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Neighbourhood walkability and transportation and leisure physical activity by residency status: A cross-sectional analysis of nationally representative Canadian data

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ABSTRACT

Objective: We aimed to 1) estimate the differences in transportation (TPA) and leisure physical activity (LPA) participation and duration between Canadian-born and immigrant adults, and 2) examine whether associations between neighbourhood walkability and physical activity differ by residency status.
Methods: We linked Canadian Community Health Survey (CCHS; 2017-2018) with Canadian Active Living Environment (2016) data. Participants were urban Canadian-born or immigrant adults (recent: <10 years, established: ≥10 years). Walkability was calculated from counts of neighbourhood intersections, dwellings, and points of interest. Covariate-adjusted Generalized Linear Models estimated the odds ratios (OR) for participation and unstandardized β for minutes of weekly TPA and LPA by residency status with and without adjustment for walkability and for walkability-by-residency interactions.
Results: Recent (OR: 1.25, 95%CI: 1.09, 1.43) and established immigrants (OR: 1.11, 95%CI: 1.02, 1.20) were more likely than Canadian-born to participate in TPA, but these differences attenuated after controlling for walkability. Recent (OR: 0.58, 95%CI: 0.51, 0.67) and established immigrants (OR: 0.81, 95%CI: 0.74, 0.89) were less likely than Canadian-born to participate in LPA, independent of walkability. Recent (β: -20.61, 95%CI: -37.89, -3.34) and established immigrants (β: -18.85, 95%CI: -28.69, -9.00) undertook fewer LPA minutes than Canadian-born, which attenuated after controlling for walkability. Despite being higher in magnitude among Canadian-born, walkability was positively associated with TPA participation and duration regardless of residency status.
Conclusions: Immigrants engaged in more TPA and less LPA than Canadian-born but adjusting for walkability attenuated TPA differences between residency groups. Walkability was positively associated with TPA, with different magnitude between residency groups.

1. Introduction

Despite its numerous benefits and public health efforts to promote physical activity (PA), globally too few adults accumulate levels that are sufficient for optimal health (World Health Organization, 2022). Neighbourhood built environments have the potential to support different types of PA (e.g., active transportation and leisure) and the accumulation of total PA (McCormack and Shiell, 2011; Smith et al., 2017; Kärmeniemi et al., 2018; Salvo et al., 2018). Neighbourhood environments consist of spatially-configured human-designed built features, such as buildings, transportation networks, public amenities, commercial areas, and greenspaces (Saelens and Handy, 2008). Studies have found numerous neighbourhood built features associated with PA (McCormack and Shiell, 2011; Smith et al., 2017; Kärmeniemi et al., 2018; Salvo et al., 2018). Notably, higher neighbourhood connectivity (e.g., intersection density), residential or population density, and mix and density of destinations are individually (McCormack and Shiell, 2011; Kärmeniemi et al., 2018; Saelens and Handy, 2008; Farkas et al., 2019; McCormack, 2017) or in combination (i.e., "walkability") (McCormack and Shiell, 2011; Kärmeniemi et al., 2018; Saelens and

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Handy, 2008; Farkas et al., 2019; Hajna et al., 2015; Hall and Ram, 2018; Herrmann et al., 2019) associated with higher PA. Neighbourhood walkability, in particular, is positively associated with transportation (Farkas et al., 2019; Hajna et al., 2015; Herrmann et al., 2019) (TPA) and leisure physical activity (LPA) (Farkas et al., 2019), albeit more consistently for TPA (Kärmeniemi et al., 2018; Saelens and Handy, 2008; Farkas et al., 2019; McCormack et al., 2012). Associations between neighbourhood walkability and PA may also differ depending on whether participation (i.e., undertaking some versus none) or duration is examined (McCormack, 2017; McCormack et al., 2012).

Associations between neighbourhood walkability and PA can vary among population subgroups. For instance, studies report differences in the direction and/or magnitude of these associations according to sex (Nichani et al., 2019), age (Colley et al., 2019), socioeconomic position (Smith et al., 2017; Christie et al., 2021), and race/ethnicity (Smith et al., 2017; Brown et al., 2013; Kelley et al., 2016). Understanding how neighbourhood walkability is associated with PA among diverse populations is critical to enhance health equity and to inform targeted health promotion interventions (Smith et al., 2017). Exploring the built environment's role in shaping PA among new immigrants is particularly important given the significant influx of immigrants into many western countries, including Canada, during the last decade (Statistics Canada, 2022b; Statistics Canada, 2022a). Immigrants bring with them distinct cultural backgrounds, social norms, preferences, and behaviours (Langøien et al., 2017) that may influence how they respond to and interact with their new environment. Upon settlement, newcomers are on average healthier than long-term residents (i.e., established immigrants and Canadian-born) but this health advantage declines over time (Vang et al., 2017) as they acculturate to their host culture and environment (Berry, 1997; Gibson, 2001). Notably, PA levels among established immigrants (>10 years post-settlement) and Canadian-born adults gradually converge (Dogra et al., 2010; Tremblay et al., 2006). However, relative to Canadian-born, recent immigrants (<10 years post-settlement) undertake more TPA (Public Health Agency of Canada, 2023) but less LPA (Tremblay et al., 2006; Mahmood et al., 2019) and less total moderate-to-vigorous PA (Dogra et al., 2010; Majed et al., 2024).

