Interventions specifically targeting use of UGS may assist with increasing PA behavior change at the community and population level. Urban Green Spaces receive significant investment for modifications and programming, particularly from local authorities. Examples include improving access to UGS, improving walking/cycle paths, and playground/park facilities in UGS. Interventions to specifically promote and encourage use of UGS or specific features of UGS include awareness, marketing and promotional campaigns, and PA programs in UGS. There is a need to identify if such investments are effective in increasing use of UGS and PA of UGS users, and subsequently determine how to make best use of UGS for public health. As with other aspects of built environment research, there has been a call for evidence of the effectiveness of environmental interventions to initiate and help maintain PA behavior change. Therefore, the aim of this study was to undertake a systematic review to assess the effectiveness of interventions to promote PA in UGS, including the development of new UGS.

Methods

Search Strategy

Five electronic databases (Medline, EMBASE, CINAHL, Sport DISCUS and PubMed) were searched for articles published up to July 2014, and reference lists of included studies were hand searched for further relevant papers. Keywords relating to ‘physical activity’, ‘urban green space’ and ‘intervention’ were searched (see Appendix I).

Eligibility Criteria

Studies were included if they met the following criteria:

- (i) intervention to promote/encourage PA in UGS
- (ii) primary outcome measure of PA levels, including subjective and objective measures of overall PA, or walking and cycling specific measure, or recreation or active travel domain specific measure
- (iii) a control/comparator group
- (iv) English language
- (v) full-text available

UGS was defined as all publicly owned and publicly accessible open space with a high degree of cover by vegetation, e.g., parks, woodlands, nature areas, and other green space within the city boundary area (Schipperijn et al, 2013).

Physical activity interventions that involved the following were included:

- (i) a physical change to the built environment including environmental improvements or creation of new environmental PA opportunities (e.g., new footpaths, improved playgrounds);
- (ii) an intervention to specifically promote/encourage use of UGS or specific features of UGS (e.g., awareness campaigns, PA programs in UGS).
- (iii) a combination of physical change to the built environment and a specific awareness/promotion program to encourage PA in UGS.

Evidence Synthesis

Studies were categorized according to the main approach of the intervention: 1) built environment only intervention; 2) PA promotion only intervention; 3) combination of built environment change and PA promotion intervention. Key characteristics and outcomes of the

studies were extracted and tabulated including study design, country, target population, description of intervention and control/comparator group, outcome measures, duration of follow-up and summary of study findings. The review followed the PRISMA guidelines (Moher et al, 2009) and risk of bias was assessed using the Cochrane Risk of Bias tool (Higgins et al, 2011), performed independently by two reviewers. While intended for controlled trials, the majority of items are applicable to other study designs and allocate lower scores to studies employing study designs which introduce bias.

Results

Appendix II shows the results of the literature search. Briefly, 2405 studies were initially identified, 64 full-text articles screened, and 12 studies included in the review.

Study Characteristics

Table 1 presents a summary of the included studies. Eleven of the studies were natural experiments with the majority using a quasi-experiment, controlled pre-post design (n=8), and one difference-in-difference design (Branas et al, 2011). Only one study employed a RCT design (Cohen et al, 2013). Studies were mainly implemented in the US (n=9), particularly in California (n=6), and the other studies took place in Australia (n=3). A number of studies were set in areas where the majority of the population were of low Socio-Economic Position (SEP) and of ethnic minority groups (Cohen et al, 2009a; Tester and Baker, 2009; Fitzhugh et al, 2010; Cohen et al, 2012; Veitch et al, 2012; Bohn-Goldhaum et al, 2013; Cohen et al, 2014), which are typical of inner-city areas. Given the heterogeneity in target populations, interventions and outcome measures it was not appropriate to pool results in a meta-analysis.

Appendix III presents the results of the risk of bias assessment described by study. Only one study had a low risk of bias (Cohen et al, 2013), which employed an RCT design, with five studies assessed as having a high risk of bias (Merom et al, 2003; Cohen et al, 2009a; 2009b; West and Shores, 2011; Bohn-Goldhaum et al, 2013) and six with an unclear risk of bias (Tester and Baker, 2009; Fitzhugh et al, 2010; Branas et al, 2011; Cohen et al, 2012; Veitch et al, 2012; Cohen et al, 2014). The bias-related concerns were allocation sequence (which generally was not possible due to trial design), allocation concealment and blinding of the participants/outcome assessors. None of the studies reported accounting for missing data and risk of contamination was difficult to assess due to the nature of the control group (no study formally measured this).

Evidence Synthesis

Table 1 presents a summary of the key characteristics and results of the studies categorized according to the type of intervention.

