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Impact of Park Size and Access and Neighbourhood Walkability on Physical Activity and Obesity: A Cross-Sectional Analysis

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Abstract

Background: We examined whether higher access to parks and greenspace is independently associated with an increase in physical activity and lower rates of obesity when neighbourhood walkability is accounted for, and to examine whether neighbourhood walkability and park access have synergistic effects on these outcomes. **Materials and Methods:** We used cross-sectional data from the Canadian Community Health Survey between 2007 and 2014 for adults aged 20 to 74 in Ontario, Canada. Neighbourhood-level access to parks exposures included size of parks and number of parks within 800m of residential areas, and neighbourhood walkability was based on a validated index. The main outcomes were physical activity during leisure time (LPA), both leisure and transportation physical activity (LTPA), and obesity. Descriptive and multivariate logistic regression analyses were conducted, stratified by age groups, accounting for sex, income, ethnicity, and season. **Results:** Among 41,945 respondents, park access was associated with higher LPA and LTPA, with effects modified by neighbourhood walkability ($p<0.001$). Physical activity was highest in neighbourhoods with high walkability and park access and lowest in low walkability areas without parks. In highly walkable neighbourhoods, ≥1 small- or medium-sized park was associated with 29% higher odds of LPA (OR:1.29, 95%CI:1.21–1.37) and 48% higher odds of LTPA (OR:1.48, 95%CI:1.38–1.57) than low walkability/no park access. In contrast, associations were modest in low walkability neighbourhoods (4–7%). High walkability was also associated with lower obesity and marked reductions with very high access to large parks (OR:0.72, 95%CI:0.55–0.94). Findings were consistent across age groups. **Conclusion:** High neighbourhood walkability was the strongest predictor of physical activity and lower obesity risk, with park access providing additional benefits primarily in already walkable environments. These findings suggest that population health interventions targeting urban design need to consider the combined benefits of neighbourhood walkability and park access on health.

Keywords: neighbourhood walkability; park and greenspace access; physical activity; obesity; urban health; city planning; population health

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1. Introduction

There is a growing recognition of the impact of natural environments on health and wellbeing. Research has shown that populations that live nearer to greenspace, including parks, forests, and other natural settings, have lower rates of obesity,[1] type 2 diabetes,[2–5] cardiovascular disease,[6,7] mental health,[8] and all-cause mortality,[9–12] compared to those who live further away from these settings. The potential pathways through which access to greenspace might lead to better health are multifold.[13] Parks and trails provide opportunities for physical activity and social connection, and are associated with improved mental health, stress relief and social capital. Greenspace also mitigates the effects of environmental harms, such as air and noise pollution, and provides protection from extreme heat. [14] Hence, as cities strive to create healthy, livable communities, there has been a growing discourse around the central role of parks and greenspace in urban design. These public spaces are also becoming a key target for population-wide interventions to curb the epidemic of obesity and related chronic diseases. [15]

A growing body of research suggests that people living in neighborhoods that have more parks, trails and tree cover are more physically active.[16–33] However, these studies vary considerably with respect to their study designs and the methods used to measure access to greenspace. Further, the majority of studies on this topic fail to account for other environmental influences, such as neighbourhood walkability and its combined effect with parks and greenspace on physical activity. High neighbourhood walkability is associated with lower rates of obesity and related diseases, including the development of prediabetes, diabetes, and cardiovascular diseases. [34–40] The health benefits of walkability are due in large part to its impact on walking and other active forms of transportation.[40] Because neighborhood walkability and park access are not evenly distributed throughout urban areas, communities may have favourable or unfavourable profiles for both characteristics. Historical planning practices have led to widespread changes over time in density and zoning standards, as well as the requirements for greenspace within residential areas. As a result, those living in highly walkable neighbourhoods may have greater access to parks or they may be more likely to use parks simply because of the ease of traveling there. In many cities, affluent neighborhoods also have substantially more tree coverage, and greater park numbers, quality and safety. This confluence of factors have created a non-equitable pattern of walkability and greenspace in cities, which makes it more challenging to disentangle the benefits of one factor over another. Furthermore, studies on park access and physical activity are not sufficiently large enough to identify subsets within the population who would benefit most from these exposures.