The neighbourhood built environment may contribute to differences in patterns of PA between recent immigrants and long-term residents, yet few studies have explored this relationship (Brown et al., 2013; Evenson et al., 2003; Oluyomi et al., 2014; Curtin et al., 2018; Edge et al., 2023; Hordyk et al., 2015). Qualitative evidence highlights the importance of accessible greenspaces and inclusive infrastructure for supporting PA among immigrants in Canada (Curtin et al., 2018; Edge et al., 2023; Hordyk et al., 2015). Quantitative studies have found mixed associations between neighbourhood perceived and objective walkability and total PA, LPA, and TPA among immigrants in the US (Brown et al., 2013; Evenson et al., 2003; Oluyomi et al., 2014; Joseph et al., 2021) but similar studies undertaken in other western countries remain scarce. Findings from these quantitative studies are informative but they lack consistency in their methodologies. For instance, these studies differ in how they define and operationalize walkability, they do not differentiate between recent and long-term immigrants or compare these groups with native-born residents, do not differentiate between PA participation and duration, and often do not differentiate by PA domain (e.g., transportation or leisure). To our knowledge, no previous study has estimated associations between neighbourhood walkability and TPA and LPA in the Canadian immigrant population.

Exploring the nuanced relationships between neighbourhood walkability and TPA and LPA according to residency status may better inform universal and targeted public health and urban design strategies to increase PA and reduce PA disparities in the population. This study had two objectives. First, we estimated differences in TPA and LPA participation and duration between Canadian-born, recent and established immigrant adults and assessed whether neighbourhood walkability accounted for these group differences. Second, we examined whether the direction and magnitude of associations between neighbourhood walkability and TPA and LPA differed between Canadian-born, recent and established immigrant adults.

2. Materials and methods

2.1. Study design and data source

Secondary analysis was undertaken using cross-sectional data from the Canadian Community Health Survey 2017-2018 two-year combined data file (CCHS 2017-2018) (Statistics Canada, 2018). We used residential postal codes to link CCHS data to the Canadian Active Living Environment dataset (Can-ALE 2016) (CANUE, 2018). The CCHS is a nationally representative survey of Canadian residents aged ≥12 years in all provinces and territories, excluding those living on Aboriginal settlements, Canadian Forces bases, institutions, and some remote areas. The CCHS utilizes a complex three-stage cluster-sampling design. For CCHS 2017-2018, the response rate for adults aged ≥18 years was 61.5% (Statistics Canada, 2018).

Fig. 1 describes the selection of participants for analysis from the merged CCHS-Can-ALE dataset (n=113,735). The dataset was reduced to n=73,929 after removing ineligible cases. Eligible cases included adults aged ≥18 years residing in urban areas, who were either Canadian-born or had non-temporary immigration status and reported duration of residence in Canada. After removal of cases with missing data for any of our variables, the final dataset included n=72,116 individuals.

2.2. Variables

2.2.1. Outcome variables

2.2.1.1. Transportation and leisure physical activity. Participation and duration of moderate-to-vigorous PA undertaken for transportation and leisure were captured using the Physical Activity for Adults Questionnaire which has been validated in the Canadian context (Colley et al., 2018; Garriguet et al., 2015). To capture TPA, respondents were asked "In the last 7 days, did you use active ways like walking or cycling to get to places such as work, school, bus stop, shopping centre or to visit friends?". To capture LPA, respondents were asked "In the last 7 days, did you do sports, fitness or recreational physical activities, organized or non-organized, that made you sweat at least a little and breathe harder?". Respondents reporting any participation also reported the total time they spent undertaking TPA and LPA for activities they had performed for at least 10 min continuously. Our analysis included two binary outcomes (*participation* in TPA and LPA) and two continuous outcomes (*duration* of TPA and LPA among those reporting any participation).

2.2.2. Explanatory variables

2.2.2.1. Residency status. We followed previous approaches for determining residency status using CCHS data (Gimeno-Feliu and al., 2019). We adopted Statistics Canada's definition of "immigrant", which refers to a person not born in Canada with granted right to live in Canada permanently (Statistics Canada, 2016). Temporary residents, including work and study permit holders and refugees, were excluded from our analyses. Using country of birth, we identified individuals born in and outside of Canada. Those born outside of Canada reported whether they were currently or had ever been an immigrant. Individuals identifying as immigrants also reported the year they arrived in Canada (i.e., landing). We estimated time since settlement by subtracting the year landed from the year the interview was completed. Subsequently, we categorized individuals according to their residency status as Canadian-born, recent immigrant (<10 years post-settlement), or established immigrant (≥10

