



# Leisure Time Physical Activity Levels in Immigrants by Ethnicity and Time Since Immigration to Canada: Findings from the 2011–2012 Canadian Community Health Survey

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## Abstract

New immigrants to Canada are mostly from Asian/South Asian countries currently experiencing low levels of physical activity (PA) and high rates of overweight/obesity. Little is known about the leisure time PA (LTPA) patterns of recent immigrants. Study sample was extracted from Canadian Community Health Survey (2011–2012). Based on reported daily energy expenditure on LTPAs over past 3 months, participants were categorized as physically active, moderately active, and inactive. Likelihood of being physically inactive was estimated for recent immigrants versus established immigrants. Higher proportion of recent immigrants were inactive (60%) compared to established immigrants (53%). Adjusted models estimated a higher likelihood of inactivity among recent immigrants (OR 1.40, 95% CI 1.13, 1.72) versus established immigrants. Inactivity was higher among immigrants of visible minorities, 58.8 versus 46.7% of white immigrants. Recent immigrants of visible minorities are at higher risk of being inactive. This highlights importance of developing programs to increase PA in specific groups of new immigrants.

**Keywords** Exercise · Physical activity · Inactivity · Immigrant · Minorities

## Introduction

Physical inactivity is an independent risk factor of non-communicable chronic diseases, contributing to an estimated 3.2 million premature deaths annually [1]. Cardiovascular events, stroke, hypertension, diabetes mellitus, breast and colon cancers have all been linked to physical inactivity [2]. Regular moderate physical activity (PA) is associated with a 30–50% reduction in the risk of cardiovascular events [3]. Physical inactivity also carries a huge economic cost. In 2009, the estimated healthcare costs attributed to physical inactivity in Canada were estimated to be around 7 billion

dollars or 4% of the total healthcare budget [4]. Current Canadian PA guidelines for adults recommend at least 150 min of moderate to vigorous-intensity aerobic PA per week, in bouts of 10 min or more [5]. Despite the evidence in favor of PA benefits, in 2014, only 53.7% of Canadians aged 12 years and older reported meeting the recommended guidelines for PA [6].

Immigrants are an important segment of Canadian society. In 2011, Canada had a total of about 6,775,800 foreign-born individuals who arrived as immigrants, representing 20.6% of the total population [7]. Visible minorities accounted for 78.0% of the immigrants who arrived between 2006 and 2011. Combined, the three largest visible minority groups—South Asians, Chinese and Blacks—accounted for 61.3% of the visible minority population in 2011 [7]. Since immigrants constitute a major proportion of the population, their health status has important implications for existing healthcare systems [8].

Immigrants' health behaviour is influenced by their new environment and the culture in the host countries [9]. Acculturation, the process of adopting attitudes, values, customs, beliefs and behaviours of another culture, may lead to change (either positive or negative) in health

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behaviour of immigrants over time [9, 10]. Numerous studies have either fully, or partially supported the hypothesis that increased acculturation is associated with higher leisure time and daily physical activity [11]. In Canada, some studies looking at the association between chronic diseases and physical activity among immigrants as well as levels of PA and time since immigration have consistently reported sub-optimal levels of PA in this group with high incidence of diabetes and cardiovascular disease [12–14]. An analysis of the pooled Canadian Community Health Survey (CCHS) data of cycles 2001–2003 by Bryan et al. and Tremblay et al. shows that despite the ‘healthy immigrant effect’, i.e., immigrants showing better health than the native born population upon their arrival to the adopted country, PA levels in immigrants overall, remain low, with physical inactivity particularly common in recent immigrants (with lower acculturation) [14]. Several complex reasons have been cited for sub-optimal physical activity in these populations, some of them pertaining to cultural and religious beliefs, issues with social relationships, socioeconomic challenges, environmental barriers, neighborhood walkability, and perceptions of health and injury [15, 16].

