SSM - Population Health 3 (2017) 722–729

Contents lists available at ScienceDirect

SSM - Population Health

journal homepage: www.elsevier.com/locate/ssmph

Article

Access and quality of parks and associations with obesity: A cross-sectional study

M. Hobbs[a,b,*], Mark A. Green[c], C. Griffiths[a], H. Jordan[d], J. Saunders[e,1], H. Grimmer[a], J. McKenna[a]

[a] Carnegie, Leeds Beckett University, Leeds LS6 3QT, UK
[b] School of Social and Health Sciences, Leeds Trinity University, LS18 5HD, UK
[c] School of Environmental Sciences, University of Liverpool, Liverpool, UK
[d] School of Health and Related Research (ScHARR), University of Sheffield, Sheffield, UK
[e] Carnegie, Leeds Beckett University, Leeds LS6 3QS, UK

ABSTRACT

Public health is increasingly engaging with multi-faceted obesity prevention efforts. Although parks represent key community assets for broader public health, they may not be distributed equitably and associations with obesity are equivocal. We investigated park access and quality relative to deprivation and obesity with individual-level data from the Yorkshire Health Study. Compared to the least deprived areas, the moderately and most deprived areas had a greater park access and park quality in terms of features and amenities. However, parks in the moderately and most deprived areas also had the most safety concerns and incivilities. Although deprivation was associated with obesity, contrary to current policy guidance, both park access and quality appear less important for understanding variations in obesity within this study. Although sub-group analyses by deprivation tertile revealed that low quality park amenities in highly and moderately deprived areas may be important for understanding obesity prevalence, all other associations were non-significant.

Introduction

Obesity is a global public health issue (Ng, Fleming, Robinson, Thomson, Graetz & Margono, 2014) and the built environment is increasingly considered a contributing factor to elevated obesity prevalence (Ng et al., 2014; Green et al., 2016). Research (Cobb, Appel, Franco, Jones-Smith, Nur & Anderson, 2015) and policy have focused extensively on how the food environment may influence younger populations (Beaulac et al., 2009; Casey, Oppert, Weber, Charreire, Salze & Badariotti, 2014; Caspi, Sorensen, Subramanian & Kawachi, 2012; Ding, Sallis, Kerr, Lee & Rosenberg, 2011; Engler-Stringer, Le, Gerrard & Muhajarine, 2014; Osei-Assibey, Dick, Macdiarmid, Semple, Reilly & Ellaway, 2012; Procter, 2007; Rahman et al., 2011) however, access to the physical activity environment has shown to be important for a variety of physical and mental health outcomes (Parsons, Besenyi, Kaczynski, Wilhelm, Blake & Barr-Anderson, 2015; Maas, Van Dillen, Verheij & Groenewegen, 2009; Sugiyama, Francis, Middleton, Owen & Giles-Corti, 2010; Sallis, Cerin, Conway, Adams, Frank & Pratt, 2016). Green spaces such as forests or woodlands provide opportunities for stress relief and reductions in air pollution (James, Banay, Hart & Laden, 2015; Sarkar, 2017) however, parks form a crucial part of the physical activity environment particularly for routine or recreational physical activity (Kaczynski & Henderson, 2008). Parks are often of particular interest to public health as they are free to use, universally accessible and amenable to public health interventions (Rundle, Quinn, Lovasi, Bader, Yousefzadeh & Weiss, 2013). Increased proximity to parks also positively impacts on nearby property values (Crompton, 2005; Hammer et al., 2007). Moreover, housing developments allowing room for parks have higher home sale prices, enhanced marketability, and faster sales than conventional developments (Levine & Inam, 2004; Mohamed, 2006). Despite these endorsements, maintenance budgets for parks have fallen in several countries (World Health Organisation, 2017; Australian Government Department of the Environment and Energy, 2016; Victoria National Parks Association, 2017; Heritage Lottery Fund, 2016), parks are under threat from increased urbanisation (World Health Organisation, 2017), and within the UK the quality of parks is expected to decline (Heritage Lottery Fund, 2016). It is therefore of high importance to explore the relationship between access to parks and obesity.

Although numerous reviews have synthesised evidence on the relationship between access to the physical activity environment and obesity (James et al., 2015; Lachowycz & Jones, 2011; Mackenbach,

* Correspondence to: Leeds Trinity University, Leeds, LS18 5HD, UK.
E-mail address: m.hobbs@leedstrinity.ac.uk (M. Hobbs).
[1] Formerly, Rotherham Metropolitan Borough Council.

http://dx.doi.org/10.1016/j.ssmph.2017.07.007
Received 12 March 2017; Received in revised form 20 July 2017; Accepted 21 July 2017

Rutter, Compernolle, Glonti, Oppert & Charreire, 2014; Soga et al., 2017; Feng, 2010), few studies focus on exclusively on parks and obesity and others do not discriminate between the type of environment or greenspace. For instance, within one recent systematic review (Lachowycz & Jones, 2011), of the 60 included papers, 50 examined associations with physical activity and 28 were US based. Furthermore, only 13 studies reported the relationship with weight status and 10 were from the US. Research published since, continues to be US-centric, include broader measures of green spaces (not parks), and commonly investigates the relationship with physical activity or usage rather than obesity (Cerin, Mitáš, Cain, Conway, Adams & Schofield, 2017; Gomez, Parra, Buchner, Brownson, Sarmiento & Pinzon, 2010; Mitchell et al., 2016; Sallis, Cerin, Conway, Adams, Frank & Pratt, 2016; Thornton, Kerr, Conway, Saelens, Sallis & Ahn, 2017; Flowers et al., 2016; Van Cauwenberg, Cerin, Timperio, Salmon, Deforche & Veitch, 2015; Van Cauwenberg, Cerin, Timperio, Salmon, Deforche & Veitch, 2017; Van Hecke, Van Cauwenberg, Clarys, Van Dyck, Veitch & Deforche, 2017). Although referring to green space, a study of several European countries found that the likelihood of obesity was around 40% lower for those living in residential environment with high levels of greenspace (Ellaway et al., 2005). Other research within England supports this demonstrating that those who use local greenspaces less than once a week were significantly more likely to be overweight or obese than those using them more often (Hillsdon et al., 2011). Despite these promising findings for greenspace, there is also little evidence outside of the US on the association between the quality of parks and obesity.