1) Built Environment Only Interventions

Nine studies investigated the influence of an UGS intervention that involved physical changes to the built environment only. Four studies (three of which were in the USA) showed a positive outcome with increases in PA and park usage (Cohen et al, 2009b; Fitzhugh et al, 2010; Branas et al, 2011; Veitch et al, 2012). Cohen et al (2009b) investigated the impact of two parks that underwent renovations to a skate park and senior center. Results showed a significant increase in skate park use but substantially fewer users of the senior center. There was also a significant increase in the perception of safety in the renovated parks ($p < 0.001$). An Australian study by Veitch and colleagues (2012) showed significant increases in the number of park users and number of people walking and being vigorously active after major

park improvements (i.e., fenced leash-free area for dogs, playground, walking track, BBQ area, landscaping, fencing). In another study that included youths, an urban greenway trail (Fitzhugh et al, 2010), designed to enhance connectivity of pedestrian infrastructure with nearby retail establishments and schools, showed significant changes between the experimental and control neighborhoods for total PA ($p=0.001$); walking ($p=0.001$) and cycling ($p=0.038$). However, there was no significant change over time for active transportation to school. Finally, a decade long study using a difference-in-difference design by Branas et al (2011) showed that greening of vacant urban lots resulted in reductions in gun assaults ($p<0.001$), vandalism ($p<0.001$), and residents reporting less stress and more exercise ($p<0.01$). Greening of vacant lots ($> 725,000\text{m}^2$) from 1999 to 2008 involved removing trash and debris, grading the land, planting grass and trees, installing low wooden fences around perimeter, and maintenance activities performed multiple times/year.

Five studies (three of which were by the same first author) showed no significant impact on PA and park usage for PA interventions involving change to the built environment only (Cohen et al, 2009a; West and Shores, 2011; Cohen et al, 2012; Bohn-Goldhaum et al, 2013; Cohen et al, 2014). Cohen et al (2009a) showed that park use and PA declined in parks that underwent major improvements including new/improved gyms, picnic areas, walking paths, playgrounds, watering and landscaping. However, during the study period the Department of Recreation and Parks suffered budget cuts that led to reduced programming and the authors suggested that 39% of the decline was directly attributable to fewer scheduled organized activities. Another Californian study by Cohen et al (2012) found that park usage increased by 11% compared to control parks (not statistically significant) following the installation of Family Fitness zones (i.e., outdoor gyms) in 12 parks. More recently, Cohen and colleagues (2014) investigated the impact of the creation of three pocket parks from vacant lots on the

number of park users and PA. This involved installation of playground equipment and benches, development of walking paths, and all areas were fenced and enclosed by lockable gates. Typically, pocket parks serve the immediate population within 0.25-0.5 miles of the park, have limited facilities, have few or no programs, lack indoor facilities, and are not staffed. Results showed that pocket parks were used as frequently or more often than playground areas in neighborhood parks (control areas); however, they were vacant during the majority of observations. The authors concluded that pocket parks may act as catalysts for PA and encourage local residents to be physically active by being a valued community destination. However, additional strategies and programs may be needed to encourage more residents to use these parks. A study by West and Shores (2011) found no significant effect for PA for five miles of greenway developed and added to existing greenway along a river. Finally, an Australian study targeting 2-12 year old children found no significant effects for park usage and children's PA compared to the control group following major park renovations involving development of three children's playgrounds within a larger park complex (Bohn-Goldhaum et al, 2013).

2) Physical Activity Promotion Only Interventions

Only one study investigated the impact of a PA promotion only intervention to encourage use and PA in UGS using a RCT design (Cohen et al, 2013). Fifty-one parks were randomly allocated to one of three groups: 1) Park Directors (PDs) only; 2) Park Directors and Park Advisory Boards (PD-PABs); or 3) control group (measurement only). Park Directors received five training sessions from a marketing consultant regarding outreach, customer service, promotion events, improving park image and building the customer base. Further, the intervention arms used the baseline data collected regarding park use and characteristics of park users from Systems for Observing Play and Recreation in Communities (SOPARC)

observations (McKenzie et al, 2006) to inform decisions regarding development of park programs to increase park use and PA. Each park received \$4,000 to spend on park programs which included signage (e.g., banners, walking path signs), promotional incentives (e.g., water bottles, park-branded key chains, individually targeted emails), and outreach activities (e.g., hiring additional instructors, buying activity materials). Results showed a significant increase in PA and number of park users for both intervention arms, generating an estimated average of 600 more visits/week/park, and 1830 more MET-hours of PA/week/park. The primary mediator of change was investment in signage which explained 37% of change in park users and 39% increase in MET-hours.

3) Combination of Built Environment Change and PA Promotion Intervention

Two studies investigated interventions that included a combination of both a physical change to the built environment and a PA promotional aspect (Merom et al, 2003; Tester and Baker, 2009). Merom et al (2003) investigated the impact of a promotion campaign of a newly constructed Rail Trail in Western Sydney, Australia. The promotion campaign included press ads, maps of trails, newspapers and local radio, brochures distributed to local organizations and schools, and a launch event. Results showed that trail usage was higher among bike-owners than pedestrians (8.9% vs 2.2%, $p=0.014$) and was moderated by proximity to the trail. Intervention group cyclists increased mean cycling time by 0.19hr (SD 1.5) per week while control area cyclists decreased cycling time (-0.24hr; SD 1.6). Overall mean bike counts on the trail increased significantly after the trail launch ($p=0.0004$). The study found that remoteness (in distance and time) was a key reason for not using the trail. In another study, by Tester and Baker (2009), significant renovations to playfields (mainly used for soccer and baseball) of two public parks as well as PA programming, and training and skills development for park and recreation program staff were evaluated. Results showed that park

playfield renovations, with and without family and youth involvement initiatives, significantly increased visitation and overall PA (4-9 fold increase) compared to the control.