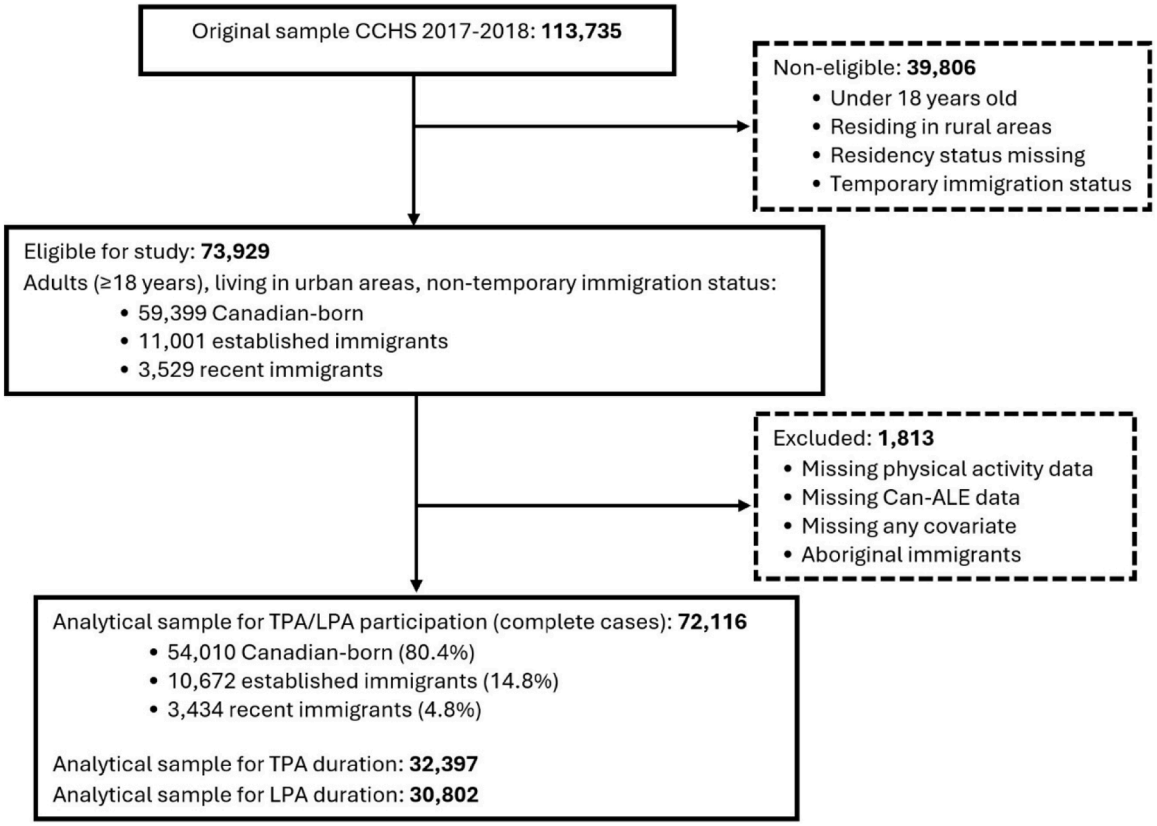

Fig. 1. Flow diagram showing selection of sample for analysis. CCHS: Canadian Community Health Survey, TPA: Transportation physical activity, LPA: Leisure physical activity, Can-ALE: Canadian Active Living Environment.

years post-settlement).

2.2.2.2. Neighbourhood walkability. We used the Can-ALE index to estimate walkability of the participants' residential neighbourhood (Herrmann et al., 2019; CANUE, 2018). The Can-ALE index is a pan-Canadian measure available for all 6-digit postal codes (Herrmann et al., 2019). It is estimated from summing z-scores of counts for three PA-supportive built environment characteristics (i.e., three-way intersection density, dwelling density, and points of interest) within a one-kilometer circular buffer around the geo-located centre points of dissemination areas (smallest geographical unit used by Statistics Canada with a population of 400-700 persons) (Herrmann et al., 2019). Higher index scores reflect higher neighbourhood walkability. Studies have found positive associations between Can-ALE index scores and PA (McCormack, 2017; Colley et al., 2019; Mah et al., 2020) and TPA specifically (McCormack, 2017; Hajna et al., 2015; Herrmann et al., 2019; Colley et al., 2019).

2.2.3. Covariates (Sociodemographic characteristics)

Informed by previous studies (Langøien et al., 2017; Bauman et al., 2012; O'Driscoll et al., 2014) and variables available within the CCHS dataset, we identified covariates for our analysis, including age, sex (i.e., male or female), marital status (i.e., married/common-law, widowed, separated/divorced, single/not-married), educational attainment (i.e., less than secondary, completed secondary, completed post-secondary, did not know/refused), employment status (i.e., employed or unemployed), English/French language proficiency (i.e., proficient in either English or French, or non-proficient), children at home (i.e., none or any aged ≤5 years, 6-11 years, and 12-18 years), race/ethnicity (i.e., White, South Asian, East/Southeast Asian, Black, Latin America, West Asian/Arab, Aboriginal, or other), annual household income (i.e., ≤CA$29,999, CA$30,000-CA$59,999, CA$60,000-CA$99,999, CA$100,000-CA$149,999, ≥CA$150,000), and health limitations (i.e., none or reporting any difficulty in seeing, hearing, mobility, communication, cognition, or self-care).