A plethora of tools now measure park quality which can be explained as evaluating the features, amenities (i.e. playgrounds or toilets) and qualities (i.e. graffiti) with respect to the parks functionality or potential functionality (Lee, Booth, Reese-Smith, Regan & Howard, 2005). Assessment of park quality helps urban planners and public health officials identify how to enhance and design safe and healthy neighbourhoods. Despite this, as acknowledged by a previous study (Stark, Neckerman, Lovasi, Quinn, Weiss & Bader, 2014), few evaluate the association between park quality and obesity in adults; most studies examine this association focus on young people and have demonstrated mixed results. In a rare exception, a study in Bristol, UK found a significant association between lower rates of obesity and greater access to 'formal' and 'informal' greenspaces but not for other designations (natural spaces or sports facilities) (Hillsdon et al., 2011; Coombes et al., 2010). Emerging US evidence (Rundle et al., 2013) suggests that qualities such as greater park cleanliness were associated with lower BMI among NYC adults. Some evidence (Rundle et al., 2013; Stark et al., 2014) does seem to support better maintained parks to reduce BMI among adults however, little if any research has investigated if the association between park access, park quality and obesity differs across levels of deprivation.

Assessing park quality is clearly important however, a focus on just park access and quality still ignores the broader social context in which they may operate (Macintyre, 2014). Although research is equivocal (Parsons et al., 2015; Macintyre, 2014; Jones, Moore, Moore, Zagorski, Brines & Diez Roux, 2015; Vaughan, Kaczynski, Wilhelm Stanis, Besenyi, Bergstrom & Heinrich, 2013; Bai, Wilhelm Stanis, Kaczynski & Besenyi, 2013) parks may not be equally distributed across society with several studies demonstrating that more deprived areas have significantly fewer and lower quality parks (Wolch, Jerrett, Reynolds, McConnell, Chang & Dahmann, 2011; Bruton & Floyd, 2014; Crawford, Timperio, Giles-Cortib, Ball, Humea & Roberts, 2008; Estabrooks et al., 2003; Macintyre et al., 2008; Moore, Diez Roux, Evenson, McGinn & Brines, 2008). For instance, recent research suggests that lower income census tracts had significantly more parks, but those parks had fewer playgrounds and more quality concerns (Kaczynski, Besenyi, Stanis, Koohsari, Oestman & Bergstrom, 2014). Similarly, three studies in New Zealand (Badland, Keam, & Witten, 2010), Australia (Crawford et al., 2008) and the US (Vaughan et al., 2013) demonstrated that parks in more deprived areas were lower quality than those in the least deprived areas. In contrast, other UK based research has shown that more affluent areas in Scotland (Ogilvie, Lamb, Ferguson & Ellaway, 2011) and Wales (Higgs et al., 2015) had poorer access to recreational physical activity facilities within walking or cycling distance and sport facilities respectively.

The aims of this study were to i) to investigate the relationship between park access, park quality and deprivation; ii) investigate if park access and park quality was associated with obesity; iii) investigate if the association between park access, park quality and obesity differs dependent upon deprivation level. This study was co-produced in collaboration with policymakers in the study area to help the translation of this evidence more effectively into practice.

Methods

Individual-level data

The sample used in this cross-sectional analysis were recruited during wave one of the Yorkshire Health Study which employed a two-stage sampling approach for initial data collection. This has been reported previously in detail (Green, Li, Relton, Strong, Kearns & Wu, 2014). Briefly, the YHS is a longitudinal observational cohort study collecting information on the residents from the Yorkshire and Humberside region in England. It aims to inform National Health Service (NHS) and local authority health-related decision making in Yorkshire. Data were collected on current and long-standing health, health care usage and health-related behaviours, with a focus on weight and weight management.

Wave one contains records on 27,806 individuals (2010–12). Participants in the cohort are slightly older that in the total South Yorkshire population with a higher proportion of females. Most participants also reported of being White ethnicity (94.1%), which was over representative of the ethnic group (2011 Census; 90.5%). The sample was restricted to adults living within Rotherham Metropolitan Borough Council as it was not feasible to assess park quality over the whole study area. Individuals with a valid self-reported height, weight, postcode, ethnicity, age, and gender were included for analysis (n = 4723). While the data are self-reported, we selected the YHS since very few alternative sources included measures of body weight that were spatially referenced. Ethical clearance was granted by the ethics committee of the Carnegie Faculty, Leeds Beckett University.

Outcome

Body mass index (BMI) was calculated (weight (kg) / height (m^2)) from the self-reported height (cm) and weight (kg) of each participant. BMI was used as a continuous variable within the descriptive statistics and participants were also split dichotomously based on their BMI into obese (BMI ≥ 30) or not obese (BMI < 30).

Area-level data

The English Indices of Deprivation (IMD) 2015 is a measure of relative deprivation for small areas (or neighbourhoods) across England. A LSOA is an administratively defined geographical area that typically contains a minimum population of 1000 and a mean of 1500. Using the digital boundary data sourced from the Ordnance Survey (Ordnance Survey, 2012), ArcGIS 10.1 (ESRI, 2011) was used to determine the IMD of each LSOA for each participant as determined by their geocoded postcode. LSOAs were then split into three tertiles of least, moderate and most deprived based on the Index of Multiple Deprivation 2015 [least deprived (4.71, 18.93); moderately deprived (18.94, 28.97); most deprived (28.98, 70.89)]. Population density (persons/km^2) and the geographic area (km^2) were obtained from the Office of National statistics (Office for National Statistics, 2014). Consistent with previous research (Thornton et al., 2016) the number of people per square km in

a LSOA and LSOA size could be associated with the distribution of parks as these could represent greater potential usage and a larger geographic region respectively.

Neighbourhood

To define neighbourhood boundaries the postcode of each participant was geocoded using their home postcode. A neighbourhood boundary was then defined using the LSOA boundary the individual resided within. Using LSOA will help present findings that assist policy makers translate evidence effectively into practice (Aytur, Jones, Stransky & Evenson, 2015). Individuals resided within 134 of 166 LSOAs equating to an average of 35 individuals per LSOA.

Park access

Rotherham Local Authority (LA) provided a list of 35 parks for the study area at the time of the data collection (2010–2012), these were then mapped in ArcGIS as polygons. A park was included as a count if its boundary edge intersected with the LSOA an individual resided in. Parks were then also assigned to a LSOA to determine whether it was in an area of low, medium or high deprivation. There were three instances where parks overlapped two or more LSOA boundaries. In these cases, parks were assigned the deprivation score of the LSOA in which the biggest proportion of the park intersected with. A binary outcome of park available or no park available coded as 0 and 1 was then created for each individual and used throughout for each analysis.

