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Neighbourhood parks and reduction in stress among adolescents: results from Buffalo, New York

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Abstract

Planners and landscape architects have long recognized the critical role of green space in urban environments. This cross-sectional field study of 68 adolescents determined the association between percent neighbourhood park area and perceived stress among adolescents, while controlling for physical activity. This study is the first to examine this association using objective measures of park area and adolescents' physical activity. A multivariate regression model indicated that percentage of park area ($\beta = -62.573$, $p < 0.03$) predicts perceived stress among adolescents. Access to neighbourhood parks buffers adolescents against perceived stress after controlling for socio-economic status and physical activity. Policy recommendations for incorporating parks into neighbourhood design are given.

Keywords

Perceived stress, Adolescent, Neighbourhood environment, Parks, Physical activity

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Introduction

Centuries ago, planners and landscape architects recognized the critical role of green space in promoting public health and high quality of life in urban environments. As early as the 1800s, noted landscape architect and planner, Frederick Law Olmsted, integrated parks and greenways into the plans for cities, arguing that the presence of such spaces were essential for promoting mental health and well-being of city residents.[1] In a paper read at the American Social Science Association on 25 February 1870, Olmsted noted the benefits of the recently designed, and partially built, Central Park in New York:

> As to the effects on public health, there is no question that it is already great. The testimony of older physicians of the city will be found unanimous on this point. Says one: Where I formerly ordered patients of a certain class to give up their business altogether and go out of town, I now often advise simply moderation, and prescribe a ride in the Park before going to their offices, and again a drive with their families before dinner. By simply adopting this course as a habit, men who have been breaking down frequently recover tone rapidly, and are able to retain an active and controlling influence in an important business, from which they would have otherwise been forced to retire. I direct schoolgirls, under certain circumstances, to be taken wholly, or in part, from their studies, and sent to spend several hours a day rambling on foot in the Park.[2]

Olmsted and the physician he references allude to the mental health benefits of parks and open space for both adults and youth (school girls). Indeed, the role parks

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and green space play in mental health and well-being remained central to the design of the parks and park systems Olmsted continued to design, including the one he designed for Buffalo, NY in the late 1890s. Yet, the role of parks and open space on mental health has largely been neglected in planning scholarship and practice. This paper contributes to planning and design and public health literature by offering empirical evidence on the role of park access on perceived stress reported by adolescents in Erie County, New York (NY), home to one of Olmsted's signature park and parkway systems. Park access in this paper is defined to include nature trails, bike paths, playgrounds, athletic fields and state-, county- and town-owned parks.

Perceived stress and park access among adolescents: A literature review

Chronic stress among adolescents may stem from multiple sources including social stressors, economic stressors and environmental stressors. Adolescents may experience social stress from peers or social networks.[3] Poverty and socio-economic status may also increase the stress of children,[4] leading to increased depression, antisocial behaviour and poor adjustment in adolescents.[5,6] Cross-sectional and longitudinal studies have demonstrated that the features of one's built environment can predict mental health.[7] The built environment in which adolescents reside may contribute towards the perceived stress they incur, and thus their health and quality of life. Youth may experience chronic stress from environmental stressors such as living in crowded housing, poor quality neighbourhoods and noise.[8] The stress of crowded housing is linked to greater blood pressure in boys and feelings of helplessness in girls.[9] Additionally, children who live in noisier neighbourhoods with chronic noise exposure have greater stress as measured by elevated blood pressure, and urinary cortisol and catecholamine concentrations.[8,9]

Not only do these stressors affect the psychological well-being of individuals, they may also affect their physiological state and overall health status. For example, chronic daily stress is associated with obesity and weight gain[3,10,11]; elevated blood pressure[12]; disorders of growth, development and metabolism[13,14] and the initiation of smoking behaviour[15] in youth. Chronic stress in adolescence is also a risk factor for chronic diseases, such as cardiovascular disease, that may appear later in life.[16,17] Although it is not possible to eliminate the usual stressors from the lives of adolescents, it is important to find effective means of buffering the effects of the stressors to limit the potential harmful effects of chronic stress.