Discussion

In summary, there was some evidence to support the use of built environment only interventions for encouraging use and increasing PA in UGS. However, more promising evidence existed for the use of PA programs combined with a physical change to the built environment. These findings highlight that multifaceted UGS intervention strategies are likely to have a more significant impact on levels of PA than changes to the built environment in isolation. However, these results should be interpreted with caution given the relative dearth of intervention-based research in this area and further work is urgently required (Harris et al, 2013).

Undertaking UGS research requires multi-component studies which incur considerable costs. In addition, the undervaluation of the PA benefits derived from UGS may also explain the relative lack of societal investment in research on UGS. Significant UGS investment is made worldwide, particularly by local authorities (Brown and Cummins, 2013). Thus, more effective strategies for using this valuable resource to enhance opportunities for PA and improve public health are required. Based on this review we have highlighted methodological considerations to help inform the design, implementation and evaluation of future PA interventions in UGS.

Methodological Considerations and Recommendations for Future Research

Table 2 details a number of methodological issues raised in this review and highlights a number of recommendations to ensure future robust evaluations of UGS-PA interventions. The implementation of specific recommendations is contingent on the research question.

1) *Sample Size*

Only one study reviewed mentioned details of a sample size calculation to inform their study population (Cohen et al, 2013) with most of the included studies employing a small sample size for research of this nature. Future studies must perform a fully justified sample size calculation to improve the rigor of this body of research, and where appropriate, account for clustering.

2) *Outcome Measures*

Eight studies used SOPARC for capturing the number of park users, characteristics of park users and their PA levels (Cohen et al, 2009a; 2009b; Tester and Baker, 2009; Cohen et al, 2012; Veitch et al, 2012; Bohn-Goldhaum et al, 2013; Cohen et al, 2013; 2014). SOPARC methodology states that data should only be collected on clement days; the protocol is designed to eliminate the weather variable as an important confounder. However, baseline and follow-up observations should be conducted at the same time of the year to control for seasonal variation, and assessment periods for intervention and control groups should be conducted at the same time to enable accurate comparisons between groups. Studies used a varying number of observation times per day and number of days. Thus, a validated protocol is required in order to compare study findings. Further, given the impact of weather conditions on park usage, detailed weather data should be collected and assessed for the data collection period.

While SOPARC has a number of strengths it does not capture whether new users are using the park, where park users have come from (local residents or visitors), socio-economic characteristics of park users or individual level change. A number of studies triangulated SOPARC data with Intercept Surveys and household interviews with local residents in order to provide a more in-depth investigation (Cohen et al, 2009a; 2009b; 2012; Bohn-Goldhaum et al, 2013; Cohen et al, 2013; 2014). Further, new technologies, such as the use of web cameras (Hipp et al, 2013; Adlakha et al, 2014), accelerometers and GPS tracking (Kerr et al, 2011; Schipperijn et al, 2014) offer new objective measures of UGS and PA interventions, however they require further methodological testing and understanding of the practical considerations.

It is imperative that future studies measure a range of purported mediators and moderators of initiation and maintenance of PA behavior change in order to test the hypothesized pathways of effect. Examples include perceived and objective measures of UGS safety, distance from UGS, awareness of UGS, barriers to UGS use, motivators for UGS use, weather, exposure to UGS, quality of UGS environment (objective and perceived measures of UGS attributes/features), neighborhood built environment features and, community level social measures such as sense of community, social support and social capital. This requires the use of multi-level conceptual models and statistical methods, and the triangulation of data, both quantitative and qualitative, from multiple sources. Further, it is important that studies report the area of UGS (e.g. km²) involved in order to outline the context of the intervention.

3) Follow up

The timing of follow-up assessments ranged from immediately post-intervention (Veitch et al, 2012) up to 14 months post-intervention (Cohen et al, 2009b; Fitzhugh et al, 2010).

Further, only one study included more than one measured endpoint which included follow-up assessments immediately post-intervention and a further follow-up 12 months post-baseline (Veitch et al, 2012). Results showed an increase in usage and PA at the first follow-up, which continued to increase at the second follow-up therefore illustrating the need for longer-term follow-up.

It is also unclear what duration of intervention exposure is required to ensure “normal usage” as opposed to capturing the “novelty factor” effect. Given the relative “permanent-ness” of built environment interventions, usage over time will change and this needs to be captured by employing a number of follow-up assessment points from immediately post-construction to longer term follow-up. For example, large scale interventions such as the development of a £32 million urban greenway has a 40 year management and maintenance strategy (Tully et al, 2013; Dallat et al, 2014). Such interventions provide a unique opportunity and need for longer term follow-ups, for example, at 2 years, 5 years and 10+ years. In regards to follow-up duration for PA programmes only, a minimum of 1 year follow-up is considered important for assessing maintenance of behaviour change.

4) Control Groups

Control groups typically involved matched control parks which did not undergo any UGS intervention. Parks were matched on the following criteria: parks of similar size, features, amenities and served a similar population that did not undergo any improvements (Cohen et al, 2009a; 2009b; Tester and Baker, 2009; Bohn-Goldhaum et al, 2013). However, for some studies, the control park (10,000m²) was only half the size of the intervention park (size 25,200m²), which has obvious implications when measuring number of users (Veitch et al, 2012).