The objectives of this study were to examine whether having better access to parks and greenspace is independently associated with an increase in physical activity and lower rates of overweight and obesity when neighbourhood walkability is accounted for, and to examine whether neighbourhood walkability and park access have synergistic effects on these outcomes. We hypothesized that residents living in more supportive environments (greater walkability/park access) will report having higher levels of physical activity and lower rates of obesity compared to those living in the least walkable areas with limited or no access to parks. We also hypothesized that these differences would be magnified by the size and number of parks that residents have access to, such that having one or more parks within walking distance or access to larger parks will result in greater levels of physical activity and lower rates of overweight and obesity. Because prior studies have shown that park and greenspace use varies by age, [42–47] we examined whether any observed associations were greater amongst younger versus older adults.

2. Materials and Methods

2.1. Study Design and Population

This study analyzed existing data collected from participants in one of eight waves of the Canadian Community Health Survey (CCHS), conducted between 2007 and 2014. The CCHS is a national cross-sectional survey developed by Statistics Canada that collects health-related information from a representative sample of the Canadian population (aged 12 and above) annually. Our analysis included adults aged 20 years and older who lived in one of 15 cities in Southern Ontario

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at the time they participated in the CCHS, including Hamilton, London, Ottawa, Toronto, and surrounding cities. Survey responses were linked to neighborhood-level measures using each participant's neighborhood of residence at the time of CCHS entry. This research was conducted at ICES, a non-profit research institution affiliated with the University of Toronto, which holds de-identified and linkable administrative health databases and surveys.

2.2. Neighbourhood Measures

Park access: We derived park access variables for all neighbourhoods within our study area. Neighbourhoods were based on dissemination areas (DA), which are small residential units created by Statistics Canada that span one or more adjacent city blocks and include a population of 400-700 residents.[47] A geographic information system (GIS)-based network analysis that considered existing roads and foot paths was used to create an 800-meter (m) buffer around the centre of each DA, corresponding to a distance that could be reached within 10 minutes of walking. Park access measures were captured using the 2009 CanMap Parks and Recreational polygon data for our study area from DMTI Spatial Inc. We included official city parks of all sizes, as well as outdoor recreational spaces (sports fields), provincial parks, parks with conservation areas, parks with trail systems, and cemeteries that were 10 hectares or greater. We excluded areas that were not considered important for recreational and transportation physical activity such as botanical gardens, campgrounds, migratory bird sanctuaries, picnic sites, and hydroelectric power corridors, however, official city parks that reside within these corridors were included. Neighbourhood-level access to parks was defined as low (0 parks), moderate (1-2 parks), and high (≥3 parks) based on the number of parks that were accessible within the 800m buffer. Because the size of park determines the type of activities that can be undertaken within its space, we further categorized access based on park size (small or medium: 0.5-4.9 hectares; large parks: ≥ 5 hectares).

Neighbourhood walkability: DA-level walkability was assigned using a validated index created for our study area, as previously described. [34–39] Briefly, the index is comprised of four equally weighted components based on street connectivity, population density, residential density, and number of retail stores, services and other walkable destinations. Standardized walkability scores ranging from 0-100 were divided into five quintiles (Q) with an equal number of DAs, with Q1 representing the lowest level of walkability and Q5 the highest level of walkability. In previous research, we observed a threshold effect whereby residents living in the highest quintile had a substantially lower rate of obesity and diabetes incidence compared to the 4 lowest quintiles of walkability.[34–36] Therefore, the index was divided into two categories only: low walkability (based on quintiles 1-4) and high walkability (based on quintile 5).