Park quality

Of the 35 original parks, two parks were excluded based on safety reasons where coders were either threatened (n = 1) or felt unsafe (n = 1) whilst carrying out data collection. A further one park was excluded due to coders being unable to locate the park based on the postcode provided by Rotherham LA (n = 1). This provided a final sample of 32 parks across the study area. Although excluded from quality assessments these were still retained for the access measure. Two trained field coders assessed each park on overall characteristics in April 2014, the number, type and quality of features and amenities it possessed, and overall incivilities using the Physical Activity Resource Assessment (PARA) instrument developed in the USA (Lee et al., 2005).

The two trained coders demonstrated excellent agreement (k = 0.89) and counted and coded 25 unique possible elements of each park that included 13 features used specifically for physical activity (PA) (e.g., basketball courts, soccer fields, playgrounds) and 12 amenities (e.g., benches, lighting, sidewalks). Each feature or amenity was also rated for quality by a three-category system, which was developed based on extensive pilot testing of PA resources not in study neighbourhoods (Lee et al., 2005). Ratings for features and amenities were listed as 3 “good,” 2 “mediocre,” 1 “poor,” and 0 “absent” with specific operational definitions developed by the research team for each item in each category (Lee et al., 2005). A higher feature and amenity score indicating a higher quality, descriptive statistics for each park component are presented within Supplementary Figure 1.

Each park was also rated on overall incivilities which included 9 elements that would reduce the pleasure associated with using that PA resource. These included auditory annoyances, broken glass, dog refuse, unattended dogs, evidence of alcohol and substance use, graffiti, litter, not enough grass or overgrown grass, sex paraphernalia, and vandalism (Lee et al., 2005). Ratings were listed as 0 “absent”, 1 “good,” 2 “mediocre,” and 3 “poor”. For instance, alongside using visual aids (where applicable) as detailed within the PARA protocols (Lee et al., 2005), auditory annoyance was rated as 0 “ absent”, 1 “sounds is irritating, but hardly noticeable”, 2 “ sound(s) is/are noticeable and interfere with enjoyment of resources”, and 3 “noticeable sounds which are unpleasant, reaction is to leave the area”. A higher raw score in this category indicated a lower quality park. To be included in subsequent analyses, scores for features, amenities and incivilities were then combined to provide an overall feature score out of 39 ($\leq$ 14 poor; $\leq$ 26 Mediocre; > 26 good), amenity score out of 36 ($\leq$12 poor, $\leq$ 24 mediocre; > 24 good) and incivility score out of 36 ($\leq$ 12 good, $\leq$ 24 mediocre, > 24 poor) for each park. Mean feature, amenity and incivility scores for each park are presented in Supplementary Figure 2.

Statistical analyses

Participant’s characteristics were summarised using descriptive statistics. To examine differences between deprivation tertiles on individual-level factors Pearson chi squared was used with independent variables as categorical predictors. Building on previous research (Thornton et al., 2016) logistic regression investigated the association between area-level deprivation and park access (Model 1). Odds ratios (ORs) are presented alongside corresponding 95% CI. Linear regression then examined the association between deprivation (tertiles) and the three aspects of park quality (Model 2). Beta (β) coefficients are presented alongside corresponding 95% confidence intervals (CI). Adjusted models accounted for the administrative LSOAs geographic size and population density per km^2. When investigating the association between the access or quality of parks and obesity, a multi-level modelling framework (two level) then accounted for the hierarchical nature of the data (individuals (i) nested within areas (j)). A binary outcome of obese or not was created and models adjusted for age, gender, ethnicity and IMD. Model 3 used multi-level logistic regression (ORs; 95% CI) to estimate associations between park access and obesity. Model 4 then used a separate multi-level logistic regression model to estimate associations between the different aspects of park quality and obesity. Finally, we then calculated subgroup-specific estimates of park access and quality and obesity across levels of deprivation. Following STROBE (Strengthening the Reporting of Observational studies in Epidemiology) guidelines, we used logistic regression with a single reference category to estimate the separate and combined associations of park access and quality and deprivation on odds of being obese. Due to the high statistical power in the dataset and assumption that data were missing at random (Supplementary Table S5) missing data were dealt with by listwise deletion. All analyses were performed in STATA IC version 14.

Results

Sample characteristics

Descriptive statistics for the study sample (n = 4723) are shown in Table 1. The average BMI was 26.6 and a large proportion of the sample were overweight (38.9%) or obese (19.7%). Just over half of participants were female (55.7%) with the majority classed as white ethnicity (98.3%). Across deprivation tertiles there was no differences by gender ($p = 0.541$) or ethnicity ($p = 0.941$). However, there were differences in weight status ($\chi^2 = 39.54$, $p < 0.001$, *Cramer’s V* = 0.065) by deprivation tertile. As shown in Table 1 significantly more participants were classified as obese within the most deprived tertile. Descriptive statistics of park quality are presented by deprivation within supplementary material Tables S1–3.

Deprivation, park access and quality

Overall, 74.3% of participants had no access to a park within their LSOA, while 19.8% and 5.9% had access to one or, two or more parks respectively. When split by deprivation, 87.0% of participants in the least deprived tertile had no access to a park compared to 56.7% and 63.6% in the moderately and highly deprived LSOAs. Overall, the least deprived LSOAs had lower quality parks than the moderately and highly deprived LSOAs. Participants in the least deprived LSOAs had the poorest park quality in terms of its features and amenities compared

Table 1
Descriptive characteristics of participants by deprivation (% (n)).