2.3. Statistical analysis

Adopted from the approaches recommended and employed in previous studies to address outliers and possible over-reporting (Colley et al., 2018; Garriguet et al., 2015), we truncated duration of TPA (n=384 outliers) and LPA (n=156 outliers) that exceeded 1500 min/-week. We estimated descriptive statistics for all variables by residency status. To examine differences in TPA and LPA (i.e., *participation* and *duration*) between Canadian-born, recent and established immigrants (first objective), we used Generalized Linear Models (GLMs). GLMs with binomial distribution and logit link estimated the odds of *participation* in TPA and LPA among recent and established immigrants relative to Canadian-born (reference group). Among the subset of cases reporting any participation (≥10 min/week; n=32,397 for TPA and n=30,802 for LPA), GLMs with gamma distribution and identity link estimated the mean differences in weekly *duration* of TPA and LPA among recent and established immigrants relative to Canadian-born (reference group). Across TPA and LPA participation and duration outcomes models, we applied sequential adjustment of covariates (i.e., no adjustment, partial adjustment for sociodemographic variables only, and full adjustment for sociodemographic variables and Can-ALE index). Observing attenuation or lack thereof resulting from sequential adjustment provided insights into whether neighbourhood walkability explained differences in TPA and LPA among recent and established immigrants and Canadian-born. To assess whether the association between walkability and TPA and LPA outcomes differed by residency status (second objective), interaction terms were added to the fully adjusted GLMs. For statistically significant interactions, we performed stratified analyses to estimate associations

Table 1
Weighted estimates of sample characteristics by residency status: CCHS 2017-2018.

	Total	Residency status		
	Mean (SD) or Proportion (95% CI)	Canadian-born Mean (SD) or Proportion (95% CI)	Recent immigrant Mean (SD) or Proportion (95% CI)	Established immigrant Mean (SD) or Proportion (95% CI)
Weighted sample	22,352,016	15,894,391 (71.1%)	1,752,550 (7.8%)	4,705,076 (21.0%)
Age	47.8 (18.04)	47.1 (18.31)	37.2 (11.74)	53.5 (16.92)
Can-ALE Index	0.8 (3.52)	0.5 (3.26)	2.2 (4.55)	1.4 (3.73)
TPA duration	212.0 (251.97)	216.2 (260.56)	199.5 (221.69)	202.9 (232.85)
LPA duration	232.6 (223.18)	238.7 (226.95)	208.1 (212.53)	215.1 (208.73)
TPA participation				
Non-participant	51.6 (50.9, 52.2)	51.7 (51.0, 52.4)	43.8 (41.2, 46.4)	54.0 (52.4, 55.5)
Participant	48.4 (47.8, 49.1)	48.3 (47.6, 49.0)	56.2 (53.6, 58.8)	46.1 (44.5, 47.6)
LPA participation				
Non-participant	54.2 (53.6, 54.9)	51.1 (50.4, 51.8)	63.1 (60.6, 65.5)	61.3 (59.9, 62.6)
participant	45.8 (45.2, 46.4)	48.9 (48.2, 49.6)	36.9 (34.5, 39.5)	38.7 (37.4, 40.1)
Sex				
Male	49.1 (48.8, 49.3)	49.3 (48.9, 49.7)	46.2 (43.6, 48.8)	49.4 (48.2, 50.5)
Female	50.9 (50.7, 51.2)	50.7 (50.3, 51.2)	53.8 (51.2, 56.5)	50.7 (49.5, 51.9)
Marital status				
Married/common-law	61.3 (60.6, 62.1)	57.8 (57.0, 58.5)	73.4 (70.9, 75.8)	68.9 (67.3, 70.3)
Widowed	4.7 (4.5, 4.9)	4.7 (4.5, 4.9)	1.5 (1.0, 2.2)	5.9 (5.4, 6.5)
Separated/divorced	8.3 (7.9, 8.7)	8.6 (8.3, 9.0)	3.4 (2.7, 4.4)	8.9 (8.0, 9.8)
Single/not married	25.7 (25.2, 26.2)	28.9 (28.3, 29.6)	21.6 (19.4, 23.9)	16.4 (15.2, 17.6)
Educational attainment				
Completed post-secondary	64.5 (64.0, 65.1)	62.6 (62.0, 63.3)	73.2 (70.5, 75.8)	67.7 (66.2, 69.2)
Other	35.5 (34.9, 36.0)	37.4 (36.7, 38.0)	26.8 (24.3, 29.6)	32.3 (30.8, 33.8)
Health limitations*				
None	92.4 (92.1, 92.7)	92.0 (91.6, 92.3)	97.9 (97.1, 98.4)	92.1 (91.2, 92.8)
Yes	7.6 (7.3, 7.9)	8.1 (7.7, 8.4)	2.1 (1.59, 2.86)	8.0 (7.2, 8.8)
Employment				
Worked at a job	60.3 (59.7, 60.8)	60.4 (59.8, 61.0)	67.6 (65.1, 70.0)	57.1 (55.8, 58.5)
Had a job but absent	5.1 (4.8, 5.4)	5.5 (5.2, 5.9)	3.8 (2.9, 5.0)	4.2 (3.6, 4.8)
Did not have a job	34.6 (34.1, 35.2)	34.1 (33.5, 34.7)	28.6 (26.3, 31.1)	38.7 (37.4, 40.0)
Race/ethnicity				
White	71.5 (70.8, 72.2)	88.0 (87.5, 88.5)	17.1 (15.2, 19.0)	36.1 (34.5, 37.7)
Visible minority	28.5 (27.8, 29.2)	12.0 (11.5, 12.5)	83.0 (81.0, 85.8)	64.0 (62.4, 65.5)
Annual household income				
0-29,999	12.3 (11.8, 12.7)	11.7 (11.3, 12.2)	19.1 (17.1, 21.3)	11.4 (10.6, 12.4)
30,000-59,999	20.5 (20.1, 21.0)	19.6 (19.1, 20.1)	26.3 (24.1, 28.6)	21.5 (20.2, 22.8)
60,000-99,999	24.1 (23.6, 24.6)	24.2 (23.6, 24.7)	23.8 (21.6, 26.1)	24.0 (22.8, 25.3)
100,000-149,999	20.7 (20.2, 21.2)	20.9 (20.4, 21.5)	18.6 (16.5, 20.8)	20.8 (19.5, 22.2)
>=150,000	22.4 (21.8, 23.0)	23.6 (22.9, 24.3)	12.2 (10.7, 14.0)	22.3 (20.9, 23.7)
Child <5 years				
None	86.4 (86.0, 86.9)	88.3 (87.8, 88.7)	66.1 (63.4, 68.6)	87.8 (86.7, 88.9)
At least one	13.6 (13.1, 14.0)	11.7 (11.3, 12.2)	34.0 (31.4, 36.6)	12.2 (11.1, 13.3)
Child 6-11 years				
None	86.4 (86.0, 86.8)	88.4 (88.0, 88.9)	74.0 (71.5, 76.3)	84.0 (82.8, 85.1)
At least one	13.5 (13.2, 14.1)	11.6 (11.2, 12.0)	26.0 (23.7, 28.5)	16.0 (14.9, 17.2)
Child 12-18 years				
None	86.0 (85.5, 86.5)	87.9 (87.4, 88.3)	78.6 (76.0, 80.9)	82.5 (81.3, 83.7)
At least one	14.0 (13.5, 14.5)	12.2 (11.7, 12.6)	21.5 (19.1, 24.0)	17.5 (16.3, 18.8)