The presence of nature in urban and suburban environments may be protective against usual chronic stressors. In addition to Olmsted's ideas, several theories including cultural/learning, arousal, overload and evolutionary theories explain this association.[18] Kaplan[19] presents an integrated framework in which to study human–environment interactions, where the natural environment not only blunts stress, but prevents it through restoration of directed attention. Ulrich proposed a psycho-evolutionary theory of restoration, where responses to nature are immediate and adaptive, not only in terms of visual preference but also in terms of physiological and emotional recovery.[20] Both theories are frequently cited in research examining the association between stress and nature.

Using these theories, several studies have demonstrated the positive association between nature and stress recovery. In adults, viewing nature from a window can reduce post-operative requests for pain medication and speed recovery.[21,22] Viewing pictures of nature also provided greater improvement of attention and recovery than viewing pictures of urban settings in students experiencing the stress of college final exams.[23] In addition, greater perceived access to green space is associated with reduced stress-related psychosocial symptoms of urban Swedish residents.[24] Increased visits and proximity to green space resulted in fewer reported stress-related illnesses in a large study of Swedish town-dwellers.[25]

The neighbourhood environment may have a greater impact on youth than on adults due to their vulnerability and reduced autonomy to travel outside of their neighbourhood.[26–28] The restorative properties of the natural environment have been tested to a limited extent in children. Children's exposure to natural or greener environments improves their cognitive function.[7] Additionally, children whose residence are surrounded by greater vegetation and nature, measured subjectively using survey data, have lower psychological distress when experiencing stressful life events.[28] The current study expands upon this research by using objective measures of the built environment to determine adolescents' exposure to nature in their environment.

There is some evidence of gender differences in psychological and behavioural responses to parks and green space. Faber Taylor and colleagues found that girls with near-home nature had greater self-discipline in the form of increased concentration and ability to delay gratification.[29] A similar effect on concentration and delay of gratification associated with near-home nature was not found in boys.[29] The location where children play may explain the gender difference[29]; boys may not have played near their homes as often as girls and thus were not affected as much as girls by near-home nature. This follows previous research[30] showing that boys play a greater distance from home than girls. These gender differences may also stem from physical activity patterns and locations of children. Boys are typically more active than girls,[31,32] and when playing outside, they have shown to be more active in parks when compared to girls.[33] This gender difference in location of play may place boys in protective park spaces more often than girls.

Viewing or interacting with nature is only one of many ways to buffer stress. Physical activity per se can also affect stress levels in children and young adults. In children, physical activity can buffer chronic stress[3,34] and can reduce stress reactivity.[16,35] Adolescents reporting greater physical activity had less stress.[36] Likewise, in college students, leisurely physical activity buffers the effects of stress on anxiety.[37] Biochemical, physiological and psycho-social mechanisms have been explored to explain the association between exercise and stress recovery.[38] Given the associations between physical activity and exposure to park access, and between physical activity and stress, it is important to determine whether park access is associated with perceived stress independent of physical activity.

To the best of our knowledge, the possible protective association between objective measures of park area in an adolescent's neighbourhood environment with perceived stress levels has not yet been studied. It is also not known whether the protective effects of neighbourhood parks differ for boys and girls. Further, it is unknown if park access offers a buffering effect against stress even after accounting for the buffering effects of physical activity. Thus, the aims of this study were to determine the association of perceived stress among adolescents with the availability of parks within their neighbourhoods; to determine if this association exists independent of the adolescents' level of physical activity and to determine whether this association differs by gender.

Methods

The empirical component of this study measures the association between perceived stress among adolescents with availability of parks (green space) while controlling for the adolescents' level of physical activity.