There is difficulty in identifying adequate control parks of similar sizes, similar features and which serve a similar population (based on socio-economic factors) yet are geographically far enough apart to limit contamination. This is an inherent limitation in that most parks are unique, being, in part, the product of the limited availability of land parcels that are allocated as park space, and the need to "squeeze" park space into what remains after real estate development. Further, other studies employed a control group based on distance from the UGS intervention (1.5-2km (Merom et al, 2003); 0.5-1 mile (West and Shores, 2011)). However, it is unknown what an appropriate distance from the UGS intervention would act as a "true" control, given that a distance decay pattern has been identified (Krizek et al, 2007). However, it is imperative that an adequate control condition is included in order to ensure robust evaluations (Craig et al, 2012).

5) Target Population

A number of studies targeted low SEP groups and ethnic minority groups which are typical of inner-city areas. Also, most studies were based in the US, particularly in California which has an average of 47 weeks per year with no precipitation. Therefore, further studies are urgently required in other parts of the world, with differing climates, particularly in low-middle income countries. There was also a paucity of evidence related to the influence of PA interventions and UGS on children, adolescents and older adults. A unique aspect of UGS is that it is a resource for people of all ages and backgrounds; therefore, future research should target all groups.

A number of studies highlighted the importance of community participation (Cohen et al, 2009a) and partnerships with local organizations and government (Veitch et al, 2012). It is important that such participation is involved from the outset of the intervention and

throughout the period of intervention and follow up to ensure sustainability of the intervention and maintenance of PA behavior change.

6) Cost-effectiveness Analyses

Built environment interventions, in particular those that undertake a physical change to the built environment are expensive and present significant investment, mainly by local authorities. Studies investigated interventions that ranged from \$45,000 per park (Cohen et al, 2012) to \$3.5 million per park (Cohen et al, 2009b), with some undertaking preliminary cost-effectiveness analyses and finding that UGS interventions are cost-effective (Cohen et al, 2012; 2013; 2014). However, future research should also consider the wider economic impact of such interventions, including health and societal costs, for example, healthcare costs, reductions in carbon emissions, improvements in safety, and reduced crime.

7) Social Environment

Finally, none of the included studies measured any features of the social environment or utilized aspects of the social environment in the intervention. It is likely that the social environment (e.g., social support, social capital (Broyles et al, 2011)) plays an important role in the initiation and maintenance of PA behavior change in UGS, particularly as most UGS is based within a community setting. Indeed, social support has been identified as an important correlate for PA behavior change (Bauman et al, 2012). Previous cross-sectional research suggests that the social environment may act as a possible mechanism through which UGS positively impacts on health outcomes (Sugiyama et al, 2008; Maas et al, 2009). The social environment is inherent in PA programs and UGS, for example, walking groups, dog walking, where people can meet and “get out and about” (Prior et al, 2014), and be active (with or without realizing it).

There is a need to move beyond individual level approaches and towards broader population interventions that provide a supportive social and built environment. Future research would be enhanced through incorporating measures of the social environment in order to further understand the role that it plays in PA and UGS research, and how it might be influenced, in association with the built environment, for PA behavior change.

Challenges

All but one of the studies were natural experiments, i.e., the researchers did not have any input or control in the design and implementation of the intervention. These are particularly complex interventions with multiple interacting factors at the individual, community and population level, and considerable variation in the quality and types of UGS. Studies of this kind raise a number of scientific and evaluative challenges, for example, aligning research timetables with the regeneration timelines, rapidly recruiting and conducting a baseline assessment prior to implementation of the intervention and, measuring confounders and levels of exposure.

Evaluations of such complex interventions need to be scientifically robust yet flexible enough to cope with unpredictable implementation and a changing environment which is not controlled by the researcher. The MRC guidelines for natural experiments recommend the specification of a priori hypotheses, clear definitions of target populations, explicit sampling criteria and the use of valid and reliable outcome measures (Craig et al, 2012). These guidelines should be followed in the design and conduct of future evaluations of PA interventions in UGS to improve the scientific rigor of the research. In addition, the RE-AIM Framework (King et al, 2010) provides a useful template to guide the design and

implementation of a comprehensive public health evaluation of large built environment interventions, expanding the assessment of interventions beyond efficacy to address multiple criteria, including Reach, Effectiveness, Adoption, Implementation and Maintenance, that better assess the potential for dissemination and public health impact of such interventions.

Unanswered Questions

In addition to detailing a number of methodological considerations, this review has also highlighted gaps in the literature. The following unanswered questions will help focus future research:

1. Do specific UGS improvements result in increased UGS usage and PA among specific groups (e.g., low SEP, different age groups, gender)?
2. Is it possible to design multi-use and multi-purpose UGS that facilitates increased PA for a wide number of user groups, for example different age groups, in different climates, cultures and countries?
3. Do improvements to UGS of varying sizes and/or functions result in similar increases in UGS usage and PA?
4. To what extent do interventions actually capture new UGS users?
5. Do increases in PA from UGS interventions result in the displacement of PA from other areas?
6. Does regular UGS usage equate to regular PA participation?
7. To what extent can marketing and outreach programs maintain early behavior change from improvements in the built environment?
8. What role does the social environment play in the uptake, initiation and maintenance of PA behavior change in UGS?

9. How can the unique 'natural' features of UGS be used to support people's need for contact with nature and facilitate increased PA?

Conclusion

Physical inactivity is a major public health concern, with implications for our health, society and economy. The public health dividend of increasing PA in the population is substantial.