2.3. Individual-Level Measures

Individual-level covariates were ascertained from self-reported responses in the CCHS, including age, sex, ethnicity, and household-income. Self-reported ethnicity was categorized as white or non-white only, due to limitations in the number of participants from different ethnoracial groups. Further, we ascertained the season during which each CCHS interview was conducted to account for seasonal changes in physical activity and body weight. These were assigned to participants based on the mean temperature during the 3-month window prior to their interview date. As detailed below, this served as the period in which physical activity was reported. This 3-month period was considered to be summer for interviews conducted between July and October; winter for interviews conducted between January and April; and a temperate season (Spring/Fall) for interviews conducted during the months of May, June, November, or December.

3. Outcomes

Physical Activity was measured using derived variables from the CCHS that reflect how physically active an individual is during both leisure time and while engaged in transportation. The

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survey collected information from participants regarding the frequency, duration, and type of physical activity undertaken during the three months prior to their interview date. This was used to calculate their total daily energy expenditure in kcal/kg/day, which was then assigned to one of three categories: 'inactive' (<1.5 kcal/kg/day), 'moderately active' (1.5 to <3 kcal/kg/day), and 'highly active' (≥3 kcal/kg/day). In this study, we combined *moderately* and *highly active* into a single category of moderate-to-high physical activity versus *inactive* and reported a combination of leisure and transportation physical activity (LTPA) and leisure physical activity alone (LPA) separately.

Obesity: Ethnic-specific body mass index (BMI) measures were created based on self-reported height and weight from the CCHS. BMI was used to categorize participants as overweight or obese (≥25 kg/m^2) and obese (≥ 30 kg/m^2). For South Asian and Chinese populations only, a BMI category of ≥23 g/m^2 and ≥25 kg/m^2 were considered overweight or obese and obese, respectively, based on categories defined by the World Health Organization and prior studies.[48–89]

4. Analyses

Descriptive statistics were calculated for baseline characteristics of the population, according to park access exposures (≥1 park versus 0 parks within 800 m). Multivariate logistic regression models were used to examine the relationships between park access ((0 parks, 1-2 parks, ≥3 parks within 800 m) and each outcome: physical activity during leisure time (LPA), both leisure and transportation physical activity (LTPA), and obesity. Models were stratified by park size (small or medium-sized versus large parks), and age group (20-49 and ≥50). We adjusted for covariates including age (as a continuous measure), sex, household income, ethnicity, season, and neighbourhood walkability.

To determine whether associations between park access, physical activity, and obesity were modified by neighbourhood walkability, we tested for interactions between park access (i.e., ≥1park, no park) and walkability (high/low) in each model. For those that were significant, we performed stratified analyses to examine the impact of park access on each set of outcomes within high and low walkability neighbourhoods. Further, we examined the impact of walkability on each set of outcomes in areas with high and low access to parks. We ran further models with four neighborhood categories with both high walkability and park access, low walkability and park access and areas with high/low and low/high walkability/park access. Lastly, we examined whether the association between park access and physical activity/obesity is similar in lower and higher income populations, by stratifying our analyses by household income. All analyses were run using SAS Enterprise 9.4.

5. Ethics Approval

ICES is an independent, nonprofit research institute whose legal status under section 45 of Ontario's Personal Health Information Protection Act provides the opportunity to collect and analyze deidentified health care and demographic data, without consent or review by a Research Ethics Board, for the purpose of health system evaluation and improvement.

6. Results

Overall, there were 41,945 CCHS participants living in our study area between 2007 and 2014, of which 34,075 lived in a neighbourhood that had at least one park within walking distance. Baseline characteristics of the study population are provided in Table 1. The average age of the study population was 51.2 years, 43% were from a high-income household and 63% had post-secondary education. The population characteristics were generally similar in communities that had access to parks and those that did not. As an exception, a higher proportion of those who had access to a park within 800 m of their home self-identified their ethnoracial identity as white compared to those who did not have access (72.2% and 67.2%, respectively). Further, residents who had no park access were more likely to live in a low walkability neighbourhood.