		Least Deprived (n = 2398)	Moderately Deprived (n = 843)	Most Deprived (n = 1482)	Overall Sample (n = 4723)
Gender	Male	43.7 [1048]	45.9 [387]	44.3 [656]	44.3 [2091]
	Female	56.3 [1350]	54.1 [456]	55.7 [826]	55.7 [2632]
Ethnicity	White	98.3 [2357]	98.5 [830]	98.4 [1458]	98.3 [4645]
	Non-white	1.7 [41]	1.5 [13]	1.6 [24]	1.7 [78]
Age	18–24	3.5 [84]	5.1 [43]	5.2 [77]	4.3 [204]
	25–34	7.1 [171]	5.5 [46]	9.6 [142]	7.6 [359]
	35–44	11.2 [269]	14.8 [125]	13.5 [200]	12.6 [594]
	45–54	15.3 [367]	15.2 [128]	15.6 [231]	15.4 [726]
	55–64	24.0 [575]	23.6 [199]	20.6 [306]	22.9 [1080]
	65+	38.9 [932]	35.8 [302]	35.5 [526]	37.3 [1760]
BMI(Mean SD)	BMI	26.20 (4.59)	26.82 (4.86)	27.13 (5.16)	26.60 (4.84)
Weight status	Underweight	1.1 [27]	1.3 [11]	1.6 [24]	1.3 [62]
	Healthy weight	43.5 [1042]	37.5 [316]	36.2 [537]	40.1 [1895]
	Overweight	38.8 [930]	39.4 [332]	38.7 [573]	38.9 [1835]
	Obese	16.6 [399]	21.8 [184]	23.5 [348]	19.7 [931]
Park Access	No access	87.0 [2087]	56.7 [478]	63.6 [942]	74.3 [3507]
	Access to 1 park	11.2 [268]	35.5 [299]	25.0 [370]	19.8 [937]
	Access to ≥2 parks	1.8 [43]	7.8 [66]	11.5 [170]	5.9 [279]

Data is (% Participants (n)) unless stated otherwise.
BMI = Body Mass Index, IMD = Index of Multiple Deprivation; lower score = lower deprivation.
Note: Park quality is presented in more detail graphically in the Supplementary material.

to those parks in the moderately and highly deprived LSOAs. However, the least deprived LSOAs also had the lowest number of incivilities compared to the moderately and highly deprived LSOAs.

Results from the logistic regression models examining the association between deprivation and park access are presented within Table 2. After adjusting for LSOA population density and geographical size, we found deprivation was strongly associated with park access. Logistic regression showed that those individuals residing within the moderately deprived and highly deprived tertiles (T2 and T3) were much more likely to have access to a park (T2 OR = 5.24 (95% CI 4.36, 6.29) T3 OR = 3.75 (95% CI 3.19, 4.40)) compared to those within the least deprived tertile of LSOAs (T1).

The three different aspects of park quality were strongly associated with deprivation after adjusting for LSOA population density and geographical size. As shown in Fig. 1, compared to those least deprived areas, moderately and highly deprived areas had higher quality parks in terms of features and amenities. However, the most and moderately deprived parks also had the most incivilities compared to the least deprived areas. Descriptive statistics by deprivation are presented within Supplementary material for park quality for features, amenities, and incivilities by deprivation tertile.

Obesity, park access and quality

Results of a multi-level model analysis of risk of obesity are displayed in Table 3. After adjustment for age, gender, ethnicity, population density, and area-level deprivation we found no evidence to suggest that either park access or quality are associated with risk of obesity. There was no association between the access of parks and risk of obesity (OR = 1.37 95% CI 0.78, 2.36) and no association between each aspect of park quality; features (OR = 1.01 95% CI 0.91, 1.12), amenities (OR = 0.97 95% CI 0.86, 1.09) and incivilities (OR = 0.94 95% CI 0.83, 1.06) and risk of obesity.

Table 2
The association between park access and deprivation.

Model 1 results	Park access OR [95% CI]
Constant	0.167 [0.139, 0.200]*
LSOA Population density	0.999 [0.995, 1.003]
LSOA Geographical size	0.999 [0.999, 0.999]*
Deprivation (IMD)	
Tertile 1 (Least deprived)	REF
Tertile 2 (Moderate)	5.236 [4.359, 6.289]*
Tertile 3 (Most)	3.746 [3.189, 4.400]*

IMD = Index of Multiple Deprivation, LSOA = lower super output area,
* $p < 0.05$.

Obesity, park access and quality by deprivation

Finally, we examine the interaction between our measures of parks by level of deprivation. Table 4 explores the interaction between park access and deprivation. Relative to those with access to parks and low deprivation, those who had access to parks and who lived in moderately (OR = 1.48, 95% CI 1.11, 1.99], or highly deprived areas (OR = 1.65 95% CI 1.32, 2.06) were more likely to be obese. Despite this, there was no association for those within no access to a park from low or moderately deprived areas.

When we examined the existence of an interaction between park quality and deprivation, we detected few associations (Table 5). Relative to those individuals who resided within the least deprived areas and had access to the highest quality parks, there was no association for both park features and incivilities. Despite this, those with lower quality amenities and who lived in moderately deprived (OR = 2.56, 95% CI 1.09, 5.85) or highly deprived areas (OR = 2.86, 95% CI 1.25, 6.57) were at an increased risk of obesity relative to those who resided within the least deprived areas with access to higher quality amenities within parks. This may suggest that poor access to park amenities and moderate to high deprivation combined may be important for understanding variations in obesity.

Discussion

This study is one of the first large-scale investigations of park access and quality relative to area-level deprivation and obesity in the UK. By analysing both the access and quality of parks, we build on previous research to offer a more nuanced understanding. Strong associations were evident between area-level deprivation and both park access and quality. However, contrary to expectations the least deprived (T1)

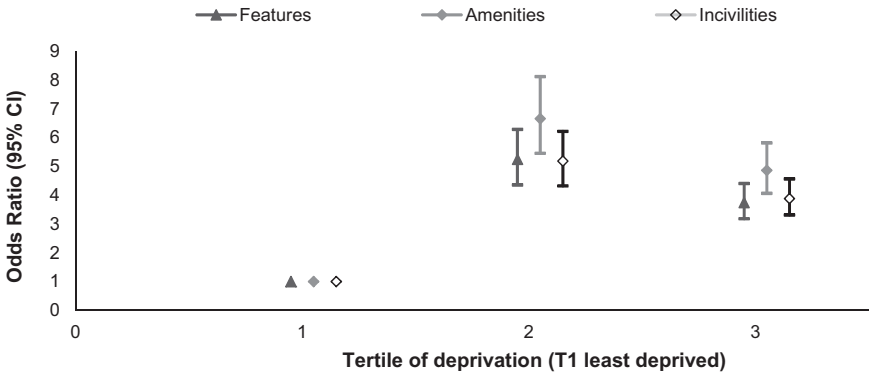

Fig. 1. The association between park quality and deprivation.

Table 3
The association between park access and aspects of park quality on risk of obesity.