In the past, majority of immigrants to Canada originated from European countries. More recently, the largest group of new immigrants have arrived from Asia, specifically from the Philippines, China, and India [17]. Many of these low-middle to upper-middle income countries in the Asian and South Asian regions like Pakistan, India, Bangladesh, and China [18] have, in recent years, witnessed rapid economic prosperity resulting in increased mechanization of tasks, sedentary lifestyle, and a higher consumption of energy dense foods leading to historically high rates of overweight and obesity [19–21]. With a dramatic change in the composition of immigrants as well as immigration patterns, it is postulated that recent immigrants originating from these countries may exhibit different PA patterns compared to the ones who immigrated a decade ago. In the presence of an established link between low PA and chronic diseases, and increasing evidence indicating that cardiovascular events and lifestyle factors vary greatly between ethnic groups [22], monitoring PA levels is important for public health surveillance and for an effective evaluation of the success of population-level interventions intended to increase levels of PA [23]. The shift in the immigration patterns necessitates an analysis of the relatively recent wave of CCHS data to assess PA levels among recently arrived immigrants. Using the 2011–2012 CCHS data, this study aims to explore the impact of time since immigration and other socio-demographic factors on LTPA behaviours of recent immigrants (< 10 years) versus established immigrants ( $\geq 10$  years) and explore potential interaction between time since immigration and ethnicity in Canadian immigrants.

## Methods

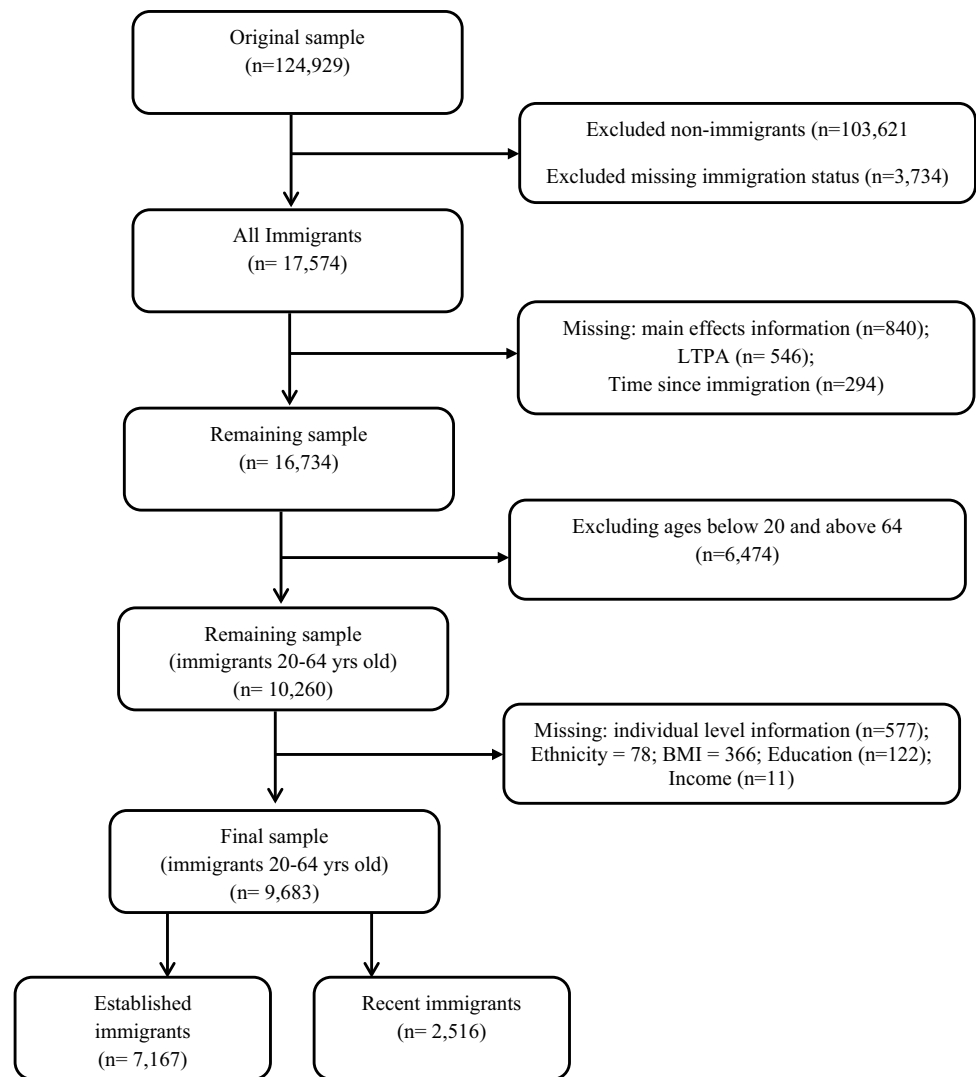
We conducted an analysis of a nationally representative cross-sectional survey, CCHS cycle 2011–2012. The CCHS uses a multistage sampling strategy to collect data about the health status of Canadians, determinants of their health status, and utilization of health care services. The survey covers approximately 98% of the Canadian population aged 12 or older excluding people living on Indian reserves or Crown lands, residents of institutions, enrolled full time members of the Canadian Armed Forces and residents of certain remote areas [24]. During 2011–2012, data were collected in 60-min interviews from 124,929 respondents residing in households in all Canadian provinces and territories, with an overall response rate of 86.5%. The 2011/2012 CCHS comprises information on a wide range of topics, including: PA, height and weight, smoking, exposure to second hand smoke, alcohol consumption, general health, chronic health conditions, injuries and use of health care services. It also provides information on the socio-demographic, income and labour force characteristics of the population [24]. Further details regarding CCHS questionnaire design, sampling and interview procedures are available from Statistics Canada [24].