Data for this study were obtained from a larger 10-week Neighbourhood Environment (NE) study. The main purpose of the broader study was to determine whether physical activity of adolescents, under reduced access to sedentary behaviours, was dependent on access to parks and recreation areas in their neighbourhood environment. Adolescents in the NE study were recruited from homes located on two different types of land parcels in Erie County, NY: those with high park access and those with low park access. Erie County, New York offers a great deal of variation in park access to its young residents (see Figure 1). All 300,000 land parcels in Erie County, NY were ranked into two land parcel groups – high park access land parcels and low park access land parcels – using a park access index value computed using the ArcGIS 9.2 software and Network Analyst extensions. Land parcels in the upper quartile of the park access index were considered to have high park access, and land parcels in the lower quartile of the park access index were considered to have low park access. Within these two land parcel groups, land parcels zoned for agricultural, commercial and industrial land uses were eliminated. Next, from January 2008 to June 2010, 92,000 letters were mailed to randomly selected addresses in each land parcel groups to recruit adolescents for the study. These addresses were randomly selected in each land parcel group without knowing if children or families were present.

Recruited children were included in the study only if they had no history of diagnosed psychiatric disorder, no current illness or pregnancy, no current use of medications that would alter reactions to stress and no limitations to physical activity. Participants included 32 boys ($n = 1$ Asian; $n = 6$ Black; $n = 25$ White) and 36 girls ($n = 5$ Black; $n = 24$ White; $n = 2$ Other; $n = 5$ More than one race). Their ages ranged from 12 to 15 years and their weight status ranged from 15^{th} to 97^{th} body mass index (BMI) percentile.

Prior to inclusion in the NE study, families practiced using all study equipment for one week. If the family was unable to adhere to study protocols, which required that children wear accelerometers during the 10-week study period, they were not included in the study. The analysis included in this paper use only the baseline measurements (weeks 1–2) of the full NE study.

Parents provided written consent and children provided assent to participate in the NE study. The study was approved by the Children and Youth Institutional Review Board.

Measures: Dependent variable

The key dependent variable in this analysis is perceived stress experienced by adolescents. Perceived stress was measured using the Perceived Stress Scale (PSS) which measures the degree to which an individual appraises experiences as stressful.[39] Items were designed to measure how unpredictable, uncontrollable and overloaded respondents find their lives. PSS scores were obtained by reversing the scores on