	Unadjusted	Adjusted (Individual-level)	Adjusted (Individual- and area-level)
Constant	0.23 [0.03, 0.15]	0.14 [0.10, 0.19]	0.12 [0.08, 0.17]
Gender			
Female	–	1.27 [1.10, 1.47]	1.27 [1.10, 1.48]
Age	–	1.01 [1.00, 1.01]	1.01 [1.00, 1.01]
Ethnicity			
Non-white	–	0.92 [0.50, 1.69]	0.92 [0.50, 1.69]
Deprivation (IMD)			
Tertile 1 (Least deprived)	REF	REF	REF
Tertile 2 (Moderate)	–	–	1.39 [1.07, 1.81]
Tertile 3 (Most)	–	–	1.54 [1.26, 1.88]
LSOA Population Density	–	–	1.00 [0.99, 1.01]
Park access			
No access	REF	REF	REF
Access	1.46 [0.82, 2.63]	1.47 [0.81, 2.66]	1.37 [0.78, 2.36]
Park quality			
Features	1.04 [0.93, 1.16]	1.03 [0.92, 1.15]	1.01 [0.91, 1.12]
Amenities	0.94 [0.83, 1.07]	0.95 [0.84, 1.08]	0.97 [0.86, 1.09]
Incivilities	0.92 [0.82, 1.03]	0.93 [0.83, 1.05]	0.94 [0.83, 1.06]
Area level variance			
var (_cons)	0.03 [0.01, 0.12]	0.07 [0.03, 0.16]	0.03 [0.01, 0.12]

Note: BMI = Body Mass Index, IMD = Index of Multiple Deprivation, LSOA = lower super output area, *p < 0.05.

Table 4
Association between park access and obesity by deprivation tertile.

	No Access		**Access**	
	Obese/not, n	Odds Ratio	Obese/not, n	Odds Ratio
Area-level deprivation				
High	124/416	1.89 [1.07, 3.36]*	224/718	1.65 [1.32, 2.06]*
Medium	74/291	1.73 [0.79, 3.76]	110/368	1.48 [1.11, 1.99]*
Low	63/248	1.58 [0.88, 2.86]	336/1751	REF

* p < 0.05.

Table 5
Association between park quality and obesity by deprivation tertile.

	Low quality		High quality	
	Obese/not, n	Odds Ratio	Obese/not, n	Odds Ratio
Amenities				
Area-level deprivation				
High	239/747	2.86 [1.25, 6.57]*	109/387	1.45 [0.88, 2.36]
Medium	117/389	2.56 [1.09, 5.85]*	67/270	1.31 [0.70, 2.42]
Low	361/1822	1.73 [0.77, 3.91]	38/177	REF
Features				
Area-level deprivation				
High	124/416	1.04 [0.57, 1.91]	224/718	1.20 [0.80, 1.79]
Medium	74/291	0.94 [0.50, 1.77]	110/368	1.09 [0.65, 1.85]
Low	63/248	0.63 [0.35, 1.14]	336/1751	REF
Incivilities				
Area-level deprivation				
High	224/718	1.20 [0.80, 1.80]	124/416	1.07 [0.58, 1.96]
Medium	110/368	1.08 [0.64, 1.84]	74/291	0.97 [0.51, 1.81]
Low	337/1753	0.65 [0.36, 1.17]	62/246	REF

* p < 0.05.

neighbourhoods experienced poorer park access than those moderately (T2) and highly deprived (T3) neighbourhoods. Compared to those least deprived areas, moderately and highly deprived areas had higher quality parks in terms of features and amenities. However, the most and moderately deprived parks also had the most incivilities compared to the least deprived areas. In line with some previous research there was no evidence of an association between both park access and quality and obesity. Given the increasing research and policy interest in modifying the environment for improvements in health, findings presented in this study further highlight the equivocal nature of the evidence base that links the physical activity environment to obesity.

Individuals of greater social disadvantage often have poorer health and access to amenities compared to those experiencing less disadvantage. However, this study supports previous evidence which suggests parks may be more equally distributed by deprivation or at least not inhibiting those in the most deprived areas (Wolch et al., 2011; Macintyre et al., 2008). Contemporary research often focuses solely on the access of parks and we address calls to explore the role of park quality as well as access expressed in the literature (Timperio, Ball,

Salmon, Roberts & Crawford, 2007). However, in contrast to previous evidence from New Zealand (Badland et al., 2010), Australia (Crawford et al., 2008) and the US (Vaughan et al., 2013) our findings suggest parks in the more deprived areas have a higher quality in terms of features and amenities compared to those in the least deprived areas. However, the more deprived areas also have more safety concerns and incivilities such as graffiti or litter. This highlights the importance of using local level analyses to inform policy as findings may differ between areas and countries.

A detailed appraisal of the park quality (Figure S1) revealed that whilst deprived neighbourhoods had higher park access, they did have more incivilities. This finding may be important as incivilities have been shown to be a key factor in park usage (Cohen et al., 2010). It is therefore plausible to suggest that despite being better served by amenities and features, parks in the more deprived areas are not utilised as much due to higher incivilities within the park (Cohen, Lapham, Evenson, Williamson, Golinelli & Ward, 2013). This is further evidenced by a recent quasi-experimental study that showed no short term effects on physical activity or general health among adults from improvements in green space in deprived neighbourhoods (Droomers, Jongeneel-Grimen, Kramer, de Vries, Kremers & Bruggink, 2016).

Neighbourhood deprivation was strongly associated with obesity with individuals in the most deprived tertile over 50% more likely to be obese than those within the least deprived tertile (Table 3). This finding corroborates with evidence elsewhere that shows poorer individuals are at greater risk of obesity and obesity-associated behaviours (El-Sayed et al., 2012). The focus of some policy makers on the wider geographical factors related to the physical activity environment may be less effective without considering the effect of deprivation. Refocusing our efforts towards tackling social disadvantage alongside environmental modifications may be an important direction for future policy and research.

Whilst there is growing evidence of the role of the PA environment and obesity, our study addresses an important research gap by assessing the contribution of both park access and quality to obesity. Current research investigating the role of contextual or environmental factors in obesity have focused on the food environment particularly in younger populations (Cobb et al., 2015). In this study, we find no evidence that either park access or quality is associated with obesity in a large metropolitan population of adults. Furthermore, although sub-group analyses by deprivation tertile revealed that low quality park amenities in highly and moderately deprived areas may be important for understanding obesity prevalence, all other associations were non-significant. Our results support findings in other countries suggesting that improvements in green space do not result in improvements in obesity (Droomers et al., 2016). Whilst green spaces and parks continue to be important community health assets for physical and mental health (Van den Berg, Wendel-Vos, van Poppel, Kemper, van Mechelen & Maas, 2015), they appear less important for understanding variations in obesity in this study.