## Study Sample

The current analysis investigated the association between time since immigration and LTPA. The overall sample included 17,574 immigrants (Fig. 1). For the purpose of this study, the sample was restricted to immigrants between 20 and 64 years of age. The target age range was selected to make the study findings comparable to those of Tremblay et al. who looked at a similar age group and outcomes using pooled data from cycles 1.1 (2000/01) and 2.1 (2003) of CCHS [14]. Individuals who did not have valid responses for the primary outcome variable ‘LTPA’ or the explanatory variable ‘length of time since immigration,’ or any of the confounding variables age, sex, ethnicity, BMI, household income from all sources, highest level of education and presence of a child  $\leq 5$  years, were excluded. After meeting the above inclusion/exclusion criteria, the final sample size included 9683 immigrants (55% of the original sample).

## Measures

The outcome LTPA was a derived variable based on the respondent’s participation in specific leisure-time physical activities. In CCHS, the LTPA is measured using a questionnaire modeled after the Minnesota Leisure Time Physical Activity Questionnaire [25]. During the interview, the interviewer read a list of 21 activities and recorded whether

**Fig. 1** Sample size changes based on exclusion of participants

or not the respondent had participated in each activity in the previous 3 months. The respondent was then asked if he or she participated in any other activities not already listed, and up to 3 “other activities” were recorded. The frequency and duration of each activity was also recorded and this information was used to calculate energy expenditure using the metabolic equivalents (METs) assigned to each activity [23]. The sum of the average daily energy expenditures of all leisure activities was used to categorize respondents into the following three groups: physically active (3.0 kcal/kg/day or more), moderately active (1.5–2.9 kcal/kg/day) and inactive (< 1.5 kcal/kg/day) [26].

Immigrant status was determined by a dichotomous response (Yes/No). The public use microdata-file (PUMF) made available by Statistics Canada categorizes time since immigration (our explanatory variable) as ‘recent’ if the individual immigrated between 0 and 9 years and ‘established’ if time since immigration was  $\geq 10$  years [27]. The above categorization was therefore applied to classify immigrants

as either recent or established. BMI was derived from self-reported height and weight of all respondents except pregnant women. Potential confounders such as age, sex (male, female), BMI (under-weight < 18.5, normal  $\geq 18.5$  to < 24.9, over-weight  $\geq 24.9$  to < 29.9, and obese  $\geq 29.9$ ), ethnicity (white, visible minority), presence of a child  $\leq 5$  years old (Yes/No), household income (income quintiles) and highest education level (< secondary, secondary, some/post secondary) were included in the model as previous studies have shown an association between these variables and level of PA in both immigrant and non-immigrant populations [14, 28–30].

