Children's activity-transportation lifestyles, physical activity participation and social-ecological correlates in Toronto, Canada

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ABSTRACT

Recent years have seen the emergence of a literature into physical activity outcomes among children, in relation to their transportation and other movement choices. As this literature continues to grow, the importance of an integrated approach to understand a child's movement/ mobility behaviour is beginning to be recognized in policy and practice. However, few studies to date have examined patterns in daily activities and transportation choices together. An important research gap also exists at the intersection of activity-transportation lifestyles and physical activity. Using data gathered from 700 students attending grades 5 and 6, in 16 public elementary schools in Toronto, Canada, this research seeks to identify activity-transportation lifestyles among children, and their associations with physical activity levels measured using accelerometry. A two-step cluster analysis identified four distinct lifestyle clusters, namely- *Homebound*, *Readers, Artists* and *Athletes*. Various measures of physical activity accumulation were significantly different across these four lifestyle groups. *Athletes*, with a high amount of sports but also a high level of inactive transportation had the best physical activity levels, while *readers* and *homebound* groups had the worst. Further analysis using logistic regression models identified that a child's likelihood of belonging to a lifestyle group can be explained by their gender, ethno-cultural diversity, neighbourhood-level income and urban location (i.e., inner-city versus suburban). Findings from this study may inform future programming and interventions that would be developed in light of emerging guidelines focusing on children's 24-hour movement behaviour.

INTRODUCTION

Western countries have seen a change in children's activity participation behaviour in recent decades (*1*). Increased reliance on inactive forms of transportation (e.g., being driven to/from school and elsewhere), at least since the mid-1980s, has been reported in international research (*2-4*). A recent report has also indicated that only 9% of Canadian children between 5 and 17 years of age are meeting the daily recommended physical activity levels of 60-minutes a day; 76% of all children spend >2 hrs a day in front of screens for recreation (*5*). There is a need to identify travel behaviour and activities that could contribute to regular physical activity accumulation, in order to reverse the current trend of increasingly sedentary lifestyle choices among children, and to minimize risks of chronic diseases such as type II diabetes and cardio-vascular diseases (*5-7*).

An emerging literature has studied transportation choices and daily activity behaviour among children, in relation to physical activity-related outcomes. In the case of transportation, this has involved an exploration of active transportation modes (mainly walking and/or cycling) and independent mobility among children (*8-12)*. Lifestyle choices studied in relation to health outcomes have included, among other things, diet, participation in sports, categorical examinations of active versus sedentary activities, and unstructured play (*13-15*). However, a child may engage in physical activity in different environments (e.g., at home, at school, on the way to school) and contexts (e.g., transportation, play, sport) (*5*). Exploring one of these environments or contexts would provide only partial insights in relation to a child's physical activity outcomes. By contrast, a systematic analysis of the diverse daily activities simultaneously, and the identification of patterns or profiles of behavioural choices among children, could provide an improved understanding of the interplay of these activities, in relation to their potential effects on a child's health and wellbeing.

The importance of an integrated approach to understand a child's movement/ mobility behaviour is beginning to be recognized in policy and practice. For example, Canadian researchers have recently produced the first-ever 24-Hour Movement Guideline for Children and Youth (*5,16,17*). The guideline recommends that for optimum health benefit, a child or youth should engage in high levels of moderate-to-vigorous physical activity (≥ 60 mins a day), several hours of unstructured and unrestricted light physical activity, low levels of sedentary activity (<2 hrs of recreational screen time; limited sitting for extended periods) and sufficient sleep (8-11 hours with consistent bed and wake-up times). Patterns of physically active and/or sedentary behaviours among children and adolescents have been explored in the past (*14,18,19*). However, fewer studies have focused on the examining both daily activities and transportation choices together, in order to identify activity-transportation lifestyle patterns among children (*19,20*). An important research gap also exists at the intersection of activity-transportation lifestyle choices and related health outcomes. In other words, the relationship between children's activity-transportation lifestyle patterns and objectively measured physical activity is less known.

Within this context, this research explores the interaction between various daily activities and transportation choices, and several measures of physical activity outcomes, among elementary school-going children living in Toronto, Canada. More specifically, this research seeks to address three research questions. First, we explore if distinct patterns in daily activity-transportation behaviour exists among children. Second, we examine if these activity-transportation lifestyles are associated with children's physical activity levels. Lastly, and using a social-ecological framework, we investigate if activity-transportation lifestyles are different across socio-demographic groups and geographic locations. The findings emphasize the

importance of a holistic approach in understanding children's daily activity and travel behaviour, and may inform an emerging body of policy (e.g., the Canadian 24-Hour Movement Guideline for Children and Youth) and related programming focused on children's physical activity and health.