These findings do not mean that we should ignore the wider role of geography or the environment. Geographical approaches offer more feasible 'upstream' approaches to local authority and we should not discount the progress they have made. It is also possible that our simple interpretation of the role of neighbourhood context, as measured just through parks, fails to account for the true nature of geography. Indeed, a recent review also demonstrated that associations between the environment and PA existed independent of residential location (McCormack & Shiell, 2011). Proximity to parks may therefore no longer be an adequate indicator of usage. A recent study showed that although low-income park neighbourhoods had more parks they were also five times more likely to have a moderate density of other unhealthy establishments such as fast-food outlets compared to parks in high income areas (Parsons et al., 2015). Extending analyses to control for these complex confounding issues will be important to assess the importance of parks for obesity.

The more equitable distribution of parks is an important finding suggesting that they offer a progressive option for policy interventions to help tackle social inequalities in health. UK evidence briefings for modifying the PA environment have been provided to local authorities in England suggesting such approaches could be useful for addressing health inequalities. Whilst our results do not demonstrate that they could be useful for tackling social inequalities in obesity, it is important to note that PA facilities may have a less equitable distribution compared to parks specifically (Parsons et al., 2015; Jones et al., 2015) and it may be this relationship that helps explain the lack of evidence to obesity. Exploring the interaction between PA facilities, park access and quality will be important for future research.

To our knowledge, this study is the first analysis of park access and quality across a large area (local authority) in England relative to area level disadvantage and obesity (Green et al., 2014). We address a distinct lack of evidence assessing the impact of the PA environment on obesity and extend previous research by assessing park quality using the PA Resource Assessment (PARA) tool. Despite assessing park quality, the PARA tool has yet to be validated within the UK. Moreover, our large sample size is concentrated across one local authority however this will mean that our findings may not be transferable in other local authorities with different environmental contexts. Park locations were confirmed by ground truthing in contrast to much previous research on the environment that uses secondary databases that may be inaccurate. We also account for confounding variables such as population and geographic size of LSOA allowing for a better isolation of associations. Despite these strengths, this study does not measure actual usage of parks or PA behaviours within parks which may more strongly influence obesity. Furthermore, the cross-sectional nature of the design limits our ability to draw causal inferences. We also acknowledge that individuals may operate beyond their local neighbourhood which was defined as a LSOA. In addition, by using administratively defined areas our analysis may be susceptible to the modifiable area unit problem (MAUP) (Stafford et al., 2008) however results may be more tangible for local authority usage. Finally, IMD was arbitrarily split to provide an equal number of parks within each tertile and a spatial component was not accounted for within the regression models.

Conclusion

Large-scale studies focusing on both the access and quality of parks relative to area-level deprivation and obesity within the UK are uncommon. Findings presented within this study can begin to inform planning efforts for future modifications of the environment relative to deprivation and obesity. Parks may remain important community health assets with areas in this study of greater deprivation experiencing a greater access. Compared to those least deprived areas, moderately and highly deprived areas had higher quality parks in terms of features and amenities. However, the most and moderately deprived parks also had the most incivilities compared to the least deprived areas. Contrary to current policy guidance, this study provides little support for the notion that the access of parks or the quality of parks are associated with obesity, even when considering the interaction by deprivation tertile. This study adds to the equivocal nature of the evidence base linking the PA environment and obesity.

Competing interests

No competing interests.

Funding

No financial funding.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.ssmph.2017.07.007.

References

Australian Government Department of the Environment and Energy (2016). *Australia State of the environment 2016.* Canberra: Australian Government Department of the Environment and Energy.

Aytur, S. A., Jones, S. A., Stransky, M., & Evenson, K. R. (2015). Measuring physical activity in outdoor community recreational environments: Implications for research, policy, and practice. *Current cardiovascular risk reports, 9*(1), 423.

Badland, H., Keam, R., Witten, K., & R K (2010). Examining public open spaces by neighborhood-level walkability and deprivation. *Journal of physical activity health, 7*(6), 818–824.

Bai, H., Wilhelm Stanis, S. A., Kaczynski, A. T., & Besenyi, G. M. (2013). Perceptions of neighborhood park quality: Associations with physical activity and body mass index. *Annals of Behaivoural Medicine, 45*(Suppl 1), S39–S48.

Beaulac, J., Kristjansson, E., & Cummins, S. (2009). A systematic review of food deserts 1966–2007. *Preventing Chronic Disease, 6*(3), 105–115.

Bruton, C. M., & Floyd, M. F. (2014). Disparities in built and natural features of urban parks: comparisons by neighborhood level race/ethnicity and income. *Journal of urban health: bulletin of the New York Academy of Medicine, 91*(5), 894–907.

Casey, R., Oppert, J.-M., Weber, C., Charreire, H., Salze, P., Badariotti, D., et al. (2014). Determinants of childhood obesity: What can we learn from built environment studies? *Food Quality and Preference, 31*, 164–172.

Caspi, C. E., Sorensen, G., Subramanian, S. V., & Kawachi, I. (2012). The local food environment and diet: A systematic review. *Health and Place, 18*(5), 1172–1187.

Cerin, E., Mitáš, J., Cain, K. L., Conway, T. L., Adams, M. A., Schofield, G., et al. (2017). Do associations between objectively-assessed physical activity and neighbourhood environment attributes vary by time of the day and day of the week? IPEN adult study. *The International Journal of Behavioral Nutrition and Physical Activity, 14*, 34.

Cobb, L. K., Appel, L. J., Franco, M., Jones-Smith, J. C., Nur, A., & Anderson, C. A. (2015). The relationship of the local food environment with obesity: A systematic review of methods, study quality, and results. *Obesity, 23*(7), 1331–1344.

Cohen, D., Marsh, T., & Williamson, S. (2010). Parks and physical activity: Why are some parks used more than others? *Preventative Medicine, 50*, S9–S12.

Cohen, D. A., Lapham, S., Evenson, K. R., Williamson, S., Golinelli, D., Ward, P., et al. (2013). Use of neighbourhood parks: Does socio-economic status matter? A four-city study. *Public Health, 127*(4), 325–332.

Coombes, E., Jones, A. P., & Hillsdon, M. (2010). The relationship of physical activity and overweight to objectively measured green space accessibility and use. *Social Science and Medicine, 70*(6), 816–822.