## Analysis Plan

Analyses were conducted using SAS University Edition (Statistical Analysis Software Institute, Cary, NC, USA). Probability survey weights developed by Statistics Canada were applied to all analyses to account for the unequal sampling

probabilities for respondents. All CCHS respondents provide informed consent for participation and the public use microdata-file (PUMF) made available by Statistics Canada was accessed in accordance with the University of British Columbia's publicly available data clause (items 1.3.1 and 7.10) under policy number 89 which provides the ethical approval for the use of these data [31].

Descriptive statistics (frequencies) were calculated to describe features of the final analytic sample. A multinomial regression model was used to investigate the association between the primary outcome (LTPA) and explanatory variable (time since immigration), accounting for sampling design and adjusting for other covariates described above. Further analysis was performed to see whether there was any additional effect of ethnicity on the levels of LTPA by time since immigration. A variable was created combining time since immigration and ethnicity with the following categories: recent/white, established/white, recent/visible minority and established/visible minority.

## Results

### Participant Profile

The sample of 9683 immigrants included a slightly higher proportion of males (51.2%) (Table 1). Approximately 31% ( $n = 2516$ ) of the study sample identified themselves as recent immigrants. The majority of immigrants (67.3%,  $n = 5206$ ), and even higher proportions of recent immigrants (79.9%,  $n = 1872$ ), self-identified as a visible minority. Recent immigrants tended to be younger, with 40.2% ( $n = 1041$ ) between 30 and 39 years of age. A higher proportion (54.6%,  $n = 1378$ ) of recent immigrant's BMI was in the normal range compared to 47.5% of established immigrants. A lower proportion of recent immigrants (31.8%) were overweight (i.e., BMI 25–29.9) compared to established immigrants (34.6%). Recent immigrants were more highly educated, with 84.1% ( $n = 2100$ ) having some post-secondary or secondary education (vs 75.1% for established). A higher proportion of established immigrants (42.9 vs 24.7% recent) reported an income  $\geq$  \$80,000. A higher percent of recent immigrants (31.7%,  $n = 924$ ) reported having a child  $\leq$  5 year in the household, compared to established immigrants (15.8%).

### LTPA Patterns

Overall, the prevalence of physical inactivity was high with 54.9% of the immigrants being inactive. Those who reported some LTPA were almost equally distributed between the 'active' and 'moderately active' categories (21.2 and 23.9% respectively). A higher proportion of recent immigrants

reported inactivity (59.6%) compared to established immigrants (52.8%), while moderate levels of LTPA were almost equal between the two groups (Table 1). Inactivity was higher among visible minority immigrants, with 58.8% reporting being inactive (vs 46.7% white immigrants). Recent visible minority immigrants were more inactive (62.3 vs 48.8% of recent white immigrants). This difference continued to persist between established immigrants from a visible minority group (56.8%) compared to established white immigrants (46.2%). LTPA tended to increase with time since immigration (from 18.2% in recent immigrants to 22.6% in established immigrants).

### Association of Time Since Immigration and LTPA

The unadjusted odds of inactivity were higher among recent immigrants compared to established immigrants (OR 1.42, 95% CI 1.18, 1.72) (Table 2). The odds of moderate activity were comparable or not statistically different across established versus recent immigrants (OR 1.10, 95% CI 0.88, 1.39).

In the multinomial logistic regression model, the odds of inactivity among recent immigrants dropped only slightly (OR 1.40, 95% CI 1.13, 1.72) after adjusting for known confounders.

The adjusted odds of inactivity were highest among the 50–59-year-old age group (OR 2.28, 95% CI 1.70, 3.07), those who reported being underweight (OR 2.10, 95% CI 1.26, 3.52), had less than secondary education (OR 2.08, 95% CI 1.37, 3.14), belonged to the lowest income quintile: i.e., none or  $<$  \$20,000 income (OR 1.87, 95% CI 1.27, 2.73), and had one or more child 5 years old or younger (OR 1.46, 95% CI 1.13, 1.87).

Our sensitivity analysis identified an interaction between inactivity and ethnicity. After adjustment for other covariates, compared to established/white immigrants, higher odds of inactivity were observed in both recent/visible minorities (OR 2.63, 95% CI 2.01, 3.43) (Table 2, adjusted OR 2) and established/visible minorities (OR 1.93, 95% CI 1.56, 2.38). Although odds of inactivity were also higher for recent/white immigrants after adjustment (OR 1.44, 95% CI 1.01, 2.05), they remained lower than those observed for both groups of visible minorities.