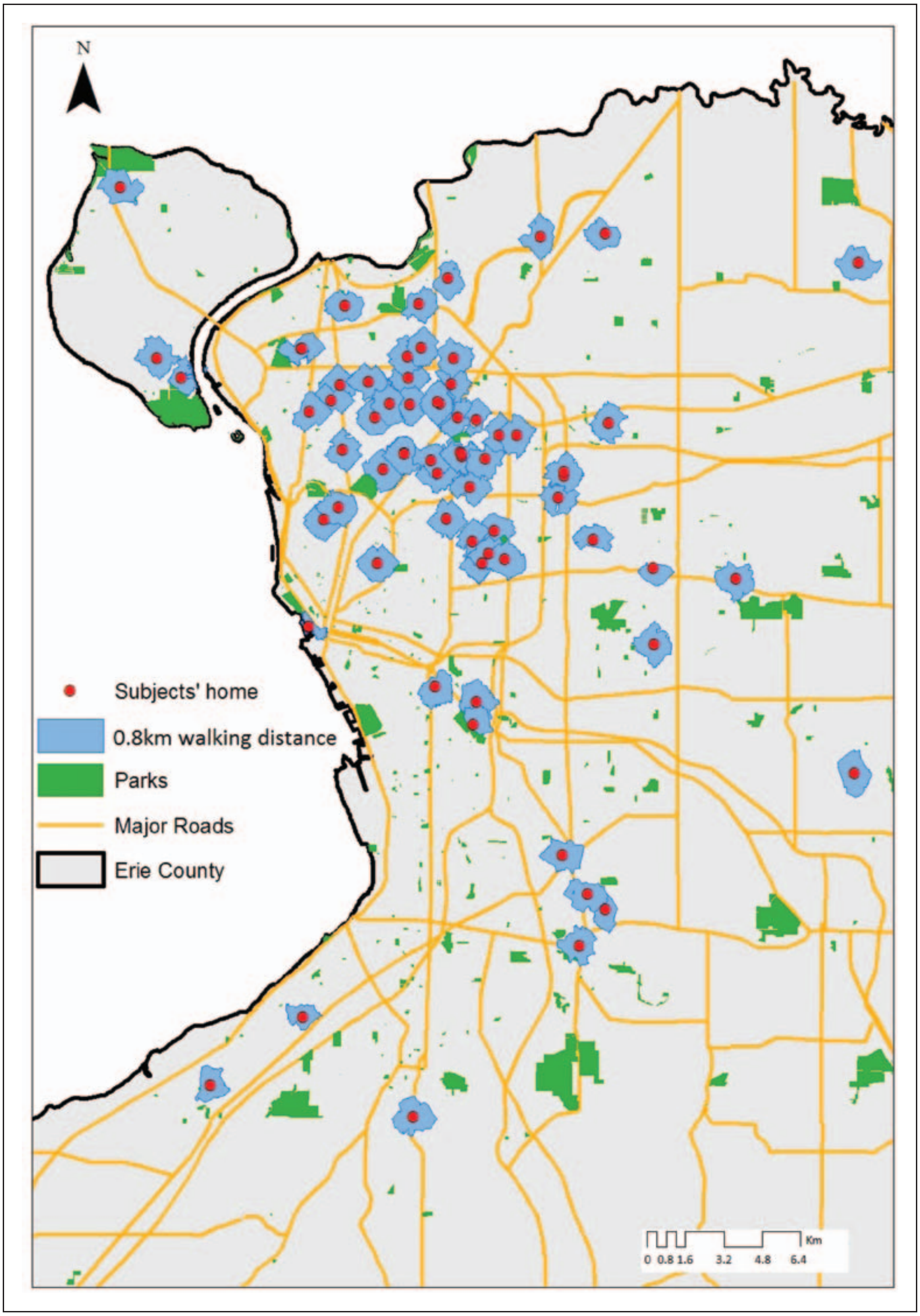

Figure 1. Map of Erie county participants overlaid with park layer and 0.8 km walking distance.

the seven positive items (e.g. 0 = 4, 1 = 3, 2 = 2, etc.) and then summing across all 14 items, yielding a potential range of scores from 0 to 56. A higher score indicates a higher level of stress among adolescents. The PSS has been validated and used in adolescent populations in previous studies of normal and clinical populations.[40–42]

Measures: Independent variables

Physical activity data was measured using an accelerometer and a habit book. For one week, participants wore an ActiGraph GT1M accelerometer (ActiGraph, Pensacola, Florida), initialized with a 60-s epoch, to determine the average intensity of physical activity.[43,44]

The monitor was worn snug against the hip in a pouch attached to a belt. Adolescents were instructed to wear the accelerometer from the time they woke up until the time they went to bed. If adolescents removed the monitor (e.g. to take a shower), they were instructed to record when the monitor was taken off and put back on. Research staff trained the adolescents to wear an accelerometer properly and record all sedentary and physical activities in a detailed habit book. Research staff reviewed habit books and accelerometer data with each child at the completion of the one-week time period. If a child did not complete a full week of data recording, they were asked to repeat the measures.

Height and weight of participants was measured in the laboratory. Body weight was measured to the nearest 0.01 kg using a Tanita scale, with the participants wearing light clothing. Height was measured with a SECA stadiometer to the nearest 0.1 cm. BMI was calculated as (weight in kg)/(height in m).^{2} BMI percentile was calculated in relationship to 50th BMI percentile based on their gender and age.[45]

Socio-economic status (SES), race and ethnicity were obtained using a standardized questionnaire completed by the parents.[46]