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Table 1. Baseline characteristics of study population by park access of any size within 800m, in Southern Ontario, Canada.

	Any park access in 800m	No park access in 800m	Total population
Variables (%)	N=34,075	N=7,870	N=41,945
Age (mean ± SD)	51.5 ± 18.4	50.1 ± 18.1	51.2 ± 18.3
Age groups			
20-49	46.8	50.3	47.5
50+	53.2	49.7	52.5
Sex (female)	56.6	56.6	56.6
Ethnicity			
White	72.2	67.2	71.3
Non-white	23.3	28.1	24.4
Household income			
Lowest income	6.3	5.0	6.0
Lower middle income	15.1	13.3	14.8
Upper middle income	28.8	27.4	28.6
Highest income	42.2	46.7	43.1
Education			
Less than high school (sec school)	11.7	10.6	11.5
Secondary or post-sec school	22.4	22.5	22.4
Post-secondary school	63.1	64.4	63.3
Marital status			
Married	46.4	54.7	47.9
Common-law	5.2	4.2	5.0
Widowed/Divorced/Separated	22.5	18.6	21.7
Single	25.8	22.3	25.1
Walkability Quintile (Q)			
Q1 (lowest)	18.7	44.2	23.5
Q2	18.8	19.5	18.9
Q3	20.6	21.5	20.8
Q4	21.5	8.9	19.1
Q5 (highest)	20.3	5.8	17.6
Season			
Summer	33.6	35.1	33.9
Temperate	31.7	30.7	31.5
Winter	34.6	34.2	34.5

Data sources: Canadian Community Household Survey (CCHS) cycles 2007-2008, 2009-2010, 2011-2012, and 2013-2014; data for parks were attained from the 2009 CanMap Parks and Recreational polygon data for Southern Ontario.

6.1. Park Access, Walkability and Physical Activity

Overall, there was a significant association between park access and physical activity, however, these effects varied significantly according to neighborhood walkability ($p<0.001$ for interaction). Figure 1 examines the combined effects of neighbourhood walkability and park access defined as the presence of 1 or more parks of a specific size. Overall, physical activity levels related to leisure (LPA) or leisure and transportation (LTPA) were greatest in the most favorable environments (high walkability/moderate to high park access) and lowest in the least favorable environments (low walkability/no park access). In most scenarios, the addition of 1 or more parks led to a further increase in physical activity levels in both low and high walkability settings, but the effects were greater in

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high walkability areas. Residents living in a highly walkable neighbourhood with 1 or more small- or medium-sized parks reported a 29% higher likelihood of being active during leisure time (OR: 1.29, 95%CI: 1.21-1.37) and a 48% greater likelihood of actively engaging in leisure *and* transportation-related physical activity (OR:1.48, 95% CI:1.38-1.57) compared to those who were living in areas with low walkability and no park access (referent) (Figure 1). In contrast, high walkability neighborhoods with no small or medium parks had a 16% increase in LTPA only. Associations were more modest in low walkability neighborhoods, where the addition of 1 or more parks of any size (low walkability/moderate to high park access) was associated with an increase in LPA and LTPA of only 4-7%. Similar patterns were observed with respect to the presence or absence of large parks within a community. As an exception, high walkability was associated with a ~40% increase in total physical activity (leisure and transportation combined) with no further benefit conferred by the presence of 1 or more large parks.