## Discussion

Overall, the study found low levels of LTPA in recent immigrants compared to established immigrants. Inactivity was higher in visible minority immigrants compared to white immigrants. After adjusting for confounding factors, the likelihood of inactivity was still 1.46 times higher among recent immigrants and almost 2.63 times higher

**Table 1** Characteristics of study sample of immigrants by immigration status, 2011–2012 Canadian Community Health Survey

Variable	Overall study sample Total (N=9683)		Time since immigration			
	N	%	Recent (0–9 years)		Older ( $\geq 10$ years)	
	N	%	N	%	N	%
Length of time since immigration						
0–9 years	2516	31.1				
$\geq 10$ years	7167	68.9				
Physical activity						
Active	2445	21.2	526	18.2	1919	22.6
Moderate active	2309	23.9	569	22.2	1740	24.7
Inactive	4929	54.9	1421	59.6	3508	52.8
Sex						
Male	4483	51.2	1143	51.7	3340	50.9
Female	5200	48.8	1373	48.3	3827	49.1
Ethnicity						
White	4477	32.7	644	20.1	3833	38.3
Visible minority	5206	67.3	1872	79.9	3334	61.7
Age (years)						
20–29	1467	17.5	760	30.6	707	11.6
30–39	2153	24.1	1041	40.2	1112	16.8
40–49	2253	25.7	542	20.8	1711	27.9
50–59	2187	21.7	146	7.2	2041	28.2
60–64	1623	11.1	27	1.2	1596	15.5
BMI						
< 18.5	338	3.6	139	5.1	199	2.9
18.5–24.9	4628	49.7	1378	54.6	3250	47.5
25–29.9	3290	33.7	780	31.8	2510	34.6
$\geq 30$	1427	13.0	219	8.5	1208	15.1
Highest level of education						
< Secondary school	720	7.7	109	3.7	611	9.4
Secondary school	1408	14.4	307	12.2	1101	15.4
Some post sec or post secondary	7555	77.9	2100	84.1	5455	75.1
Total household income from all sources						
None or < \$20,000	799	7.9	275	12.4	524	5.9
\$20,000–\$39,999	1816	18.3	585	24.9	1231	15.3
\$40,000–\$59,999	1896	20.0	533	21.7	1363	19.2
\$60,000–\$79,999	1588	16.6	400	16.3	1188	16.7
$\geq$ \$80,000	3584	37.3	723	24.7	2861	42.9
No. of persons in household 5 years or less						
None	7777	79.3	1592	68.3	6185	84.2
One or more	1906	20.7	924	31.7	982	15.8

among recent immigrants of visible minority when compared to established white immigrants.

According to the 2012–2013 Canadian Health Measures Survey (CHMS) which measures PA objectively using an accelerometer, only 15% of Canadian adults meet the current PA guidelines for weekly moderate to vigorous PA [32]. Although, there has been no objective measurement of PA in immigrants in Canada at a national level, a pattern of low PA relative to non-immigrants has been

observed in previous studies among children as well as adults [13, 14, 21, 33, 34].

Time since immigration, (often used as a proxy measure for acculturation) [11], has been reported to influence PA behaviour in immigrants in Canada as well as in other countries including US and Britain [12, 14, 35–37]. A study examining correlates of health behaviours and self-rated health in middle-aged and older Asian Indian immigrants in the U.S. found younger age, longer length of residence

**Table 2** Unadjusted and adjusted multinomial logistic regression results (odds ratios) for relationship between time since immigration and physical activity, Canadian Community Health Survey sample (2011–2012)