PREVIOUS RESEARCH ON CHILDREN'S DAILY MOVEMENT BEHAVIOUR

In recent years, significant policy and research interests have been placed on the use of active modes of transportation among children. Walking or bicycling, along with other means human-powered means of movement, can be a regular source of physical activity for children and youth (*21,22*). A smaller body of literature has elucidated the importance of active unstructured play, and the dangers of sedentary recreational activities. Studies have shown that children's physical activity outcomes are associated with higher amounts of active, unstructured, often outdoor, play (*23,24*). On the contrary, worse outcomes have been observed in children with a higher amount of time spent sedentary, which is most often associated with screen time in the form of television, video game or computer use (*25,26*).

A limited research has emphasized the importance of examining activity lifestyles among children, the scope of which spans more than one traditional area of inquiry (*14,19,20*). Some researchers have also explored transportation choices and lifestyle activities together to identify activity-transportation lifestyles (*19,20*). For example, Voulgaris et al. (*20*) sought to compare time spent in travelling to school with daily activity participation patterns, and found that those who actively travelled to school spent less time studying, exercising and engaging in structured extracurricular activities. In other words, their results indicated that patterns of both physically active and inactive activities may co-exist in a group of students, a suggestion that is also shared by other researchers (e.g., *14,19*).

To our knowledge, the relationship between activity and/or transportation lifestyles and objectively measured physically activity levels has yet to be systematically examined. Existing research, however, has used estimated measures of physical activity based on self-reported hours of engagement in physical or sedentary activity, in order to explore their correlations with a child's/ adolescent's activity lifestyles (*14,19*). The results from this limited literature remains mix, indicating that there may be no direct association between patterns of activity behaviour and physical activity levels.

A child's likelihood of undertaking a healthy behaviour (or opportunities for participation) can potentially be explained by social and ecological influences that may operate at multiple levels (e.g., personal, household and neighbourhood levels) (*27*). Several studies have explored the socio-demographic correlates of activity lifestyle, and have reported that patterns of daily activity participation may vary by a child's gender, race and ethnicity and household income (*14,18-20*). The abovementioned social-ecological model, as well as recent research focusing on children's active school transportation (*8-10*), independent mobility (*11*) and play (*23*), has emphasized the importance of physical environment. In the context of children's activity and/or transportation lifestyles, household environment (e.g., access to technology) has previously been studied (*18*). However, the potential influence of the neighbourhood environment on a child's daily activity-transportation participation patterns remain less known.

STUDY AREA AND DATA

This research explores children's activity-transportation lifestyle patterns in Toronto, Canada. Toronto is the largest city in Canada with a population of over 2.6 million people (*28*). The city features a diverse citizenry of different socio-economic statuses, and ethnic and cultural

backgrounds. Being one of the most multicultural cities in the world, nearly 45% of residents do not identify English or French (the two official languages in Canada) as their mother tongue (*28*). The neighbourhoods within the city have evolved over the last two centuries. The urban "inner-city" neighbourhoods are dominated by dense residential developments on gridded street networks, with mixed residential-commercial developments along the main-streets. Much of these inner-city neighbourhoods are resided by wealthier population groups, however, pockets of low-income and ethnic enclaves are also common. In contrast, the newer "suburban" neighbourhoods, largely built during the post-World War II period, became part of Toronto after a political amalgamation in 1998. These neighbourhoods are dominated by low-density houses along curvilinear streets that are designed for automobiles. These suburban neighbourhoods are largely populated by middle-to-higher income households, who represent a great diversity in terms of ethnicity and culture. The socio-demographic and environmental diversity within Toronto's neighbourhoods may also lead of a diversity in activity and transportation choices, which makes the city a suitable case study for this research.

Data used in this study came from Project BEAT (Built Environment and Active Transportation: www.beat.utoronto.ca). Between April 2010 and June 2011 (Fall and Spring), more than 1000 surveys were conducted among students in grades 5 and 6 and their parents/caregivers, from 16 public elementary schools within the City of Toronto. Half of these schools were located in inner-city neighbourhoods, while the other half were in the suburban neighbourhoods. In this paper, three types of data were analyzed: (1) parental/caregiver survey data containing socio-demographic and geographical information about the children and their households, (2) data from the activity diary completed by parents for their children, and (3) objective data on children's physical activity participation collected using accelerometry.