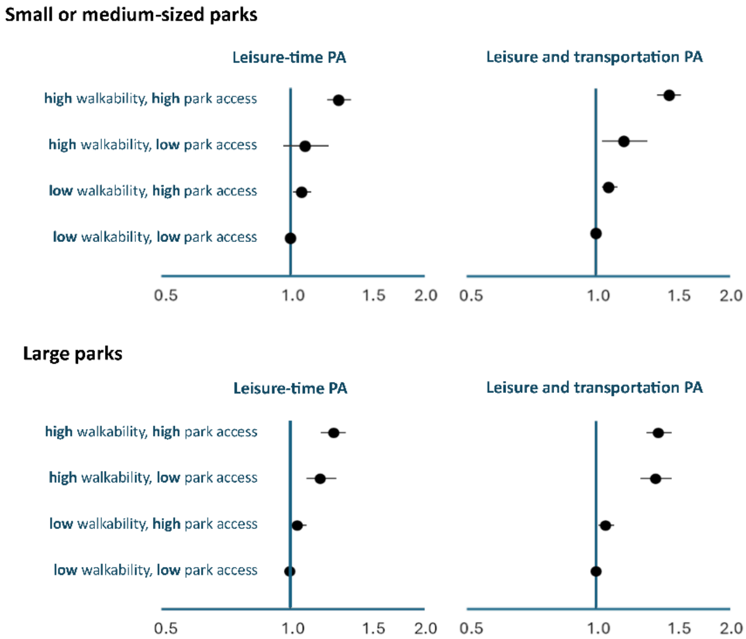

Figure 1. Combined effects of neighborhood walkability and park access on the **odds of being physically active**, by park size. PA: Physical activity; Referent: Low walkability and low park access; High walkability was based on quintile 5 and low walkability was based on quintiles 1-4. High park access was defined as ≥ 1 parks within 800m, Low park access was defined as 0 parks within 800m. Adjusted for age, sex, ethnicity, season, and household income, neighbourhood walkability, park access, and interaction terms of neighbourhood walkability and park access; Data sources: Data for LTA, LTPA and obesity were attained from Canadian Community Household Survey (CCHS) cycles 2007-2008, 2009-2010, 2011-2012, and 2013-2014; data for parks were attained from DMTI, Ministry of Education, and City of Toronto.

These findings appeared to be largely driven by areas that had *very high access* to parks, defined as 3 or more parks within 800m (Figure 2). In highly walkable neighborhoods, very high access to *small and medium sized parks* was associated with a 16% increase in LPA and 27% increase in LTPA compared to high walkability alone (i.e., no park access); while very high access to *large parks* was associated with a 36% increase in LPA and a nonsignificant increase (18%) in LTPA. A similar pattern was noted in lower walkability neighborhoods although the magnitude of these effects were diminished; very high access to parks of any size were associated with only a 13 to 16% increase in rates of LPA and LTPA. These findings appeared to be dose-related, as having only moderate access to parks (1-2 locations within 800 m) was generally associated with a smaller increase in physical activity levels of any type. Overall, residents living in high walkability neighborhoods engaged in greater amounts of leisure and leisure- and transportation related physical activity compared with

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those living in low walkability neighborhoods. The benefits of high walkability on LTPA appeared to be augmented in the presence of small or medium parks.