Unweighted sample size = 72,611.
Health limitations is defined as reporting any difficulty in seeing, hearing, mobility, communication, cognition, or self-care).
TPA: Transportation physical activity, LPA: Leisure physical activity.
Note: To meet the confidentiality and cell count threshold requirements of the Statistics Act, language proficiency is not reported. Educational attainment is aggregated into two groups: those who have completed post-secondary education and those with less education (encompassing less than secondary, completed secondary, and unknown or refused responses). Race/ethnicity is classified as either white or visible minority.

(slope) between walkability and PA separately for Canadian-born individuals, recent immigrants, and established immigrants. We then conducted pairwise comparisons using Wald tests to compare the magnitude of these slopes (i.e., log-odds and unstandardized β coefficients).

The analyses were undertaken using Stata 18.0 (StataCorp, College Station, TX, USA). We estimated 95% confidence intervals (CI) and statistical significance was determined using a *p*-value of 0.05. Survey weights provided by Statistics Canada were employed to address non-response bias and to improve generalizability of estimates to the Canadian population. We used bootstrap replicate weights (n=1000) for variance estimation to account for the complex survey design of the CCHS.

3. Results

3.1. Sample characteristics

Table 1 shows descriptive statistics for the weighted sample. Of the sample, 71.1% were Canadian-born, 7.8% were recent immigrants, and 21.0% were established immigrants. The average age of participants was 47.7 (SD=18.0) years and the sample included similar proportions of males and females. Compared to Canadian-born (Can-ALE: 0.52, SD=3.26), recent (Can-ALE: 2.19, SD=4.55) and established immigrants

Table 2
Odds ratios (OR) and 95% confidence intervals (CI) for the associations between residency status and participation in transportation and leisure physical activity.

	Unadjusted		Partially adjusted[#]		Fully adjusted[##]	
	OR (95% CI)	***p*-value**	**OR (95% CI)**	***p*-value**	**OR (95% CI)**	***p*-value**
Transportation physical activity participation						
Residency status						
Canadian-born	Ref.		Ref.		Ref.	
Recent immigrant	**1.46** (1.36, 1.57)	<0.001	**1.25** (1.09, 1.43)	0.001	1.02 (0.89, 1.18)	0.738
Established immigrant	0.98 (0.94, 1.02)	0.422	**1.11** (1.02, 1.20)	0.017	0.99 (0.91, 1.07)	0.759
Can-ALE Index	-	-	-	-	**1.18** (1.16, 1.20)	<0.001
Leisure physical activity participation						
Residency status						
Canadian-born	Ref.		Ref.		Ref.	
Recent immigrant	**0.83** (0.77, 0.89)	<0.001	**0.58** (0.51, 0.67)	<0.001	**0.58** (0.50, 0.66)	<0.001
Established immigrant	**0.79** (0.76, 0.82)	<0.001	**0.81** (0.74, 0.89)	<0.001	**0.81** (0.74, 0.88)	<0.001
Can-ALE Index	-	-	-	-	1.01 (0.99, 1.02)	0.056

Estimates based on GLM (binomial distribution and logit link function) using weighted sample (n=22,352,016)
[#] Partially adjusted model controls for sociodemographic variables only (age, sex, marital status, education, employment, income, language proficiency, race/ethnicity, health limitation, number of children aged < 18 years).
[##] Fully adjusted model controls for sociodemographic variables plus walkability (Can-ALE index).