Parental/caregiver survey data provided information about a child's age and gender, household composition, ethnic background (i.e., language spoken at home), immigration/ residential mobility status (i.e., duration of stay in current residence), and household location categorized into inner-city versus suburban neighbourhoods. The BEAT surveys did not collect data on household income. As a result, we used dissemination area (DA: the smallest geographic unit at which Canadian census data is aggregated)-based census records of household income. Data from 2006 Population Census was used for this purpose; the more recent census data (2011) is less reliable due to changes in data collection method (*28*).

A parent or adult caregiver recorded their child's daily activities that were >15 mins in length, and related travel, in a travel diary/ journal. The dataset, which resulted from the recording of the travel diary over a four- day period (including two weekdays and the weekend), included more than 27,000 individual activities (self-described in an open-ended format) by 783 student participants.

In addition, objective data on children's physical activity participation was collected using accelerometry (ActiGraph© GT1M) for a seven-day period; further detail of the accelerometry protocol is reported elsewhere (*29*). The accelerometers collected data using a 5 second epoch, which is appropriate to capture rapid transitions in activity typical in children (*29,30*). From this data, several measures of a child's movement intensity were computed, using widely-recognized standards (*5,16,30*). Average daily minutes of accumulated Moderate- to-Vigorous Physical Activity (MVPA) for each child was estimated, using a threshold of >3580 counts$\cdot$min^{-1}; activities with lesser intensities were identified as Light Physical Activity (LPA). Percent of time in a day (i.e., of the duration for which a child wore the accelerometer) spent sedentary was identified as a measure of Sedentary Behaviour (SB).

DATA ANALYSIS

The goal of this research is to explore children's daily activities and travel in order to identify patterns of activity-transportation behaviour that may have an impact on their physical activity levels. This was achieved by means of cluster analysis. Cluster analysis focuses mainly on the process of categorization (*31*). By grouping children who are homogenous with regard to their daily activity participation and transportation, behavioural profiles of activity-transportation could be identified, which may not be apparent otherwise (e.g., *19,20*).

A total of 783 students had returned activity diaries as part of the BEAT study. For the purpose of this research, only children who recorded daily activities for at least one weekday and at least on weekend day were considered, in order to capture potential variations in daily activities between weekday and weekends during the school year. In addition, children who reported less than four trips overall were excluded from the sample.

The activities were self-reported and open-ended (i.e., students wrote down whatever activities they had performed). In order to perform an analysis seeking to categorize the sample according to similar attributes, these activities were initially grouped into a total of 26 categories. However, the purpose of this study was to identify daily patterns of activity and travel behaviour. As a result, categories that were not related to typical day-to-day activities (e.g., dentist's appointment) and/or did not constitute choices (i.e., without variations in participation time, such as attendance to school) were excluded from further analysis. Some activities were removed due to nature of reporting, because they were not specific enough to be identified as active or sedentary episodes (e.g., "after school program"). The importance of adequate sleep time is beginning to be recognized in policy and guidelines (e.g., *16*). However, in our activity diaries, the reported sleeping durations were not reliable, and as a result, this data was not included for analysis.

Next, time spent travelling to/from out-of-home activities were estimated based on geo-coded locations of origins and destinations. Mode-specific average speeds (walk: 4 km/ hr, cycle: 15 km/ hr, bus: 13 km/ hr, streetcar: 14 km/ hr, and car: 42 km/hr) were used for this estimation (*32-34*). A total of 186 trips had to be excluded because no travel mode information was reported.

After the abovementioned considerations, daily duration of a total of eight types of activities (Table 1) related to 700 students were included for cluster analysis. However, physical activity and socio-demographic data for all these children were not available, and as a result, subsequent multivariate analyses were performed using smaller sample sizes.

Cluster analysis was then performed using the two-step cluster model approach in SPSS (SPSS Statistics v.23). In a two-step approach, a hierarchical analysis is first performed to determine if there is a point where clearly separated clusters emerge. A *k*-Means cluster analysis is conducted next, with the desired number of clusters indicated (*31*). Daily time spent (min/ day) on each activity type by a child (averaged across the duration of activity diary) was used as the Euclidean "distance" measure for the cluster analysis. The goodness-of-fit for the cluster solutions was measured using the silhouette measure of cohesion and separation, which is based on the average distances between the variables, and can range between – 1 and +1 (*31,35*).