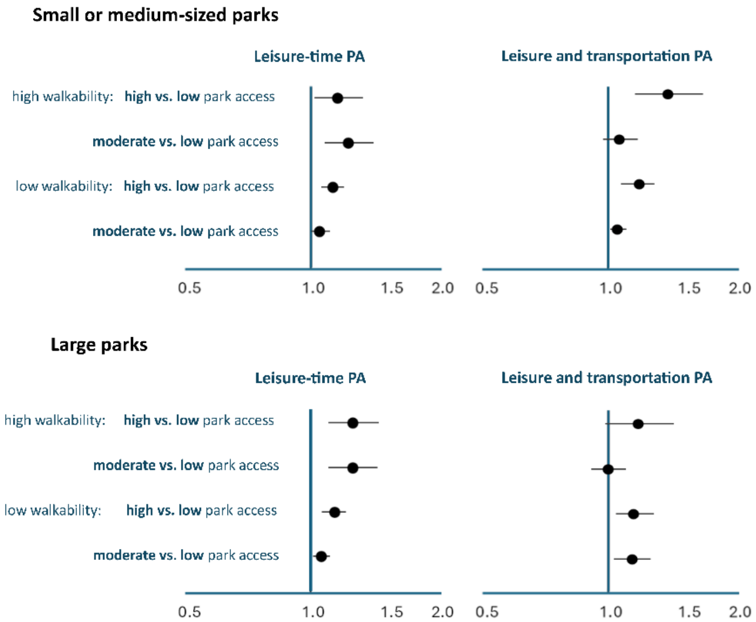

Figure 2. High (A) and moderate (B) park access verses low access within 800 m and the **odds of being physically active**, by park size and neighborhood walkability. PA: Physical activity; Referent: Low park access; Adjusted for age, sex, ethnicity, season, and household income, neighbourhood walkability, and park access; Analyses were stratified by walkability. High walkability: quintile 5, Low walkability: quintiles 1-4. High park access was defined as ≥ 3 parks within 800m, moderate park access was defined as 1-2 parks within 800m, low park access defined as 0 parks within 800 m. Data sources: Data for LTA, LTPA and obesity were attained from Canadian Community Household Survey (CCHS) cycles 2007-2008, 2009-2010, 2011-2012, and 2013-2014; data for parks were attained from DMTI, Ministry of Education, and City of Toronto.

6.2. Park Access, Walkability and Obesity

Figure 3 demonstrates the associations between park access, walkability and obesity. As demonstrated in the Figure, high walkability (with or without park access) was associated with the greatest reduction in the odds of obesity compared to communities with low walkability and no park access); with no or little additional benefit conferred by having 1 or more parks within walking distance. However, within highly walkable neighborhoods, having 3 or more large parks within walking distance was associated with a further reduction in the odds of obesity (OR: 0.72 (0.55-0.94) compared to highly walkable areas without any access to parks (Supplementary Figure S1). Very high access to small- or medium-sized parks was not associated with obesity rates in highly walkable areas. In low walkability neighborhoods, obesity rates were also unaffected by park access.

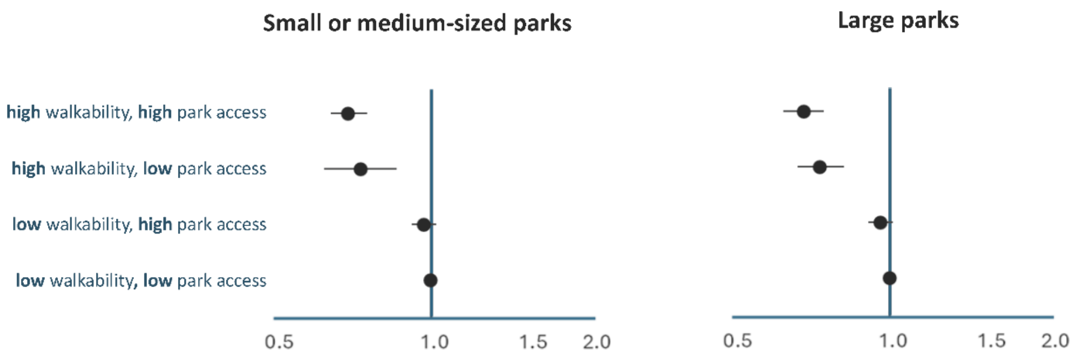

Figure 3. Combined effects of neighborhood walkability and park access on the **odds of obesity**, by park size. PA: Physical activity; Referent: Low walkability and low park access; Adjusted for age, sex, ethnicity, season, and household income, neighbourhood walkability, park access, and interaction terms of neighbourhood walkability and park access; High walkability was based on quintile 5 and low walkability was based on quintiles 1-4. High park access was defined as ≥ 1 parks within 800m, Low park access was defined as 0 parks within 800m. Data sources: Data for LTA, LTPA and obesity were attained from Canadian Community Household Survey (CCHS) cycles 2007-2008, 2009-2010, 2011-2012, and 2013-2014; data for parks were attained from DMTI, Ministry of Education, and City of Toronto.