UGS has the potential to contribute significantly to public health as a setting that encourages participation in PA. Physical activity behavior change at the community and population level might be increased by interventions specifically targeting use of UGS (Cohen et al, 2007).

Results from this review show promising evidence to support the use of PA programs and physical changes to the built environment for increasing UGS use and PA. There are multiple strategies for increasing PA in UGS and future work should explore these. Focused attention to the issues raised in this review is likely to lead to more robust evaluations of interventions to promote the use of and PA in UGS and contribute to improving public health. This review provides a platform for guiding the design, implementation and evaluation of future research investigating PA interventions and UGS research.

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Table 1: Summary of included studies

Reference	Study Design	Country	Study Descriptor			Results			
			Population	Intervention	Control	Outcome	Follow-up (months)	Outcome Measures	Risk of Bias
Change to built environment only									
Cohen et al, 2009a	Quasi-experiment: controlled, pre-post design	US	Predominantly Latino and African-American and low-income neighborhoods (mean 31% of households in poverty)	5 parks (mean 8 acres) underwent major improvements including new/improved gyms, picnic areas, walking paths, playgrounds, watering and landscaping (cost: >\$1m each)	Each intervention park had a matched control park (n=5) of similar size, features, amenities and served a similar population that did not undergo any improvements	-ve: Overall park use and PA declined in both intervention and control parks	Baseline (Dec 2003-Nov 2004); follow-up (Apr 2006-Mar 2008) Follow up measures were initiated at least 3 months after construction (range 3-14 months post construction)	SOPARC: 4 time points over 7 days Intercept surveys Interviews with residents within 1-2 miles from each park: use of park and PA levels	High
Cohen et al, 2009b	Quasi-experiment: controlled, pre-post design	US	Residents living within 2 mile radius of parks Youths and seniors	2 parks (48-67 acres) underwent renovations: (1) improvements to skate park surfaces only (cost \$3.5m) (2) improvements to entrance, courtyard areas and gymnasium of senior center (cost \$3.3m)	Control skate park and control senior center that did not have any improvements matched on neighborhood characteristics (demographics and economic distribution) and physical features (size and type of facilities)	+ve: 510% increase in skate park use compared to 77% in comparison skate park Substantially fewer users of senior center	Baseline and follow-up 1-3 months following opening of renovated areas	SOPARC: 4 timepoints over 7 days Face to face interviews with park users and residents (age 18+) living within a 2-mile radius of park Perception of safety; park proximity;	High
Fitzhugh et al, 2010	Quasi-experiment: controlled, pre-post design	US	Children, adolescents and adults in free-living conditions in neighborhood (17.7% ethnic minority; 32.2% living in poverty)	Retrofit of an urban greenway/trail (2.9 miles long) to enhance connectivity of pedestrian infrastructure with nearby retail establishments and schools (cost: \$2.1m)	2 control neighborhoods with similar socioeconomic dimensions and 2 elementary and 1 middle control schools	+ve: Pre and post intervention changes between experimental and control neighborhoods were sig different for total PA (p=0.001); walking (p=0.001) and cycling (p=0.038) There was no sig change over time for active transport to school	Baseline (Mar 2005) and follow-up (Mar 2007) 14 months after construction complete	Pedestrian count surveys at school and neighborhood areas (2 hours on 2 days) for 1-week at baseline and follow-up	Unclear
Branas et al, 2011	Quasi-experiment:	US	Cohort of 50000	Greening of vacant urban land (n=4436)	Matched control vacant lots (n=13,300) were	+ve: Greening associated with	Southeastern Pennsylvania	Survey included self-report question of PA levels	Unclear

	difference in difference design		Philadelphians from household survey	(> 725000m ²) from 1999 to 2008 involving removing trash and debris, grading the land, planting grass and trees, installing low wooden fences around perimeter; maintenance activities performed multiple times/year	randomly selected and matched to intervention lots at a 3:1 ratio	reductions in gun assaults (p<0.001), vandalism (p<0.001), residents reporting less stress and more exercise (p<0.01)	Household Health Survey (random digit dialing every 2 years to a new cohort of 50000 Philadelphians) using waves 1998-2008		
West and Shores, 2011	Quasi-experiment: controlled, pre-post design	US	Residents (n=597) living within 0.5 mile radius of greenway in midsized Southeastern US city, owned a single-family dwelling (90% Caucasian)	5 miles of greenway developed and added to existing greenway along a river	Randomly selected households (n=591) living 0.5-1 mile radius from greenway	-ve: No sig difference between intervention and control group However, increases were observed in the mean number of days in which respondents walked or were moderately active for both groups	Baseline and follow-up (conducted 11 months after the opening of the greenway)	Household survey included self-report question of PA levels	High
Cohen et al, 2012	Quasi-experiment: controlled, pre-post design	US	Residents within 1 mile radius of parks (mean 29% of households in poverty, 59% Latino population)	12 parks (mean 14 acres) involving installation of Family Fitness zones (outdoor gyms), 8 pieces of equipment at each park (average cost \$45,000 for each park)	10 matched control parks that did not install Family Fitness zones (mean 12 acres)	-ve: Park usage increased by 11% compared to control parks but this was not statistically significant Self-reports of being a new park user increased more in Fitness Zones parks and estimated energy expenditure in Fitness Zones parks was higher at both follow-ups than at baseline	Baseline (winter of 2008-2009); 1 st follow-up 1 year later during winter 2009-2010; 2 nd follow-up a few months thereafter (Spring 2010) *for control parks the timing of data collection from baseline to follow-up was an average of 2 years compared to 1 year in the intervention parks	SOPARC 3 times per day for 4 days Intercept survey: use of park, use of fitness equipment, perceptions of park, distance travelled to park	Unclear
Veitch et al, 2012	Quasi-experiment: controlled, pre-post design	Australia	Most disadvantaged decile in state of Victoria	1 park (size 25,200m ²): involving establishment of a fenced leash-free area for dogs (12,800m ²); an all-abilities playground; a 365m walking	1 matched control park (size 10,000m ²) located in same neighborhood as intervention park and having similar features at baseline	+ve: Sig. increase from pre to post-improvement in number of park users for intervention park (T1=235, T3=985) and number of people walking (T1=155,	Baseline (Aug-Sept 2009), immediately following park improvement (Mar-Apr 2010) and 12 months after baseline	SOPARC: 7 times each day on 9 days (over 4 weeks)	Unclear