(Can-ALE: 1.37, SD=3.37), on average, resided in more walkable neighbourhoods. Relative to other residency groups, recent immigrants were younger and included a higher proportion reporting married or common-law relationships, no physical limitations, being employed, identifying as a visible minority, having an income ≤CA$59,999/year, and having at least one child of any age. Apart from marital status and race/ethnicity, Canadian-born and established immigrants appeared more similar to one another with regard to their sociodemographic characteristics than to recent immigrants.

3.2. Residency status and TPA participation

In our sample, 48.3% (95%CI: 47.6, 49.0) of Canadian-born, 56.2% (95%CI: 53.6, 58.8) of recent immigrants, and 46.1% (95%CI: 44.5, 47.6) of established immigrants participated in TPA in the last week. Controlling for sociodemographic characteristics only (partially adjusted model), the odds of TPA participation were significantly higher among recent (OR: 1.25, 95%CI: 1.09, 1.43) and established immigrants (OR: 1.11, 95%CI: 1.02, 1.20) (Table 2). After controlling for walkability (fully adjusted model) however, the odds of TPA became similar between the three residency groups, suggesting that differences in neighbourhood walkability explained the variations in TPA between these groups. Walkability was also positively associated with TPA participation (OR: 1.18, 95%CI: 1.16, 1.20) (Table 2). We found a significant interaction between walkability and residency status in relation to TPA participation (p=0.002). The stratified analysis revealed increased walkability associated with increased odds of TPA participation among Canadian-born (OR: 1.21, 95%CI: 1.18, 1.23), recent (OR: 1.11, 95%CI: 1.06, 1.16), and established immigrants (OR: 1.14, 95%CI: 1.09, 1.19) (Table 4). The association between walkability and TPA participation was higher in magnitude among Canadian-born (log-odds: 0.19) compared to recent (log-odds: 0.10; W=11.37, p<0.01) and established (log-odds: 0.13; W=6.28, p<0.05) immigrants.

3.3. Residency status and TPA duration

Among those participating in TPA, the average weekly duration of TPA was 216.2 (95%CI: 210.6, 221.8), 199.5 (95%CI: 182.4, 216.7), and 202.9 (95%CI: 191.3, 214.5) minutes in Canadian-born, recent, and established immigrants, respectively. In the partially adjusted model, there was no significant difference in the average weekly minutes of TPA for recent (β: 13.72, 95%CI: -6.04, 33.48) and established immigrants (β: 4.54, 95%CI: -8.92, 18.37) compared to Canadian-born (Table 3). After controlling for walkability (fully adjusted model), the average weekly minutes of TPA remained similar between the three residency groups. Walkability was also positively associated with TPA minutes (β: 5.63, 95%CI: 4.01, 7.24) (Table 3). We found a significant interaction between walkability and residency status in relation to duration of TPA (p=0.02). The stratified analysis revealed positive associations between walkability and average weekly minutes of TPA among Canadian-born (β: 6.76, 95%CI: 4.42, 9.11), recent (β: 3.49, 95%CI: 0.59, 6.39), and established immigrants (β: 2.43, 95%CI: 0.32, 4.53) (Table 4). The association (β) between walkability and TPA minutes was significantly higher in magnitude among Canadian-born compared to established (W=7.28, p<0.01) but not recent immigrants (W=2.96, p=0.082).

3.4. Residency status and LPA participation

In our sample, 48.9% (95%CI: 48.2, 49.6) of Canadian-born, 36.9% (95%CI: 34.5, 39.5) of recent immigrants, and 38.7% (95%CI: 37.4, 40.1) of established immigrants participated in LPA in the last week. In the partially adjusted model, the odds of LPA participation were significantly lower among recent (OR: 0.58, 95%CI: 0.51, 0.67) and established immigrants (OR: 0.81, 95%CI: 0.74, 0.89). Controlling for walkability (fully adjusted model) did not alter these estimates, with recent (OR: 0.58, 95%CI: 0.50, 0.66) and established immigrants (OR: 0.81, 95%CI: 0.74, 0.88) remaining less likely to participate in LPA than Canadian-born. This suggests that differences in neighbourhood walkability may not explain residency group differences in LPA participation. Walkability was also not associated with LPA participation (OR: 1.01, 95%CI: 0.99, 1.02) (Table 2). The interaction between walkability and residency status in relation to LPA participation was not significant.

3.5. Residency status and LPA duration

Among those participating in LPA, the average weekly duration of LPA was 238.7 (95%CI: 234.3, 243.1), 208.1 (95%CI: 189.6, 226.6), and 215.1 (95%CI: 206.1, 224.0) minutes in Canadian-born, recent, and established immigrants, respectively. In the partially adjusted model, compared to Canadian-born, the average weekly minutes of LPA were significantly lower among recent (β: -20.61, 95%CI: -37.89, -3.34) and established immigrants (β: -18.85, 95%CI: -28.69, -9.00). After controlling for walkability (fully adjusted model) however, the average weekly minutes of LPA became similar between the three groups suggesting neighbourhood walkability accounted for residency group differences in LPA duration. Walkability was not significantly associated with LPA minutes (β: -1.28, 95%CI: -2.87, 0.38) (Table 3). The interaction between walkability and residency in relation to duration of LPA

Table 3
Unstandardized beta coefficients (β) and 95% confidence intervals for the associations between residency status and duration of transportation and leisure physical activity.