6.3. Sensitivity Analyses

Findings were relatively consistent in both younger (aged 20-49 yrs) and older adults (aged ≥50 yrs). Among adults aged 20-49 years, living in the most favourable environments (high walkability /moderate to high park access), higher levels of LPA and LTPA and lower levels of obesity were reported, regardless of park sizes (Supplemental Table S1). Similar, but more modest trends were observed for older adults, highlighting the benefits of combined neighbourhood walkability and park access on physical activity and obesity.

7. Discussion

Our findings suggest that neighbourhood parks have a strong influence on physical activity levels and obesity in the population. Among adults of all ages, those living within a short walking distance of local parks and greenspace had a greater likelihood of being physically active during their leisure time or during leisure and transportation-related activities combined. While these benefits were observed in a variety of urban settings, they appear to be even greater in neighbourhoods that are highly walkable - highlighting the importance of designing urban areas where these resources can be reached on foot. Furthermore, access to parks conferred additional benefits to those already living in a highly walkable area, with apparent increases in both leisure and transportation-related physical activity.

In recent decades, there has been a growing body of research illustrating the health benefits of parks and greenspace.[2–39] Beyond its effects on physical activity, local parks and greenspace promote social cohesion and offer protection against excess heat, noise and air pollution.[12,14,36,51]As a co-benefit, spending time in nature appears to have favourable effects on mental health, sleep quality, cognitive function, stress, and loneliness [42,51,52] Studies examining the association between neighbourhood greenspace and physical activity have been largely positive and the patterns we observed are similar to those seen in other studies from Australia, Europe, the United States, Canada, and Central America.[17–22,26,33,40,54,55] However, the literature overall has shown mixed results. Heterogeneity in the evidence base appears to be due in part to the use of variable methods.[16,18,19,23–26,56,57] This includes differences across studies regarding how park and greenspace access is measured (e.g., distance to parks or greenspace, travel time to the closest park, tree canopy coverage and/or quality of green space), how health outcomes are collected (i.e., self-report versus objective measures, individual vs. population data sources), and which population is being studied (i.e., children, young versus older adults). Inadequately addressing important interactions between neighborhood features, such as greenspace and walkability, likely also contributed to differences in findings across built environment studies.

A number of studies have found positive associations between greenspace and obesity.[49,50] In contrast, our study found that neighborhood walkability, but not parks, had a significant impact on the odds of obesity. However, highly walkable neighbourhoods were also far more likely to offer access to parks. To date, very few studies have explored the combined effects of park access and neighbourhood walkability on physical activity and obesity. While it is often difficult to disentangle these effects, it is possible that some benefits previously attributed to park exposure were in fact due to neighbourhood walkability or other characteristics. Highly walkable neighbourhoods provide residents an opportunity to engage in active transportation and to reduce one's reliance on cars for

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mobility.[57] From previous studies, high neighbourhood walkability was associated with a reduced likelihood of being overweight or obese, and of developing prediabetes, diabetes, hypertension and cardiovascular disease.[2–5,34–39] From our study, park access was associated with physical activity but generally offered little additional benefit with respect to obesity. An exception was in highly walkable neighbourhoods, where proximity to high access (i.e., *three or more*) large-sized parks was associated with a further reduction in the rate of obesity in the population. Since larger parks often have walking loops, trails, playgrounds, sports amenities, and open spaces for a variety of recreational activities, they may support individuals to be even more physically active.[18,19,59].

Our study may have missed favourable associations between greenspace and body weight for several reasons. First, there are inherent limitations in using BMI as a surrogate for metabolic health. In both normal and overweight individuals, moderate levels of physical activity (such as achieved through brisk walking) may yield beneficial effects on visceral (abdominal) adiposity in the absence of significant changes in BMI. Visceral adiposity is more closely associated with insulin resistance and the risk of type 2 diabetes and related diseases.[61] Populations that have different ethno-racial backgrounds have different BMI thresholds that predict the presence of visceral adiposity and insulin resistance.[49,50] In fact, the presence of the latter is more common in non-white groups who have a lower BMI. Studies examining the association between greenspace and health often fail to account for socioeconomic status or ethnicity, which is one reason why residual confounding occurs in epidemiological studies.[60] In our study, residents living in higher income communities reported being more physically active and had lower rates of overweight and obesity. High income neighborhoods tend to be greener and have more amenities within parks, a concept known as green gentrification. To account for this, we adjusted for household income in all of our analyses.