				track; BBQ area; landscaping; fencing to prevent motor vehicle access to the park		T3=369) and being vigorously active (T1=38, T3=257).	(Aug-Sept 2010)			
Bohn-Goldbaum et al, 2013	Quasi-experiment: controlled, pre-post design	Australia	Lower socio-economic urban neighborhood within the city of Sydney, Australia. Targeted children aged 2-12 years and their parents	1 park (size 4.6 hectares): involving 3 new children's playgrounds dispersed throughout the park. Playground features include public art, aboriginal theme, water feature, swings, climbing structure, soft-fall feature, wood chip flooring, basketball and skating area. Also, upgrading paths, adding new greenery, lighting and facilities, sports field opened for public use increasing the accessible park size from 2.2-4.6 hectares	1 matched control park (size 4.2 hectares) located in located in nearby urban neighborhood (population generally socio-economically similar to intervention park); both parks included a playground, a large open area, and a sports field	-ve: No sig difference between groups for park usage or children's MVPA. At the intervention park, there was a significant decline in girls engaging in MVPA at follow-up (p=0.04)	Baseline (May 2007) and 9 months after the park upgrade was completed (May 2009)	Observations of playground visitors aged 2-12 years old using SOPARC; conducted during 2-hour periods, 3 times per day over a 2-week period Intercept survey with adults accompanied by children: parent's demographics, PA behavior and park usage	High	
Cohen et al, 2014	Quasi-experiment: post-test only comparison	US	Residents living within 0.5 mile radius of parks. High rates of household poverty (30-41%) and minority populations (70-80% Latino, 3-17% African-American, 0-16% Asian)	Creation of 3 pocket parks (0.15-0.32 acres) from vacant lots and undesirable urban parcels. Playground equipment and benches installed, walking path developed around the perimeter, all fenced and enclosed by lockable gates (average cost \$1m each funded by local non-profit groups)	15 playground areas in neighborhood parks (15-50 times larger than pocket parks) matched to each pocket park by % of households in poverty	-ve: Pocket parks were used as frequently or more often than playground areas in neighborhood parks. However, they were vacant during the majority of observations	Baseline (mid July-mid Aug 2006) and follow-up (same season 2008) and comparison parks in 2008-2009	SOPARC: 4 times per day over 7 days. Surveyed park users and residents about park use. Random sample of household addresses (n=824) within 0.25 miles of pocket park and another between 0.25-0.5 miles of the park was selected, field staff went door to door to conduct the surveys (adults 18+yrs)	Unclear	
Physical activity programming intervention only										
Cohen et al, 2013	RCT: parks randomized to 3	US	Parks users and residents living	2 intervention groups:	17 control parks: measurement only	+ve: In both PD-only and PAB-PD parks,	Baseline (Apr 2008-Mar 2010)	SOPARC (4 times per day over 7 days)	Low	

<p>study arms (17 parks per study arm) Eligible parks randomized based on park size, number of facilities and programs offered by the park and socio-demographic characteristics of the pop within 1-mile radius</p>	<p>within 1 mile radius of park</p>	<p>1) PD only; 2) PAB-PD PDs and PABs involved in all aspects of research and in using baseline results to design park-specific interventions to increase park use and PA; PDs received 5 training sessions from a marketing consultant Each park received \$4000 to spend on signage; promotional incentives; outreach and support for group activities</p>	<p>PA increased, generating an estimated average of 600 more visits/week/park, and 1830 more MET-hours of PA/week/park Both residents and park users in the intervention arms reported increase frequency of exercise. No differences between PD and PAB-PD parks. PA declined in control parks</p>	<p>and in same season at follow-up (Apr 2010-Apr 2012)</p>	<p>Survey of random sample of residents living within 1 mile of park. A sample of 75 adult park users were interviewed in each park at baseline and follow-up</p>
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Combination of built environment and physical activity programming intervention