TABLE 1 Children's Daily Activity Types (n = 700)

Activity Type	Description	Avg. min/ day (S. D.)
Active Transport	Walking, bicycling, skateboarding and other similar human-powered means of transportation.	33.3 (41.8)
Inactive Transport	Being driven (car, transit, schoolbus)	29.4 (41.9)
Active Unstructured Play	Playing a game such as tag, or similar.	54.4 (59.1)
Sports	Any activity which is identifiably related to a sport or specifically identifies a sport e.g. 'hockey', 'soccer'.	32.4 (46.8)
Arts	Activities such as painting, drama or colouring.	10.0 (21.4)
Education	Tutoring, or attending club activities that emphasize scholastic achievement.	10.3 (24.1)
Reading	This category is only comprised of situations where the activity is specifically listed as 'reading'	11.4 (23.1)
Screen time	This category broadly contains use of television, computer and videogame play.	87.2 (70.7)

Following the cluster analysis, additional analyses were conducted to further explore the identified clusters of activity-transportation behaviour among children. First, one-way analysis of variance (ANOVA) and chi-square tests were performed to examine the differences in physical activity accumulation, sedentary episodes, socio-demographic characteristics and residential locations across the identified clusters. Second, a set of binomial logistic regression models for n=683 children were estimated to examine the social-ecological correlates of each cluster, in reference to all other lifestyle groups. The results are presented as odds ratios (OR= e^{β}), which represents the odds of a child's belonging to an activity-transportation cluster. Findings from this analysis are discussed below.

RESULTS AND DISCUSSION

Daily activity participation and transportation choices, among 700 children attending grades 5 and 6, in 16 public elementary school across Toronto, Canada, were examined. The average age of the sample was 10.4 (+/- 1.1) years, and 56% these children were female (Table 2). The median household income of the neighbourhoods was $69,121; 47% of the sample lived in inner-city neighbourhoods, while the other 53% lived in suburban neighbourhoods. The sample was also culturally and ethnically diverse, with 46% parents indicating that they spoke a language at home that is other than English or French (Table 2). In addition, only 31% of the sampled households had lived in their current residence for >10 years (42% had lived <5 years in their current residence), which demonstrates a high degree of residential mobility, but may also be representative of a high proportion of newly immigrant population in Toronto.

With regard to physical activity participation, students accumulated 28.9 (+/-13.5) minutes of MVPA per day on average, which is significantly low compared to the daily recommended level (*16*). In addition, these children spent less than three hours a day, on average, engaging in activities that contribute to light-intensity physical activity (LPA) (Table 2). In contrast, and consistent with what has been reported elsewhere (*5*), children demonstrated a high degree of sedentary behaviour. Accelerometry data showed that, on average, a child remained sedentary 79% of the day (excluding times when a child did not wear an accelerometer, including during sleep). In addition, children in grades 5/6 spent nearly an hour and a half (87.2 +/- 70.7 mins/ day) on average in front of a screen (Table 1), and 29% of them had >2 hr/ day of

screen time (Table 2), demonstrating a high degree of sedentary behaviour, similar to what has been reported elsewhere (*5,16,20,36*).

TABLE 2 Descriptive Statistics

	N	Mean	S. D.	%
Age (years)	694	10.4	1.1	
Gender	683			
Male				44.1
Female				55.9
Household Composition	695			
Single Parent				11.2
Not Single Parent				88.8
Language / Ethnicity	683			
English or French				54.3
Asian				36.2
Other				9.5
Years Living in Current Residence	683			
5 years or less				42.3
5 to 9 years				26.8
10 years or more				30.9
Neighbourhood Median Household Income (CAD)	698	69,121.1	24,388.2	
Residential Location (Built Env.)	698			
Inner-city				46.9
Suburban				53.1
Physical Activity Levels	618			
MVPA (min/ day)		28.9	13.5	
LPA (min/ day)		171.5	31.8	
SB (% of day time)		79.2	5.0	
% students with <2 hr screen time				71.0

Patterns of Daily Activity-Transportation Behaviour

The first research question of this study was to explore if patterns of daily activity and travel behaviour exist among children in grades 5 and 6. A two-step cluster analysis identified four clear clusters namely: “Homebound”, “Readers”, “Artists” and “Athletes”. The goodness-of-fit score (i.e., the silhouette score) was 2.0, indicating that the clusters are clearly discernible (i.e., far from zero), and suggesting a fair cluster solution (*31,35*). The ratio of sizes between the largest and the smallest clusters was 4.36.