Features of the built environment included park access (the key independent variable) and housing density. Built environment features were measured using a Geographic Information System. Park access was measured as the area of park land divided by total land within 0.80 km distance (along street networks) of a participant's home. Various thresholds have been used for defining neighbourhood such as 0.40 km, 0.80 km and 1.61 km.[47–49] In this study, we assumed that a reasonable walking distance buffer can effectively represent a neighbourhood.[49] Our empirical analysis of the 2009 National household travel survey data[50] in Buffalo-Niagara Falls metropolitan statistical area region shows that the average travelling distance on foot is 1.13 km in urban areas and 0.97 km in non-urban areas. More specifically, the average walking distance to places for recreational purposes, such as gym to exercise or play sports, and visiting parks is 0.80 km by walking in urban areas, and 1.77 km in non-urban areas.[50] Similarly, Yang and Diez-Roux's study indicates that the mean and median walking distances were 1.13 km and 0.80 km, respectively; the mean and median for walking duration were 14.9 and 10 minutes, respectively.[49] According to Bohannon and his colleague's meta-analysis, 0.80 km distance can be converted approximately to a 10-minute walking duration.[47] As a result, from the range of 0.40 km to 1.77 km, we employed a parsimonious value, a 0.80 km walking distance to define neighbourhood in this study (i.e. an area that could be traversed along a 0.80 km street network from an adolescent's home).

Park area included nature trails, bike paths, playgrounds, athletic fields and state-, county- and town-owned parks. Housing density was calculated as housing units per acre by combining housing unit data obtained from the U.S. Census with the geographic information system (GIS) database. A GIS was used to build a spatial database to measure each adolescent's built neighbourhood environment, as described previously by Roemmich and colleagues.[24] Computations were completed using ArcGIS 9.2 and extensions such as Network Analyst. The parcel layer data were obtained from the Office of Geographic Information Services, Erie County, NY. The street segment layer was obtained from New York State GIS Clearinghouse.

The descriptive statistics for the participating adolescents are shown in Table 1 first for the overall population, then by gender. Briefly, boys and girls were 13.5 years on average, with an average weight of 64.6 kg and height of 162.9 cm. These measures placed the overall population in the 79th BMI percentile, or within normal weight status. Participants had an average MET value of 1.9 for their weekly activity, indicating they engaged in light physical activity. When stratified by gender, boys and girls did not differ by weight ($p > 0.94$), BMI percentile ($p > 0.88$), age ($p > 0.49$), SES ($p > 0.07$), percentage of park area (park area/total area) ($p > 0.07$) or housing density ($p > 0.65$). Boys' neighbourhoods had greater areas of total park land ($p < 0.02$) when compared to girls. Boys were also taller ($p < 0.03$) and had lower PSS scores ($p < 0.006$) compared to girls.

Data analysis

Physical activity counts from accelerometer data were converted to METs using validated equations.[43] Separate one-way analysis of variance models tested differences in physical characteristics and neighbourhood characteristics of boys and girls. Multiple regression analysis was used to test the associations of parks, and the interaction term of 'gender and park', with perceived stress. A multivariate model was estimated, with percentage of land devoted to parks within an adolescent's neighbourhood (an area that could be traversed along a 0.80 km street network from an adolescent's home) as the independent variable (Table 2).

SES and usual physical activity were included as covariates in the model. Age and housing density, a surrogate measure of crowding, were considered for inclusion in the model, but were non-significant predictors and were excluded to create a more parsimonious model. Moreover, SES and housing density were correlated ($\rho = -0.24$, $p < 0.05$) and therefore only SES was included in the model. All p values are two-tailed.

Table 1. Demographics, physical characteristics and neighbourhood environment variables.