This study has some limitations that are important to acknowledge. Our study was cross-sectional and despite using several cycles of the CCHS to create our sample, exposures and outcomes were captured at a single point in time. Therefore, our findings cannot be used to infer causation. Next, our outcomes were based on self-reported information and participants may have had incomplete recall or may have exaggerated the amount of physical activity they engaged in. Additionally, people who are more physically active may choose to live near a park and therefore may be systematically different than those who do not live near these resources. Further, we did not account for other park characteristics in our analyses, such as the presence of amenities, walking trails, sufficient lighting or safety. These features may be more common in higher income neighborhoods due to greater investments in these areas. Although we adjusted for many factors in our analyses, including age, sex, season, household income, and self-reported ethnicity, unmeasured population characteristics may have resulted in residual confounding. Several prior studies used propensity score methods to account for systematic imbalances between populations living in high versus low walkability settings, however, these analyses yielded similar results as multivariate regression models alone.[38] Thus, it is unlikely that the use of more complex methods would have altered our findings.

Our study also has many strengths. We used data from 15 municipalities in Southern Ontario, Canada which included both urban and suburban landscapes. Therefore, we had a sufficiently large sample size to assess the interaction between neighborhood features. Ours was the first large population-based study using household survey and administrative data to understand the relationships between parks and greenspace and their impact on physical activity and obesity. Although, there is great heterogeneity in the evidence-base on greenspace access and health, our study contributes to this growing field by supporting the notion that creating highly walkable environments with access to parks and greenspace is beneficial for promoting healthy living – by providing residents opportunities to engage in leisure and transportation-related physical activity to reduce their risk of obesity.

8. Conclusions

These findings have important implications for future research and policy development to address these global public health challenges through healthy and sustainable urban designs. According to the World Obesity Federation, an estimated 2.7 billion people are overweight or obese.[62] Physical inactivity is an important contributor to these trends and an essential target for public health intervention.[63] Our study revealed an important interplay between features that promote physical activity. In highly walkable neighborhoods, the presence of small/medium and large parks was associated with a further increase in transportation-related and leisure-time physical activity, respectively. However, urban parks and greenspace may be insufficient in overcoming the inherent barriers imposed by unsupportive environments, such as those caused by low walkability. Understanding these multilayered and intersecting effects is a necessary step in designing neighbourhoods that optimally promote and sustain healthy behaviours, like physical activity. Moreover, the fact that neighbourhood features which promote physical activity differ across communities calls for more context-specific rather than a one-size-fits-all solution to address physical inactivity. With respect to parks and greenspace, it is essential to understand how local residents use these spaces and what attributes are essential to meet a community's needs.[64,65] There is a move towards more inclusive mechanisms to incorporate community perspectives in green space planning. These processes may be essential to ensure that future policy efforts are both equitable and optimally effective in promoting physical activity and healthy living.

Supplementary Materials: The following supporting information can be downloaded at: Preprints.org, Supplemental Table S1: Combined effects of neighborhood walkability and park access on the odds of being physically active, by park size and age group; Supplemental Figure S1. Association between park access and the odds of obesity, by park size and neighborhood walkability.

Author Contributions: GF and GB, conceived and designed the study. PG secured and created neighbourhood-level park measures and JP conducted all statistical analyses at ICES. GF and GB drafted the manuscript. All authors (GF, JP, AJ, PG, JP, GB) contributed to study methodology, critically revised the manuscript for important intellectual content, approved the final version, and agree to be accountable for all aspects of the work.

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Conflicts of Interest: The authors declare that they have no competing interests.

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