Table 3 shows average time (mins/ day) spent on the eight activity/transportation types by children belonging to each cluster. The first cluster, ***Homebound,*** comprised 366 of the 700 (52.3%) students in the sample, had the highest screen time and also the highest engagement in active unstructured play. This group had the lowest engagement in arts, education and organized sports. The homebound students also had the lowest mean minutes spent in active transportation and inactive transportation. It appears that for this group, the majority of daily activities take place in and around home location.

The second cluster, ***Readers***, comprised of 116 (16.6%) children, and had the highest amount of time spent in education and reading. This group also had the lowest engagement in active unstructured play.

The third cluster, ***Artists,*** explained 84 (12.0%) children in the sample. This group had the highest amount of time spent engaging in the arts, and also exhibited the highest duration of active transportation (Table 3).

The fourth group are the ***Athletes,*** and includes 134 (19.1%) students. As the name suggests, this group had the highest average engagement in sports, and also demonstrated the highest level of inactive transportation (i.e., being driven in a car, transit or school bus). Screen time was the lowest among four groups.

TABLE 3 Mean Activity and Transportation Participation (Min/Day) by Cluster (n=700)

Variable	Homebound (52.3%) Mean (SD)	Readers (16.6%) Mean (SD)	Artists (12.0%) Mean (SD)	Athletes (19.1%) Mean (SD)
Active Transportation	22.8 (21.6)	27.8 (30.4)	89.8 (77.1)	31.2 (32.3)
Inactive Transportation	17.2 (20.0)	25.6 (39.7)	22.5 (26.4)	70.1 (65.0)
Active Unstructured Play	61.3 (66.0)	42.8 (46.5)	57.0 (57.9)	44.2 (45.7)
Sports	14.6 (22.0)	19.4 (25.2)	22.3 (26.4)	98.4 (61.0)
Arts	4.8 (9.3)	7.4 (12.9)	40.8 (43.7)	7.1 (12.3)
Education	2.6 (7.5)	46.2 (39.5)	4.9 (13.2)	3.6 (9.7)
Reading	5.8 (10.6)	35.5 (41.8)	8.2 (16.0)	7.7 (14.6)
Screen time	99.6 (79.4)	80.9 (55.4)	74.8 (59.0)	66.6 (56.3)

Activity-Transportation Lifestyle and Physical Activity Level

Having identified four distinct patterns of daily activity-transportation lifestyles among children, the next objective of this research was to examine the implications for physical activity levels. Previous research reported mixed results in relation to the correlation between a child's activity lifestyle and physical activity (*14,19*). Our analysis, on the contrary, suggested that all measures of physical activity, including MVPA and LPA levels, as well as SB, were significantly different across these four groups at $p<0.05$. The *athletes* were the most active group of all, accumulating an average of 29.4 mins of MVPA, which is 30% higher than the least active group, the *readers.* The *athletes* also accumulated the highest amount of LPA on average (10% more than the *readers),* although the difference across groups were not as large. The *readers,* on the other hand, were sedentary for 80 (+/- 4.7) percent of their day on average, demonstrating the highest level of SB among all groups (Table 4).

Previous research focusing on specific physical activity behaviours, such as active school transportation or unstructured play, assumed the existence of patterns of physically active (or inactive) behaviours (*6,23,37*). The research contributes to a limited literature that has adopted this approach, and identifies combinations of activities that may produce higher or lower levels of physical activity on average. It appears that higher levels of sport participation and/or active transportation co-exist with lower levels of screen time, among children living in Toronto who demonstrated higher levels of physical activity (i.e., the *athletes* and the *artists*). On the contrary, the *homebound* group, which had one of the lowest physical activity levels, had the lowest active transportation and sports participation, and spent the longest time in front of a screen.

Disagreement to this pattern also exists. For example, the *athletes* were engaged in the highest amount of inactive transportation on an average day, despite demonstrating the highest MVPA and LPA levels among all four groups (Tables 3 and 4). This result contradicts current literature that associates being driven with poorer physical activity outcomes (*37*). However, in the context of this study, more inactive transportation may have enabled a child's participation in organized sports, which in turn, produced a higher level of MVPA.