Merom et al, 2003	Pre and post population based telephone survey	Australia	Random sample of adults aged 18-55 years within 1.5km of the trail	Promotional campaign of newly constructed Rail Trail to develop community awareness of the facility. Media components included press ads, map of trail, newspapers and local radio, brochure distributed to local organizations, schools, (over 17000); launch event and in site promotion at 9 City Rail stations (15000 brochures distributed to commuters over 4 days)	Random sample of adults aged 18-55 years 1.5-2km from trail	+ve: Trail usage was higher among bike-owners than pedestrians (8.9% vs 2.2%, p=0.014) and was moderated by proximity to trail Intervention group cyclists increased mean cycling time by 0.19hr (SD 1.5) while control area cyclists decreased cycling time (-0.24hr; SD 1.6) Mean bike counts increased sig after trail launch (p=0.0004)	Pre-campaign survey (Nov-Dec) and post campaign survey (Mar)	Objective concurrent monitoring of daily bike counts (4 locations along trail Oct 2000-Mar 2001). Survey included questions on walking and cycling behavior, short term intention to be more active, awareness of trail, barriers for trail use, purpose of use, likelihood of future use	High
Tester and Baker, 2009	Quasi-experiment: controlled, pre-post design	US	Low-income neighborhoods in San Francisco, California	2 public parks underwent significant renovations to their playfields mainly	1 control park: selected because of similar socioeconomic and racial/ethnic demographics of nearby	Both intervention parks playfields saw sig increases in male and female visitors, with over a 4-fold	Baseline (late May) 2006; follow-up 2007	SOPARC 8 times per day over 7 days	Unclear

One park was part of an initiative to increase the quality of family and youth-oriented services and programs	used for soccer and baseball Including artificial turf replaced uneven dirt fields, new fencing, landscaping, lighting, and picnic benches; new soccer goals and walkway around field; programming; training and skills development for park and recreation program staff (total cost \$5.5m)	residents and approximation in features (e.g. presence of playground, and soccer/baseball area)	increase in the average number of visitors per observation For both genders, there was a sig increase in sedentary, moderate activity and vigorous activity visitors to the intervention park playfields Sig increases in number of visitors to non-playfield areas
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+ve, significant difference for park usage and/or PA levels in favor of intervention group versus control group; -ve, no significant difference for park usage and/or PA levels in favor of intervention group versus control group; MET, Metabolic equivalent; MVPA, moderate-vigorous physical activity; PA, physical activity; PAB, Park Advisory Board; PD, Park Directors; RCT, Randomized Controlled Trial; SD, standard deviation; sig, significant; SOPARC, Systems for Observing Play and Recreation in Communities; US, United States

Table 2: Summary of Recommendations for Future Research

Methodological Issue	Recommendation
1. Sample Size	Perform appropriate sample size calculation
2. Outcome Measures	Use objective measure of PA where possible
	Use domain specific and/or PA behavior specific measures (e.g., walking, cycling) related to intervention
	Include measures of purported mediators and moderators
	Incorporate analyses of mediators and moderators to assess direct and indirect effects
	Include triangulation of quantitative and qualitative data from multiple sources
	Use of complex conceptual and statistical models to account for cross-level interactions of socio-ecological model
3. Follow-up	Conduct follow-up at same time of year as baseline to control for seasonal variation
	Allow sufficient delay post-construction to ensure capture of “normal” usage
	Conduct a number of longer term follow-up assessments to account for maintenance of behavior change and sustainability of UGS intervention
4. Control Group	Use UGS of similar size and features, serving similar populations in terms of socio-economic characteristics and have no planned changes during the study period
	Ensure geographically far enough apart to limit contamination
	Informed by MRC guidelines for natural experiments (Craig et al, 2012)
5. Target Population	Need for studies outside of the US
	Need for studies in low and middle income countries
	Need for studies investigating the influence of PA and UGS in children and adolescents
	Evaluations should target populations living in target communities not only park or trail users
6. Cost-effectiveness Analysis	Include cost of maintenance of UGS in analyses
	Model wider impacts of health and society, for example, healthcare costs, reduced carbon emissions, improvements in safety, less crime
7. Social Environment	Potential influence of the social environment in association with the built environment should be considered in the design of future interventions

Appendix I: Search Strategy

Physical Activity

1	(physical* adj activ*).ti, ab
2	exercise/ or exerc*.ti, ab
3	walking/ or walk*.ti, ab
4	(cycling or cycle or bike or biking or bicycle or bicycling). ti, ab
5	((active adj travel*) or (active adj transport*) or (active adj commut*)). ti, ab
6	(active adj play*).ti, ab
7	(recreation* or leisure* or sport*). ti, ab
8	1 or 2 or 3 or 4 or 5 or 6 or 7