	Unadjusted		Partially adjusted[#]		Fully adjusted[##]	
	B (95% CI)	***p*-value**	**B (95% CI)**	***p*-value**	**B (95% CI)**	***p*-value**
Transportation physical activity duration						
Residency status						
Canadian-born	Ref.		Ref.		Ref.	
Recent immigrant	-16.65 (-34.86, 1.55)	0.073	13.72 (-6.04, 33.47)	0.174	3.68 (-15.39, 22.75)	0.705
Established immigrant	**-13.31** (-26.23, -0.39)	0.044	4.72 (-8.92, 18.37)	0.498	-0.02 (-13.93, 13.89)	0.998
Can-ALE Index	-	-	-	-	**5.63** (4.01, 7.24)	<0.001
Leisure physical activity duration						
Residency status						
Canadian-born	Ref.		Ref.		Ref.	
Recent immigrant	**-30.61** (-49.56, -11.67)	0.002	**-20.61** (-37.89, -3.34)	0.019	-5.23 (-24.20, 13.73)	0.589
Established immigrant	**-23.65** (-33.64, -13.66)	<0.001	**-18.85** (-28.69, -9.00)	<0.001	-5.91 (-18.51, 6.70)	0.358
Can-ALE Index	-	-	-	-	-1.28 (-2.87, 0.31)	0.115

Estimates based on GLM (gamma distribution and identity link function) using weighted sample (n= 10,827,863 for transportation duration, n= 10,236,749 for leisure duration)

[#] Partially adjusted model controls for sociodemographic variables only (age, sex, marital status, education, employment, income, language proficiency, race/ethnicity, health limitation, number of children aged < 18 years).

[##] Fully adjusted model controls for sociodemographic variables plus walkability (Can-ALE index).

Table 4
Odds ratios (OR) and unstandardized beta coefficients (β) with 95% confidence intervals (CI) for the associations between neighbourhood walkability and transportation physical activity by residency status.

	TPA participation OR (95% CI)[*]	***p*-value**	TPA minutes β (95% CI)[**]	***p*-value**
Association with walkability				
Residency status				
Canadian-born	**1.21** (1.18, 1.23)	<0.001	**6.76** (4.42, 9.11)	<0.001
Recent immigrant	**1.11** (1.06, 1.16)	<0.001	**3.49** (0.59, 6.39)	0.019
Established immigrant	**1.14** (1.09, 1.19)	<0.001	**2.43** (0.32, 4.53)	0.024

Note: all models are adjusted for sociodemographic variables (age, sex, marital status, education, employment, income, language proficiency, race/ethnicity, health limitation, number of children aged < 18 years).

TPA: Transportation physical activity, LPA: Leisure physical activity.

[*] Estimates based on GLM (binomial distribution and logit link function) using weighted sample (n=22,352,016).

[**] Estimates based on GLM (gamma distribution and identity link function) using weighted sample (n= 10,827,863).

was also not significant.

4. Discussion

This study estimated the differences in TPA and LPA between Canadian-born, recent and established immigrant adults, and assessed whether neighbourhood walkability accounted for these differences. We also assessed whether associations between neighbourhood walkability and TPA and LPA differed between residency groups. Recent and established immigrants had higher participation (but not duration) in TPA compared to Canadian-born, and this difference attenuated after adjusting for neighbourhood walkability. Conversely, compared to Canadian-born, both recent and established immigrants had significantly lower participation in and duration of LPA but differences in the latter dissipated after adjusting for neighbourhood walkability. We also found interactions between walkability and residency status for TPA participation and duration such that associations between walkability and TPA were positive for all residency groups but differed in magnitude between them.

Previous studies have reported that recent immigrants walk, bike, and use public transport for their daily commutes more than Canadian-born even in more car-centric urban areas (Delbosc and Shafi, 2023; Harun et al., 2022; Preston et al., 2023). We found that compared to Canadian-born, recent and established immigrants were more likely to participate in TPA but this difference was no longer statistically significant after adjusting for neighbourhood walkability. Recent and established immigrants, on average, resided in more walkable neighbourhoods than Canadian-born, which may have contributed to the observed differences prior to walkability adjustment. We also found that despite recent and established immigrants being more likely than Canadian-born to participate in TPA, their average weekly duration of TPA was not significantly different. Nevertheless, higher neighbourhood walkability was positively associated with TPA participation and duration in Canadian-born, and recent and established immigrants, with association being higher in magnitude in Canadian-born. Our results are similar to a US study where higher Walk Score® was associated with an increased likelihood of purposive walking and more minutes walked in recent Cuban immigrants (Brown et al., 2013), though the authors did not compare the magnitude of this association between the residency groups. Factors such as lack of familiarity with the local environment and different perceptions of quality, safety, and comfort might explain why recent immigrants were less responsive to differences in neighbourhood walkability in terms of their TPA relative to Canadian-born. Cultural norms and previous experiences that might shape perceptions have been reported as factors affecting immigrants' interaction with built environments (Edge et al., 2023; Hordyk et al., 2015). Qualitative evidence suggests that Canadian immigrants are eager to participate in active transportation and recognize its health benefits, but consider car dependency, cold weather, and limited daylight hours as barriers (Curtin et al., 2018).