TABLE 4 Difference in Physical Activity Levels, Socio-demographics and Neighbourhood Characteristics across Activity-Transportation Lifestyle Groups

Variable or Descriptive Statistic	Homebound Mean (SD) or %	Readers Mean (SD) or %	Artists Mean (SD) or %	Athletes Mean (SD) or %	Test Results
Levels of Physical Activity					
MVPA min/day (n= 618)	27.5 (12.7)	26.4 (11.9)	29.5 (13.3)	34.3 (15.4)	F= 9.093 (p<0.000)
% with > 60 min/day of MVPA (n= 618)	1.6%	3.0%	0.0%	7.6%	χ2=11.13 (0.011)
LPA min/day (n= 618)	168.8 (31.5)	166.1 (26.6)	172.0 (31.6)	183.1 (34.4)	F= 7.24 (p<0.000)
SB % day time (n= 618)	79.5 (5.0)	80.0 (4.7)	78.5 (5.4)	77.7 (5.1)	F=5.36 (p=0.001)
% with < 2 hr Screen time (n= 700)	62.8%	79.3%	77.6%	81.3%	χ^2=24.46 (p<0.000)
Socio-demographic Characteristics					
Age (n= 694)	10.5 (1.0)	10.4 (0.6)	10.3 (1.4)	10.3 (1.5)	F= 1.65 (p=0.176)
Gender (n= 683)					χ^2= 0.16 (p=0.001)
Male	40.7%	39.1%	39.5%	60.3%	
Female	59.3%	60.9%	59.5%	39.7%	
Household Composition (n= 695)					χ^2=0.04 (p=0.794)
Single Parent	11.0%	10.4%	14.5%	10.5%	
Not Single Parent	89.0%	89.6%	85.5%	89.5%	
Language/ Ethnicity (n=683)					χ^2=0.23 (p<0.000)
English/ French	53.9%	24.4%	64.2%	75.6%	
Asian	35.4%	65.2%	25.9%	19.1%	
Other	10.7%	10.4%	9.9%	5.3%	
Years Living in Current Residence (n=683)					χ^2=0.080 p=(0.358)
5 years or less	44.6%	44.3%	39.5%	35.9%	
5 to 9 years	26.7%	28.7%	27.2%	25.2%	
10 years or more	28.4%	27.0%	33.3%	38.9%	
Neighbourhood Characteristics					
NH median income in CAD (n=698)	68,982.05 (24,172.66)	64,027.03 (19,797.68)	70,878.51 (28,434.72)	72,821.15 (25,338.57)	F=2.886 (p=0.035)
Residential Location/ Built Env. (n=698)					χ^2=0.193 (p<0.000)
Inner-city	39.2%	44.8%	59.0%	61.9%	
Suburban	60.8%	55.2%	41.0%	38.1%	

NOTE: Tests results reflect outputs from one-way ANOVA to compare means, or Chi-square tests to compare frequency distributions, across the four activity-transportation lifestyle clusters.

In summary, the results from this research echoes a limited literature (*20,38*) in indicating that the patterns in which physically active and inactive behaviours may co-exist in a child's daily routine may not be as simple as it has been assumed in some previous research (e.g., *6,23,37*), and emphasize the importance of exploring a child's daily movement behaviour more systematically and holistically, as has been suggested in some recent policy (e.g., *16*).

It is worth noting that regardless of activity-transportation lifestyles, only a small proportion of students met the daily recommended level of MVPA of 60 mins/day (*16*), although the rate was higher among the *athletes* compared to other groups (Table 4). In addition, all groups spent large proportions of their day being sedentary. Clearly, each group offers opportunities for improvements in physical activity levels, however, future policy and programs

may particularly focus on the *homebounds* and the *readers*, who accumulate the lowest amounts of physical activity in an average day. These two groups, combined together, are representative of 69% of all grade 5/6 children in Toronto.

Social-Ecological Correlates of Activity-Transportation Lifestyles

Using a social-ecological framework (*27*), we hypothesized that the socio-demographic and neighbourhood characteristics would be different across various activity-transportation lifestyle groups. Our preliminary analysis indicated no difference in mean age, or household composition, across the four activity-transportation lifestyle groups (Table 4). Lifestyle patterns were also not associated with the duration of stay in current neighbourhood at α=0.05. However, a child's activity-transportation lifestyle appears to be gendered, and strongly correlated with the ethnic background of the household (Table 4). Children's lifestyles were also different across residential locations (i.e., inner city versus suburban) and across neighbourhoods with different median household incomes.