	All ($n = 68$)	Boys ($n = 32$)	Girls ($n = 36$)
Age	13.5 ± 1.1	13.4 ± 1.0	13.5 ± 1.1
Ht (cm)[a]	162.9 ± 8.2	165.4 ± 8.9	160.8 ± 6.9
Wt (kg)	64.6 ± 15.4	64.5 ± 14.6	64.7 ± 16.3
Body mass index percentile	79.3 ± 23.3	79.7 ± 23.7	79.0 ± 23.3
Socio-economic status[b]	43.8 ± 11.4	46.4 ± 12.1	41.4 ± 10.4
Average METs	1.9 ± 0.2	1.9 ± 0.2	1.8 ± 0.2
Perceived Stress Score[a]	21.8 ± 6.5	19.6 ± 6.3	23.8 ± 6.1
Housing density (housing units/acre)	4.3 ± 2.7	4.2 ± 2.9	4.5 ± 2.6
Area of park land /total land	0.02 ± 0.04	0.03 ± 0.04	0.01 ± 0.04
Park land within 0.8 km (km^2)[a]	45.1 ± 86.6	70.1 ± 101.6	22.8 ± 64.2

Note: Data are mean ± standard deviation.
[a]Boys and girls significantly different, $p < 0.05$.
[b]A socio-economic status of 40 through 50 is equivalent to medium size business owners, minor professionals and technical jobs, such as computer programmers, real estate agents, sales managers, social workers and teachers.

Table 2. Multiple regression analyses predicting perceived stress.

Independent variable	Coefficient	Coefficient standard error	Standardized coefficient	*P*
Intercept	24.811	4.337		0.00
Socio-economic status	−0.126	0.067	−0.222	0.065
Usual physical activity	0.006	0.007	0.104	0.378
Gender	2.222	1.776	0.172	0.215
Park area (%)	−62.573	27.794	−0.375	0.028
Gender × Park area (%)	59.530	39.550	0.251	0.137
			$R = 0.46$, $R^2 = 0.21$	

Results

The results of the analysis show that percentage of park area ($\beta = -62.573$, $p < 0.03$) predicted perceived stress even when controlling for SES and usual physical activity. The interaction term of 'gender and percentage park area' ($p > 0.13$) did not predict perceived stress. An interaction term was also added to the model to test the influence of physical activity as a moderator. Usual physical activity as a moderator term was not significant ($p > 0.05$) and was not included in the final model.

Discussion

Consistent with prior research on children's stress and exposure to green spaces,[28] the current study demonstrated that the percentage area of park land in an adolescent's neighbourhood may act as a buffer against perceived stress. Previous research examining the buffering effect of neighbourhood green space on children's stress used self-report data for neighbourhood attributes.[28] By using objective measures, the current study extends previous research by quantifying the association between objective neighbourhood green space attributes such as parks.

The results of the current study are consistent with other studies finding positive health benefits associated with green space in the neighbourhood environment.[26–28] Wells and Evans[28] found that children whose residence is surrounded by greater vegetation and nature have lower psychological distress when experiencing stressful life events. Wells,[51] using a prospective design, also found an increase in children's cognitive functioning after relocating to a greener environment. Using postal codes to determine percentage of green space within 1 km and 3 km radii, Maas and colleagues found that youth living near a greater percentage of green space had more positive perceived general health.[12] Adults also receive health benefits from neighbourhood green space. Van de Berg and colleagues[27] found a greater positive perception of mental health, and lesser effects of stressful life events in individuals residing in neighbourhoods with more green space, compared to those living in areas with lower amounts of green space.

Adding physical activity to the regression model in the current study provided an opportunity to determine the association of neighbourhood parks with perceived stress, independent of the effects of activity on perceived stress or access to parks on activity. Previous research has shown that physical activity is influenced by the neighbourhood environment. Greater physical activity participation was predicted by a greater proportion of park area in young children's neighbourhoods[12] and boys' physical activity, compared to girls' physical activity, is more strongly associated with the neighbourhood park environment.[33] Physical activity is also protective against stress. In children, physical activity can dampen acute stress reactivity,[16] and physical activity can buffer the effects of chronic stress on adiposity and health.[3,34,52] In adults, physical activity during leisure time also buffers stress effects on perceived stress, work strain, work stress, mental stress and life dissatisfaction.[53–55]

By controlling for the stress buffering of physical activity, the current study offers a unique perspective on the association of perceived stress and neighbourhood parks. Our findings indicate that beyond the stress-reducing benefits the adolescents may have experienced from their usual physical activity, the total percentage of parks within 0.80 km predicted further reductions in their perceived stress. Based on previous research findings in children of gender differences in impulsivity, concentration, delay of gratification,[29] attention deficit disorder[29] and physical activity[33] by park access and green space, we hypothesized that a similar gender difference may have existed between perceived stress and parks. Although the current study did not find that the buffering effects of parks on stress varied by gender, it is a positive finding that both boys and girls may be similarly protected by neighbourhood green space.