	Unadjusted		Adjusted OR 1st		Adjusted OR 2nd <sup>a</sup>	
	Inactive OR (95% CIs)	Moderate active OR (95% CIs)	Inactive OR (95% CIs)	Moderate active OR (95% CIs)	Inactive OR (95% CIs)	Moderate active OR (95% CIs)
<b>Length of time since immigration</b>						
≥ 10 years	1		1		1	
0–9 years	1.42 (1.18, 1.72)	1.10 (0.88, 1.39)	1.40 (1.13, 1.72)	1.25 (0.97, 1.61)	N/A	N/A
<b>Sex</b>						
Male	1		1		1	
Female	1.39 (1.17, 1.65)	1.31 (1.07, 1.60)	1.32 (1.10, 1.60)	1.29 (1.05, 1.59)	1.32 (1.10, 1.60)	1.29 (1.05, 1.59)
<b>Age group</b>						
20–29	1		1		1	
30–39	2.04 (1.58, 2.62)	1.58 (1.18, 2.13)	2.00 (1.51, 2.65)	1.52 (1.09, 2.09)	2.00 (1.51, 2.65)	1.50 (1.08, 2.08)
40–49	1.80 (1.40, 2.30)	1.56 (1.16, 2.08)	2.20 (1.69, 2.86)	1.70 (1.25, 2.31)	2.20 (1.69, 2.86)	1.69 (1.25, 2.30)
50–59	1.56 (1.17, 2.06)	1.70 (1.19, 2.31)	2.28 (1.70, 3.07)	2.06 (1.44, 2.94)	2.29 (1.70, 3.08)	2.07 (1.45, 2.96)
60–64	1.52 (1.14, 2.01)	1.60 (1.15, 2.21)	2.19 (1.58, 3.04)	1.94 (1.35, 2.81)	2.20 (1.58, 3.04)	1.97 (1.36, 2.85)
<b>Ethnicity</b>						
White	1		1		1	
Visible min	1.92 (1.61, 2.30)	1.40 (1.15, 1.71)	1.90 (1.59, 2.28)	1.49 (1.20, 1.85)	N/A	N/A
<b>Ethnicity by time since immigration</b>						
White and established	1		1		1	
White and recent	1.23 (0.88, 1.72)	1.22 (0.85, 1.75)	N/A	N/A	1.44 (1.01, 2.05)	1.51 (1.03, 2.23)
Visible and recent	2.31 (1.80, 2.97)	1.43 (1.06, 1.92)	N/A	N/A	2.63 (2.01, 3.43)	1.84 (1.31, 2.59)
Visible and established	1.86 (1.15, 2.29)	1.46 (1.15, 1.85)	N/A	N/A	1.93 (1.56, 2.38)	1.59 (1.24, 2.03)
<b>BMI</b>						
< 18.5	1		1		1	
18.5–24.9	2.28 (1.40, 3.71)	1.42 (0.80, 2.60)	2.10 (1.26, 3.52)	1.40 (0.75, 2.62)	2.11 (1.26, 3.53)	1.41 (0.75, 2.63)
25–29.9	1.13 (0.93, 1.40)	1.13 (0.90, 1.42)	1.17 (0.96, 1.43)	1.16 (0.92, 1.46)	1.17 (0.96, 1.43)	1.16 (0.92, 1.46)
≥ 30	1.70 (1.32, 2.18)	1.13 (0.84, 1.53)	1.71 (1.29, 2.28)	1.20 (0.86, 1.68)	1.72 (1.29, 2.29)	1.20 (0.86, 1.68)
<b>Highest level of education</b>						
Some or post secondary	1		1		1	
< Secondary school	2.27 (1.56, 3.31)	1.42 (0.87, 2.32)	2.08 (1.37, 3.14)	1.45 (0.88, 2.41)	2.08 (1.37, 3.14)	1.45 (0.88, 2.41)
Secondary school	1.28 (1.00, 1.64)	0.97 (0.73, 1.28)	1.24 (0.95, 1.62)	0.97 (0.72, 1.30)	1.24 (0.95, 1.62)	0.97 (0.72, 1.30)
<b>Total household income from all sources</b>						
\$80,000 or more	1		1		1	
No Income or < \$20,000	2.30 (1.61, 3.30)	1.27 (0.80, 2.01)	1.87 (1.27, 2.73)	1.16 (0.74, 1.84)	1.87 (1.27, 2.75)	1.18 (0.74, 1.87)
\$20,000–\$39,999	1.98 (1.55, 2.53)	1.02 (0.77, 1.35)	1.64 (1.28, 2.11)	0.93 (0.70, 1.24)	1.65 (1.28, 2.11)	0.94 (0.70, 1.25)
\$40,000–\$59,999	1.96 (1.54, 2.48)	1.00 (0.75, 1.34)	1.71 (1.33, 2.19)	0.90 (0.67, 1.21)	1.71 (1.33, 2.19)	0.90 (0.67, 1.21)
\$60,000–\$79,999	1.82 (1.43, 2.32)	1.29 (0.97, 1.72)	1.65 (1.28, 2.11)	1.25 (0.93, 1.67)	1.64 (1.28, 2.11)	1.24 (0.93, 1.66)
<b>No. of children in household 5 years or less</b>						
None	1		1		1	
1 or more	1.73 (1.40, 2.14)	1.37 (1.05, 1.77)	1.46 (1.13, 1.87)	1.31 (0.97, 1.78)	1.46 (1.13, 1.87)	1.31 (0.97, 1.78)