Crawford, D., Timperio, A., Giles-Cortib, B., Ball, K., Humea, C., Roberts, R., et al. (2008). Do features of public open spaces vary according to neighbourhood socio-economic status? *Health and Place, 14*, 889–893.

Crompton, J. L. (2005). The impact of parks on property values: Empirical evidence from the past two decades in the United States. *Managing Leisure, 10*(4), 203–218.

Ding, D., Sallis, J. F., Kerr, J., Lee, S., & Rosenberg, D. E. (2011). Neighborhood environment and physical activity among youth a review. *American Journal of Preventative Medicine, 41*(4), 442–455.

Droomers, M., Jongeneel-Grimen, B., Kramer, D., de Vries, S., Kremers, S., Bruggink, J.-W., et al. (2016). The impact of intervening in green space in Dutch deprived neighbourhoods on physical activity and general health: Results from the quasi-experimental URBAN40 study. *Journal of Epidemiology and Community health, 70*(2), 147–154.

Ellaway, A., Macintyre, S., & Bonnefoy, X. (2005). Graffiti, greenery, and obesity in adults: Secondary analysis of European cross sectional survey. *BMJ, 331*(7517), 611–612.

El-Sayed, A. M., Scarborough, P., & Galea, S. (2012). Unevenly distributed: A systematic review of the health literature about socioeconomic inequalities in adult obesity in the United Kingdom. *BMC Public Health, 12*(1), 1–12.

Engler-Stringer, R., Le, H., Gerrard, A., & Muhajarine, N. (2014). The community and consumer food environment and children's diet: A systematic review. *BMC Public Health, 14*(1), 522.

ESRI (2011). *ArcGIS desktop: release 10.* Redlands, CA: Environmental Systems Research Institute.

Estabrooks, P., Lee, R., & Gyurcsik, N. (2003). Resources for physical activity participation: Does availability and accessibility differ by neighbourhood socioeconomic status? *Annals of Behaivoural Medicine, 25*, 100–104.

Feng, J. (2010). The built environment and obesity: A systematic review of the epidemiologic evidence. *Health Place,* 16.

Flowers, E. P., Freeman, P., & Gladwell, V. F. (2016). A cross-sectional study examining predictors of visit frequency to local green space and the impact this has on physical activity levels. *BMC Public Health, 16*, 420.

Gomez, L. F., Parra, D. C., Buchner, D., Brownson, R. C., Sarmiento, O. L., Pinzon, J. D., et al. (2010). Built environment attributes and walking patterns among the elderly population in Bogota. *American Journal of Preventive Medicine, 38*(6), 592–599.

Green, M., Li, J., Relton, C., Strong, M., Kearns, B., Wu, M., et al. (2014). Cohort profile: The Yorkshire Health Study. *International Journal of Epidemiology*. http://dx.doi.org/10.1093/ije/dyu121.

Green, M. A., Subramanian, S. V., & Razak, F. (2016). Population-level trends in the distribution of body mass index in England, 1992–2013. *Journal of Epidemiology and Community health*.

Hammer, T. R., Coughlin, R. E., & Horn, E. T. (2007). The effect of a large urban park on real estate value. *Journal of the American Institute of Planners, 40*(4), 274–277.

Heritage Lottery Fund (2016). *State of UK public parks 2016.* London: Heritage Lottery Fund.

Higgs, G., Langford, M., & Norman, P. (2015). Accessibility to sport facilities in Wales: A GIS-based analysis of socio-economic variations in provision. *Geoforum, 62*, 105–120.

Hillsdon, M., Jones, A., & Coombes, E. (2011). *Natural England Commissioned Report NECR067: Green space access, green space use, physical activity and overweight.* Peterborough: Natural England.

James, P., Banay, R. F., Hart, J. E., & Laden, F. (2015). A review of the health benefits of greenness. *Current Epidemiology Reports, 2*(2), 131–142.

Jones, S. A., Moore, L. V., Moore, K., Zagorski, M., Brines, S. J., Diez Roux, A. V., et al. (2015). Disparities in physical activity resource availability in six US regions. *Preventive medicine, 78*, 17–22.

Kaczynski, A., Besenyi, G., Stanis, S., Koohsari, M., Oestman, K., Bergstrom, R., et al. (2014). Are park proximity and park features related to park use and park-based physical activity among adults? Variations by multiple socio-demographic characteristics. *International Journal of Behavioral Nutrition and Physical Activity, 11*, 146–159.

Kaczynski, A. T., & Henderson, K. A. (2008). Parks and recreation settings and active living: A review of associations with physical activity function and intensity. *Journal of Physical Activity and Health, 5*(4), 619–632.

Lachowycz, K., & Jones, A. (2011). Greenspace and obesity: A systematic review of the evidence. *Obesity Reviews, 12*, 183–189.

Lee, R. E., Booth, K. M., Reese-Smith, J. Y., Regan, G., & Howard, H. H. (2005). The Physical Activity Resource Assessment (PARA) instrument: Evaluating features, amenities and incivilities of physical activity resources in urban neighborhoods. *International Journal of Behavioral Nutrition and Physical Activity, 2*(1), 1–9.

Levine, J., & Inam, A. (2004). The market for transportation-land use integration: do developers want smarter growth than regulations allow? *Transportation, 31*(4), 409–427.

Maas, J., Van Dillen, S., Verheij, R., & Groenewegen, P. (2009). Social contacts as a possible mechanism behind the relation between green space and health. *Health and Place, 15*(2), 586–595.

Macintyre, S. (2014). Deprivation amplification revisited; or, is it always true that poorer places have poorer access to resources for healthy diets and physical activity? *International Journal of Behaviour Nutrition and Physical Activity, 4*, 1–7.

Macintyre, S., Macdonald, L., & Ellaway, A. (2008). Do poorer people have poorer access to local resources and facilities? The distribution of local resources by area deprivation in Glasgow, Scotland. *Social Science and Medicine, 67*(6), 900–914.

Mackenbach, J. D., Rutter, H., Compernolle, S., Glonti, K., Oppert, J.-M., Charreire, H., et al. (2014). Obesogenic environments: A systematic review of the association between the physical environment and adult weight status, the SPOTLIGHT project. *BMC Public Health, 14*(1), 233.

McCormack, G. R., & Shiell, A. (2011). In search of causality: A systematic review of the relationship between the built environment and physical activity among adults. *International Journal of Behavioral Nutrition and Physical Activity, 8*, 125.