The study is not without limitations. One limitation of this study is the question of temporal relationship between the neighbourhood environment and perceived stress. Our study was unable to measure the length of time needed to establish the relationship between parks and perceived stress. For this study, participants' average years lived in their current home was 9.4 (±6.1). A prospective study could determine the time it takes to develop benefits of neighbourhood parks and green space, particularly regarding perceived stress levels. Another limitation was that these analyses do not examine where the adolescents were physically active nor do they examine adolescents' interaction with parks and green space. Future studies could incorporate GPS monitoring of adolescents to determine the association between park usage, physical activity and perceived stress. A further limitation is the small number of participants in the study. With a greater number of participants, we may have been able to detect stronger associations or associations more specific to the type of park. Future research could further parse the types of parks to provide better guidance for urban planning and policy decisions.

Conclusion

In conclusion, this study shows that parks matter for adolescents' mental health. Specifically, an inverse association exists between perceived stress and park access in adolescents. This association exists even after controlling for potential stress buffering effects of physical activity. Overall, interacting with parks provides the opportunity to improve physical fitness, control weight and reduce stress among adolescents. If parks were easily and freely accessible, children of a wide range of socio-economic classes could reap physical and mental health benefits from physical activity in parks. To do so, planners and policy makers must ensure the following:

a. Parks are built within neighbourhoods that are home to families with children

The availability of parks within proximity of children's homes has the potential to improve their mental health as well as provide attendant benefits. Municipalities' land use plans should ensure that good quality parks are available at a neighbourhood scale in addition to ensuring their availability at a municipal-scale.

b. Physically proximate parks *practically* accessible to children living in their vicinity

Some parks and playgrounds that are physically located within neighbourhoods may be cordoned off from neighbourhoods by fences or other barriers. This is certainly the case for a number of school playgrounds in Erie County, New York. [We excluded these inaccessible parks and playgrounds from our measurement of available parks in Erie County.] A number of municipalities in the USA are experimenting with the use of joint-use agreements between municipalities and school districts (as well as other institutions that have playgrounds) as a policy tool to enable community-wide access to these cordoned off spaces during after school hours.

c. Safe to access parks

A growing body of literature also suggests that people are unlikely to use parks even when they are available.[56–58] In the case of children's use of parks, behaviour is often regulated by parents' concerns about actual and perceived lack of safety in and around parks. To assure children's use of parks, local governments must develop a systematic strategy that tackles both the demand for, use of, and supply of good quality parks. Such programming would necessarily require engaging multiple departments including parks and recreation, public health and public safety. Departments of public safety especially have a crucial role to play by ensuring traffic surveillance, and crime prevention strategies are effectively deployed within parks as well as along neighbourhood routes leading to parks.

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DMF implemented the protocol, collected data, drafted the manuscript, analysed and interpreted the data, and prepared the tables. AS collected data and revised the manuscript. SB computed the built environment variables, prepared the figure and revised the manuscript. SR and LY contributed to the study design and revised the manuscript. JNR developed the study concept and design, supervised acquisition of data, analysed and interpreted the data in collaboration with DMF, and revised previous and the final versions of the manuscript. All authors approved the final version of the manuscript for submission. None of the authors declared had conflicts of interest with respect to their authorship or the publication of this article. We would also like to thank Maya Lambiase, and Christina Lobarinas for their data collection, and Alex Brian Ticoalu for data process efforts. This work was supported by National Institutes of Health grant [HD055270] to JNR. The funding agency played no role in data collection, analysis or publication.

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