<sup>a</sup>Adjusted for sex, age, ethnicity by time since immigration, BMI, education, income and children in household ≤ 5 years of age

and a more American ethnic identity was associated with greater participation in PA [37]. In Canada, Tremblay et al. showed a gradient in the prevalence of moderate physical activity with recent immigrants (16%), established immigrants (20%), and non-immigrants (24%) [14]. This corroborates the findings of some previous studies conducted

in Canada and United States that found a similar pattern in their immigrant populations [38–40]. In our study, a similar trend was seen regarding moderate physical activity levels in recent versus established immigrants with a higher proportion of established immigrants (24.7%) reporting moderate levels compared to recent immigrants (22.2%).



Apart from time since immigration, ethnicity has also been shown to be associated with PA levels. A number of studies have shown low levels of PA among ethnic minority groups within the UK, USA and Canada [12, 36, 41]. Bryan et al.'s analysis of the pooled data from cycles 1.1 (2000/01) and 2.1 (2003) of CCHS revealed that compared to white men, West Asian or Arab, South Asian and East or South-East Asian men, had the lowest odds of being moderately to highly active (OR 0.6, 95% CI 0.5, 0.7) [12]. Low levels of PA in South Asian immigrants and specifically women have also been reported in studies from the UK and USA [33, 37, 42]. Overall, visible minorities exhibit lower levels of PA compared to their white European/Caucasian counterparts [35, 43–45].

In our multivariable model, odds of physical inactivity remained high among recent immigrants even after controlling for confounders known to influence PA behaviour such as sex, age, ethnicity, BMI, education, income and having a child younger than 5 years old. Studies have shown the influence of life transition factors such as parenthood being associated with decreased PA participation whereby a drop in PA levels has been observed for both men and women [46]. In a study involving more than 7000 women aged 18–23 years followed up over a period of 4 years, Brown and Trost found that becoming a mother for the first time led to decreased PA participation over a 4-year follow-up period [28]. Recent immigrants being younger and a higher proportion of them having children under five, may thus be at a greater risk for decreased PA.

In our study, the unadjusted odds of inactivity were highest in the 30–39 years old age group (OR 2.04, 95% CI 1.58, 2.62) followed by 40–49 years old age group (OR 1.80, 95% CI 1.40, 2.30). However, once adjusted for known confounders, the odds of inactivity were highest among the 50–59-years old age group (OR 2.28, 95% CI 1.70, 3.07). This trend seems to be contrary to what was observed in the 2012–2013 CHMS. While a direct comparison with the CHMS survey may not be possible due to dissimilar age categories as well as a different mode of measurement, the CHMS survey results reported the 40–59 years old age group as being sedentary for 9 h and 49 min—only second in line to the most sedentary age group of 60–79 years old [32]. Other studies too have shown similar patterns of prevalence of physical inactivity increasing with age [47, 48]. Our analysis, on the contrary, shows the oldest age group of 60–64 years old being less inactive than the 50–59 years old age group. This warrants further investigation. A possible explanation could be the older age group having more leisure time at hand compared to younger age groups who may be working long hours.

Studies have also documented psychosocial and emotional factors that may cause stress resulting in poor health and negative health behaviors in immigrants [49–51].