In alignment with findings elsewhere (Tremblay et al., 2006; Juárez et al., 2022; Lear et al., 2009), we observed that compared to

Canadian-born, recent and established immigrants had significantly lower weekly LPA participation and duration. However, after adjusting for walkability, we found that between-group differences in LPA participation remained relatively unchanged while between-group differences in LPA duration attenuated. Similar to results from a US study in a sample of Mexican-American adults with a high proportion of immigrants (Oluyomi et al., 2014), we did not find any significant interactions between walkability and residency status for LPA participation and duration. Previous qualitative evidence suggests accessible urban greenspaces, culturally-appropriate and inclusive infrastructure, and opportunities to engage with local communities are important for supporting LPA among immigrants (Edge et al., 2023; Hordyk et al., 2015). Our findings could suggest that cultural, social, and structural barriers faced by immigrants might be more influential than neighbourhood walkability in shaping their participation in LPA. Such barriers may include limited language proficiency and social isolation that hinder their access to recreational opportunities and activities (Langøien et al., 2017; Dogra et al., 2010). Additionally, financial constraints due to job market disparities and underemployment might lead immigrants to work in multiple low-wage jobs (Moyce and Schenker, 2018; Raihan et al., 2023). This situation might result in reduced discretionary time (Statistics Canada, 2024), leading immigrants to deprioritize leisure activities.

4.1. Strengths and limitations

The strengths of our study include the analysis of nationally representative data which enhances generalizability, our focus on participation and duration for two domains of PA (i.e., transportation and leisure), inclusion of an objective measure of neighbourhood walkability, and the novelty of this study with regard to comparing associations between neighbourhood walkability and PA among Canadian-born, recent and established immigrants. Our study also has several limitations. The Can-ALE index does not capture the full spectrum of neighbourhood built features (e.g., parks and greenspace, sidewalks and pathways, interesting sites, architecture) that may be important for encouraging PA, and in particular LPA (McCormack and Shiell, 2011; Kärmeniemi et al., 2018). The cross-sectional data does not allow for causal inferences and there is potential for confounding due to residential self-selection (McCormack and Shiell, 2011; Lim et al., 2015). While statistically controlling for sociodemographic characteristics might mitigate some of this bias, the reasons for neighbourhood choice are likely to differ between recent and established immigrants, and non-immigrant Canadian-born individuals. Neighbourhood preferences may be anchored and informed by the built environments to which immigrants were exposed before settling in their host country. New immigrants might prioritize neighbourhoods with proximity to cultural communities or services that cater to their specific needs (Charles, 2003), whereas long-term residents might have different priorities when choosing neighbourhoods (e.g., quality of schools or amenities, property values, crime) (Wen, 2019). PA outcomes included in our study were self-reported and therefore susceptible to recall and social desirability biases (Sylvia et al., 2014). While our study is generalizable to the Canadian context, its applicability to other countries may be limited due to regional differences in built and natural environments, climate, culture, and immigration patterns.

5. Conclusion

Compared to Canadian-born, recent and established immigrants had lower LPA minutes, lower participation in LPA and higher participation in TPA, with the two latter explained by differences in neighbourhood walkability. Our findings suggest that the reasons behind lower LPA duration among immigrants deserve more research and public health attention. It might be useful for future studies to consider the more granular aspects of the neighbourhood built environment beyond walkability, including features that are particularly relevant to immigrant adults. For example, the presence of local recreational facilities offering amenities and activities that appeal to a broad range of cultures. Despite finding differences in the magnitude of associations between walkability and TPA, higher walkability was associated with higher TPA participation and duration regardless of residency status. Nevertheless, future studies should aim to deepen our understanding of the reasons and or mechanisms that explain why the relationships between neighbourhood walkability and TPA differ between recent and established immigrants, and non-immigrant Canadian-born individuals. Health promotion and urban planning interventions should consider the differential effects of neighbourhood walkability according to residency status to prevent widening disparities in PA.

Ethics approval and consent to participate

The Canadian Community Health Survey (CCHS) is conducted by Statistics Canada and regulated by the Statistics Act. This study was a secondary analysis of data available through a mechanism described in legislation or regulation and shared by Statistics Canada following an approval and vetting process to protect participant confidentiality. Thus, it does not require ethics review (exempt per Tri-Council Policy Statement, Ethical Conduct for Research Involving Humans (TCPS 2 2018), article 2.2). Participation in the Canadian Community Health Survey is voluntary, and participants provide informed consent.

Availability of data and materials

The data supporting the findings are from the Canadian Community Health Survey (2017-2018). No direct link to the dataset is available outside of the Research Data Centre. Data are available from Statistics Canada and accessible through the Canadian Research Data Centre Network (https://crdcn.ca/). Research Data Centres are operated under the provisions of Canada's Statistics Act, which states that persons retained under contract to perform special services under this act are deemed to be persons employed under this act while performing those services, in accordance with all the confidentiality rules. On approval, researchers undergo a deeming process and a contract is granted. Thus, access to the data is granted on a need-to-know basis. For those interested in obtaining access to these data sets, detailed contact information and application processes to gain access and guidelines to use Research Data Centre data can be found at https://www.statcan.gc.ca/eng/rdc/process.

CRediT authorship contribution statement

Hasti Masihay Akbar: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Tanvir C. Turin:** Writing – review & editing, Methodology, Conceptualization. **Dana Lee Olstad:** Conceptualization, Methodology, Writing – review & editing. **Gavin R. McCormack:** Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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