Mitchell, C. A., Clark, A. F., & Gilliland, J. A. (2016). Built environment influences of children's physical activity: examining differences by neighbourhood size and sex. *International Journal of Environmental Research and Public Health, 13*, 1.

Mohamed, R. (2006). The economics of conservation subdivisions. *Urban Affairs Review, 41*(3), 376–399.

Moore, L. V., Diez Roux, A. V., Evenson, K. R., McGinn, A. P., & Brines, S. J. (2008). Availability of recreational resources in minority and low socioeconomic status areas. *American Journal of Preventive Medicine, 34*(1), 16–22.

Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., Margono, C., et al. (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: A systematic analysis for the Global Burden of Disease Study 2013. *The Lancet, 384*(9945), 766–781.

Office for National Statistics (2014). *Annual small area population estimates: 2013.* London: Office for National Statistics.

Ogilvie, D., Lamb, K. E., Ferguson, N. S., & Ellaway, A. (2011). Recreational physical activity facilities within walking and cycling distance: Sociospatial patterning of access in Scotland. *Health and Place, 17*, 1015–1022.

Ordnance Survey (2012). *Points of interest database – User guide and technical specification.* Southampton: Ordnance Survey.

Osei-Assibey, G., Dick, S., Macdiarmid, J., Semple, S., Reilly, J., Ellaway, A., et al. (2012). The influence of the food environment on overweight and obesity in young children: A systematic review. *British Medical Journal, 12*(2), 6–20.

Parsons, A., Besenyi, G., Kaczynski, A., Wilhelm, S., Blake, C., & Barr-Anderson, D. (2015). Investigating issues of environmental injustice in neighborhoods surrounding parks. *Journal of Leisure Research, 47*(2), 285–303.

Procter, K. L. (2007). The aetiology of childhood obesity: A review. *Nutrition Research Reviews, 20*(1), 29–45.

Rahman, T., Cushing, R. A., & Jackson, R. J. (2011). Contributions of built environment to childhood obesity. *Mount Sinai Journal of Medicine, 78*, 49–57.

Rundle, A., Quinn, J., Lovasi, G., Bader, M., Yousefzadeh, P., Weiss, C., et al. (2013). Associations between body mass index and park proximity, size, cleanliness and recreational facilities. *American Journal of Health Promotion, 27*(4), 262–269.

Sallis, J. F., Cerin, E., Conway, T. L., Adams, M. A., Frank, L. D., Pratt, M., et al. (2016). Physical activity in relation to urban environments in 14 cities worldwide: A cross-sectional study. *The Lancet*.

Sallis, J. F., Cerin, E., Conway, T. L., Adams, M. A., Frank, L. D., & Pratt, M. (2016). Physical activity in relation to urban environments in 14 cities worldwide: A cross-sectional study. *Lancet,* 387.

Sarkar, C. (2017). Residential greenness and adiposity: Findings from the UK Biobank. *Environment International, 106*, 1–10.
Soga, M., Gaston, K. J., & Yamaura, Y. (2017). Gardening is beneficial for health: A meta-analysis. *Preventive Medicine Reports, 5*, 92–99.
Stafford, M., Duke-Williams, O., & Shelton, N. (2008). Small area inequalities in health: Are we underestimating them? *Social Science and Medicine, 67*(6), 891–899.
Stark, J. H., Neckerman, K., Lovasi, G. S., Quinn, J., Weiss, C. C., Bader, M. D. M., et al. (2014). The impact of neighborhood park access and quality on body mass index among adults in New York City. *Preventive medicine, 64*, 63–68.
Sugiyama, T., Francis, J., Middleton, N., Owen, N., & Giles-Corti, B. (2010). Associations be-tween recreational walking and attractiveness, size, and proximity of neighborhood open spaces. *American Journal of Public Health, 100*(9), 1752–1757.
Thornton, C. M., Kerr, J., Conway, T. L., Saelens, B. E., Sallis, J. F., Ahn, D. K., et al. (2017). Physical activity in older adults: an ecological approach. *Annals Behavioral Medicine, 51*(2), 159–169.
Thornton, L. E., Lamb, K. E., & Ball, K. (2016). Fast food restaurant locations according to socioeconomic disadvantage, urban–regional locality, and schools within Victoria, Australia. *SSM - Population Health, 2*, 1–9.
Timperio, A., Ball, K., Salmon, J., Roberts, R., & Crawford, D. (2007). Is availability of public open space equitable across areas? *Health Place, 13*(2), 335–340.
Van Cauwenberg, J., Cerin, E., Timperio, A., Salmon, J., Deforche, B., & Veitch, J. (2015). Park proximity, quality and recreational physical activity among mid-older aged adults: Moderating effects of individual factors and area of residence. *International Journal of Behavioral Nutrition and Physical Activity, 12*(1), 46.
Van Cauwenberg, J., Cerin, E., Timperio, A., Salmon, J., Deforche, B., & Veitch, J. (2017). Is the association between park proximity and recreational physical activity among mid-older aged adults moderated by park quality and neighborhood conditions? *International Journal of Environmental Research and Public Health, 14*(2).
Van den Berg, M., Wendel-Vos, W., van Poppel, M., Kemper, H., van Mechelen, W., & Maas, J. (2015). Health benefits of green spaces in the living environment: A systematic review of epidemiological studies. *Urban Forestry Urban Greening, 14*(4), 806–816.
Van Hecke, L., Van Cauwenberg, J., Clarys, P., Van Dyck, D., Veitch, J., & Deforche, B. (2017). Active use of parks in Flanders (Belgium): an exploratory observational study. *International Journal of Environmental Research and Public Health, 14*(1), 35.
Vaughan, K. B., Kaczynski, A. T., Wilhelm Stanis, S. A., Besenyi, G. M., Bergstrom, R., & Heinrich, K. M. (2013). Exploring the distribution of park availability, features, and quality across Kansas City, Missouri by income and race/ethnicity: An environmental justice investigation. *Annals of Behaivoural Medicine, 45*(Suppl 1), S28–S38.
Victoria National Parks Association (2017). *Victoria national parks association: annual report 2015–2016.* Carlton Vic 3053: Victoria National Parks Association.
Wolch, J., Jerrett, M., Reynolds, K., McConnell, R., Chang, R., Dahmann, N., et al. (2011). Childhood obesity and proximity to urban parks and recreational resources: A longitudinal cohort study. *Health place, 17*(1), 207–214.
World Health Organisation (2017). *Urban green space interventions and health: A review of impacts and effectiveness.* Copenhagen: WHO.