Immigrants of an ethnic minority specifically may experience negative influences of racism, discrimination, higher rates of unemployment or underemployment, loss of social networks, social class and family support in their countries of adoption [52]. These social inequalities and exclusions are associated with both chronic disease risk and less healthful lifestyle behaviors [53]. We tried to adjust for some of these psychosocial stressors by adding income and education in our multivariable multinomial model but even after adjustment, odds of physical inactivity still remained high among recent immigrants.

With major shifts in the pattern of immigration in recent years, majority of immigrants coming to Canada identify themselves with a visible minority and are increasingly from countries in the Asian/South Asian region [17]. As noted earlier, many of these lower middle to upper middle income countries in the region like India, Pakistan, Bangladesh and China are currently undergoing a nutrition transition triggered by economic prosperity that in turn has been associated with low PA and rising prevalence of overweight and obesity in these regions [19, 54, 55]. Factors like access to new technologies, mechanization of many of the tasks that were once performed manually, a higher consumption of edible oils and high-calorie packaged foods, and modern supermarkets have changed the dietary and physical activity patterns at a global level [55]. In face of these changing dietary and PA behaviors in their countries of origin and long-term health implications of these continued behaviors in their country of adoption, an ongoing surveillance of these differentials in PA of immigrants is important for developing targeted programs for vulnerable groups. In our current analysis, we did not have access to ethnic classification as the public use microdata-file, for security purposes, limits access to high-level data only. But our findings show that recent immigrants of visible minority were more likely to be physically inactive. Given the shift in distribution of immigration with more immigrants coming from Asian countries (visible minorities), this may translate into a higher proportion of Canadians being physically inactive at the population level. This also highlights a need for developing and testing the effectiveness of intervention programs that could be delivered at the time of immigration as is done for infectious diseases such as tuberculosis to prevent future disease burden.

In our current study, ethnicity was only available as a categorical measure of 'white' or 'visible minority' and additional analysis to see if there was an interaction between the two broadly classified ethnicity categories of 'white' and 'visible minorities' and 'time since immigration' supported results reported in earlier studies [12, 21, 22, 42]. After adjustment for potential confounders, the odds of inactivity in recent as well as established visible minorities remained significantly high compared to

established/white immigrants. Since recent immigrants of visible minority groups are younger in age, there is a need for developing and testing intervention programs for engaging immigrants of visible minority group in PA promoting programs and activities at the time of immigration to prevent sedentary behavior related diseases among this population group in future.

Despite the large nationally representative samples used in this study, there are some limitations. Firstly, the energy expenditure values were based on the sum of the average daily energy expenditures of all leisure time physical activities only. Occupation related or active transportation activities were not included and including those could influence results. Secondly, terms like ‘moderate’, ‘vigorous’ PA may have different interpretations among immigrants of diverse cultures/ethnicities, thus resulting in measurement error [56, 57]. Thirdly, the 10-year interval differentiating recent immigrants from established immigrants is wide and does not allow assessment of how LTPA may change over shorter time periods. Lastly, the categorization of the ethnicity variable into white/visible minority was broad and relied on self-report. Although our results showed a strong association between physical inactivity and visible minority identification, future analysis should look at various ethnic groups within white and visible minority immigrant populations as this will provide more useful information for policy and intervention.

In summary, this study has shown that LTPA levels vary among immigrants based on time since immigration and ethnicity, with highest odds of inactivity in recent immigrants from visible minorities. It is projected that by 2031, visible minorities will constitute 31% of the total Canadian population [58]. Given evidence that immigrants who belong to certain groups such as South Asians are at higher risk for diabetes, obesity, hypertension and cardiovascular events due to genetic predispositions, poor diet and low levels of PA, the high prevalence of physical inactivity in visible minority Canadian immigrants poses a concern for future health of Canadian populations, particularly the chronic disease burden. The findings of this study underscore the importance of continued monitoring of PA behavior of immigrants, and the need for developing and implementing PA interventions targeting recent immigrants.

### Compliance with Ethical Standards

**Ethical Approval** This was a secondary analysis of data provided by Stats Canada. All CCHS respondents provide informed consent for participation and the public use microdata-file (PUMF) made available by Statistics Canada was accessed in accordance with the University of British Columbia’s publicly available data clause (items 1.3.1 and 7.10) under policy number 89 which provides the ethical approval for the use of this data [31].

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