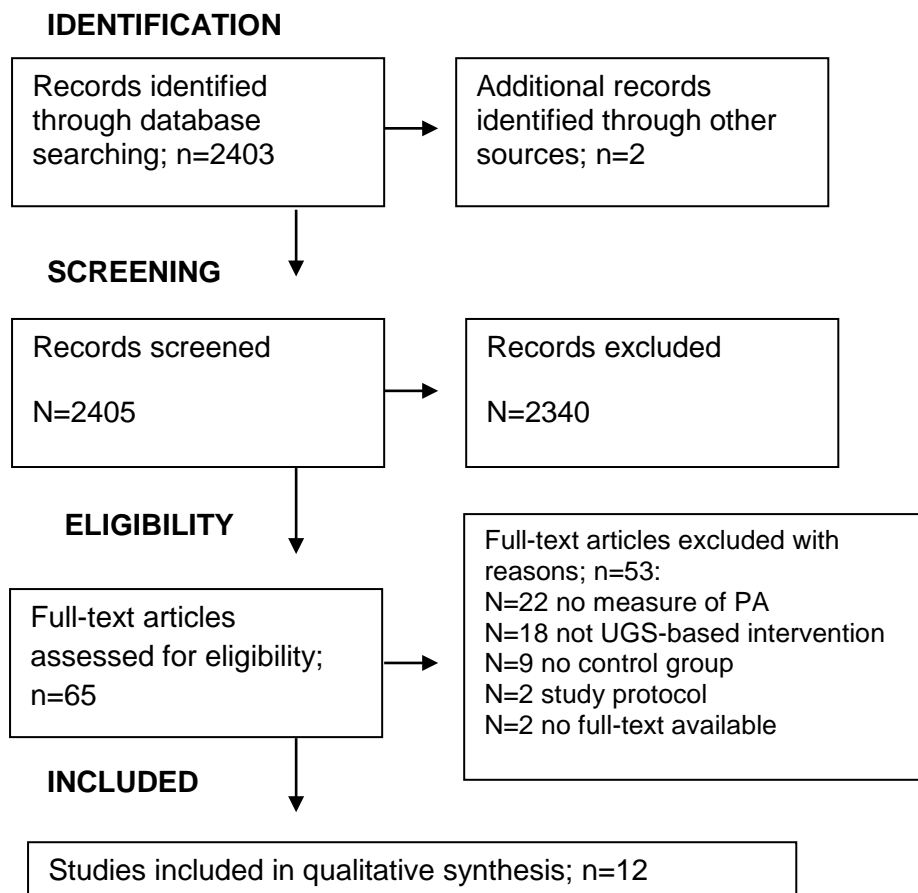
Urban Green Space

9	(urban adj green adj space). ti, ab
10	green*space. ti, ab
11	(open adj space). ti, ab
12	(public adj space). ti, ab
13	(public adj open adj space). ti, ab
14	(park not parkin*). ti, ab
15	(city adj park). ti, ab
16	(public adj park). ti, ab
17	(urban adj park). ti, ab
18	(municipal adj park). ti, ab
19	(greenway or urban greenway). ti, ab
20	(urban adj regen*). ti, ab
21	(trail* or urban adj trail*). ti, ab
22	9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21

Intervention

23	intervention stud*.mp.
24	randomised control* trial.mp.
25	randomized control* trial.mp.
26	comparative stud*.mp.
27	control group.mp.
28	(randomised or randomized or randomly or groups).mp.
29	quasi*experiment*.mp.
30	natural experiment*.mp.
31	(pre test or pretest or pre intervention or post intervention or post test or posttest).mp.
32	((control* or before or (before and after stud*) or follow up assessment).mp.
33	(intervention or interventional or process or program*).mp.
34	(evaluat* or intervention or interventional or treatment).mp.
35	23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34
36	8 and 22 and 36

“ti, ab”, Title and Abstract; “adj”, Adjacent

Appendix II: Flow Diagram

Appendix III: Results of Risk of Bias Assessment

Reference	Allocation sequence	Allocation concealment	Baseline measurements	Baseline characteristics	Incomplete data	Blinding	Contamination	Reporting	Summary
Changes to built environment only									
Cohen et al, 2009a ²¹	No	No	Unclear	No	Unclear	No	Unclear	No	High
Cohen et al, 2009b ²⁹	No	No	No	No	Unclear	No	Unclear	Yes	High
Fitzhugh et al, 2010 ²³	No	No	No	Yes	Unclear	No	Unclear	Yes	Unclear
Branas et al, 2011 ¹⁹	Yes	No	Unclear	Unclear	Unclear	No	Unclear	Yes	Unclear
West and Shores, 2011 ³⁰	No	No	No	No	Unclear	No	Unclear	Yes	High
Cohen et al, 2012 ²⁴	No	No	No	Unclear	Unclear	No	Unclear	Yes	Unclear
Veitch et al, 2012 ²⁵	No	No	No	Yes	Unclear	No	Unclear	Yes	Unclear
Bohn-Goldbaum et al, 2013 ²⁶	No	No	No	No	Unclear	No	Unclear	Yes	High
Cohen et al, 2014 ²⁷	No	No	Not applicable	Not applicable	Unclear	No	Unclear	Yes	Unclear
Physical activity programming intervention only									
Cohen et al, 2013 ²⁰	Yes	Unclear	Yes	Yes	Unclear	No	Unclear	Yes	Low
Combination of built environment and physical activity programming intervention									
Merom et al, 2003 ²⁸	No	No	No	No	Unclear	No	Unclear	Yes	High
Tester and Baker, 2009 ²²	No	No	No	Unclear	Unclear	No	Unclear	Yes	Unclear

Allocation sequence: Was the allocation sequence adequately generated?

Allocation concealment: Was allocation adequately concealed?

Baseline measurements: Were baseline outcome measurements similar?

Baseline characteristics: Were baseline characteristics similar?

Incomplete data: Were incomplete outcome data adequately addressed?

Blinding: Was knowledge of the allocated intervention adequately prevented during the study?

Contamination: Was the study adequately protected against contamination?

Selective reporting: Are reports of the study free of suggestion of selective outcome reporting?