The relationship between various activity-transportation lifestyles and these social-ecological characteristics were further explored using a series of binomial logistic regression models. The goodness-of-fit for most models were satisfactory, except the *artists* model, which produced a poor fit with only one statistically significant correlate (Table 5).

Several observations can be made with regard to the logistic regression results presented in Table 5, which may have important implications for policy and programming focused on children's physical activity and health. First, current research has repeatedly found higher physical activity levels among boys compared to girls (*36*,*37*). Previous studies have also reported an association between a child's gender and activity lifestyle (*14*,*19*). The results from our analysis supports existing literature in indicating that boys are more likely to demonstrate a pattern of healthier activity-transportation behaviours (i.e., more likely to belong to the *athletes* group, and less likely to be *homebound*) (Table 5). While more research is necessary to fully understand the culture and perceptions of mobility/ physical activity among girls and their adult caregivers, our findings emphasize the importance of enabling physical activity and active behaviours among girls in order to improve physical activity levels at a population level.

Second, and similar to what has been reported elsewhere (e.g., *37*), our results indicate a strong association between culture/ethnic backgrounds and physical activity levels. Table 5 shows that a child who has a non-English or non-French background was less likely to belong to the *athletes* cluster (i.e., the lifestyle group with the highest daily MVPA and LPA levels) and was more likely to belong to the *readers* cluster (i.e., the lifestyle group with the lowest levels of physical activity). It is possible that priorities and perceived importance of educational achievements are higher among certain cultural and ethnic groups, when compared to engagement in physical activity, but such relationships could not be directly explored within the context of this study. However, findings such as the ones presented here may begin to inform the development of targeted interventions in the context of ever-increasing ethno-cultural diversity in Toronto and similar metropolitan regions.

TABLE 5 Correlates of Cluster Membership (n = 683)

	Cluster 1: Homebound (Ref: all other)		Cluster 2: Readers (Ref: all other)		Cluster 3: Artists (Ref: all other)		Cluster 4: Athletes (Ref: all other)	
	OR (95% CI)	Pr(>|z|)	OR (95% CI)	Pr(>|z|)	OR (95% CI)	Pr(>|z|)	OR (95% CI)	Pr(>|z|)
Age	1.16 (0.96-1.40)	0.113	0.96 (0.77-1.19)	0.706	0.96 (0.75-1.22)	0.722	0.88 (0.71-1.09)	0.228
Gender (Ref: Female)								
Male	***0.74 (0.54-1.01)***	***0.059***	0.76 (0.49-1.17)	0.210	0.81 (0.50-1.30)	0.381	**2.43 (1.62-3.64)**	**0.000**
HH Composition (ref: other)								
Single-parent households	1.04 (0.63-1.72)	0.865	0.95 (0.47-1.91)	0.882	0.85 (0.42-1.73)	0.663	1.08 (0.56-2.08)	0.824
Ethnicity (Ref: English/French)								
Asian	**0.68 (0.47-0.99)**	**0.042**	**5.89 (3.44-10.09)**	**0.000**	0.71 (0.39-1.29)	0.262	**0.41 (0.24-0.70)**	**0.001**
Other	1.24 (0.71-2.15)	0.445	**2.81 (1.34-5.93)**	**0.007**	0.91 (0.41-2.05)	0.827	**0.33 (0.14-0.77)**	**0.010**
Years in Canada (Ref: <10 yrs)								
10 years or more	0.84 (0.59-1.18)	0.315	1.11 (0.67-1.82)	0.692	0.97 (0.58-1.62)	0.903	1.26 (0.82-1.93)	0.290
Neighbourhood HH Income	**0.99 (0.99-1.00)**	**0.038**	0.99 (0.99-1.00)	0.782	1.00 (0.99-1.00)	0.327	***1.00 (0.99-1.00)***	***0.053***
Neighbourhood (Ref: Suburb)								
Inner City	**0.42 (0.29-0.60)**	**0.000**	1.36 (0.81-2.29)	0.240	**1.81 (1.07-3.08)**	**0.028**	**2.06 (1.31-3.24)**	**0.002**
Intercept	0.75 (0.09-6.13)	0.788	0.13 (0.01-1.75)	0.125	0.16 (0.01-2.58)	0.195	0.27 (0.02-3.14)	0.298
Model Fit								
Null Deviance: -2L[0]	945.61		619.21		497.38		667.73	
Residual Deviance: -2L[B]	911.55		559.30		486.67		603.97	
Chi-square (dF)	34.06 (8)		59.91 (8)		10.71 (8)		63.76 (8)	
p	<0.000		<0.000		0.219		<0.000	
AIC	929.55		577.3		504.67		621.97	

NOTE: The table shows results from binomial logistic regressions of cluster membership.
Odds Ratios in **bold** are significant at α=0.05; ORs in ***bold italics*** are significant at α=0.10.

Lastly, the results suggest that systematic patterns of activity participation and travel behaviour may exist in inner-city and suburban neighbourhoods, which has significant implication on a child's daily physical activity accumulation. For example, a child living in an inner-city neighbourhood was more likely to belong to the *athletes* or *artists* group (Table 5), both of which had higher average physical activity levels compared to the other two groups. At least hypothetically, a mixed use inner-city neighbourhood may offer more opportunities to participate in out-of-home activities (e.g, organized sports and arts programs) that are often accessible and sometimes within walkable distances. In contrast, a child living in a suburban neighbourhood was more likely to belong to the *homebound* group (Table 5), which perhaps can partly be explained by the lack of accessibility to a wider range of extracurricular activities in suburban locations. Similar comments can also be made with regard to neighbourhood-level household income. Our model results indicated a positive association between household income and a child being an *athlete*, and a negative association between income and a child being *homebound* (Table 5), which is perhaps due to the difference in access to opportunities across various income groups. However, residential self-selection may also explain some of the observed lifestyles, when economically capable and motivated households move to neighbourhoods where opportunities for a healthier lifestyle exist. A more in-depth analysis of these relationships remains subject to our future research.

In summary, our results indicate that problems related to sedentary lifestyles may be more severe among some population groups and in some areas compared to others. It appears that females, ethno-cultural population groups, and those living in low income, suburban neighbourhoods may benefit most if future policies and programs are specifically catered to their activity/mobility-related challenges, perceptions and opportunities.

CONCLUSION

The purpose of this study was to conduct an exploratory analysis of activity and transportation choices in relation to physical activity outcomes among elementary school- aged children in Toronto, Canada. A cluster analysis identified four distinct activity-transportation lifestyle groups, namely: *homebound, readers, artists* and *athletes.* Various measures of the levels of physical activity accumulation were significantly different across these four lifestyle groups. Further analysis identified that a child's likelihood of belonging to a lifestyle group can be explained by their gender, ethno-cultural diversity, neighbourhood-level income and urban locations (i.e., inner city versus suburban).

The results from this study, however, are generalizable only to the extent that is permitted by the data. First, the focus in this study was kept limited only to students attending grades 5 and 6, in order to avoid variations in activity participation and travel behaviour relating to a child's physical and cognitive development. Second, parents of each child self-reported daily activities and duration in an activity diary, over a period of two to four days. Some assumptions had to be made to classify those self-reported activities into specific activity types; travel times were estimated using previously established standards. The accuracy of these modifications could not be verified. Third, activity-transportation lifestyles of broad groups of students were discussed. This broad generalization might have masked the nuance differences individual students.

Despite some limitation, this study makes a novel contribution by clearly linking children's activity-transportation lifestyles with objective measures of physical activity, and by systematically identifying the socio-demographic and environmental correlates of these different lifestyle groups. With the emergence of policy and guidelines that encourage a healthy balance

of daily activities in order to achieve optimum health benefits (*5,16*), this research could not be more timely. Our results emphasize the importance of a holistic approach in addressing the current challenges relating to sedentary lifestyles among children in Toronto and more generally in the Western World. The findings also call for targeted interventions catered toward girls and ethno-cultural population groups living in lower income, suburban neighbourhoods. We hope that the study will inform future programming and interventions that would be developed in light of these newly emerging guidelines, and in the long run, help in creating healthy and active communities for children and youth.

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REFERENCES

1. James, P.T., Leach, R., Kalamara and E., Shayeghi, M. The worldwide obesity epidemic. *Obesity Research,* Vol. 9, No. 4, 2001, pp. 228S-233S.
2. McDonald, N. C. Active transportation to school: Trends among U.S. schoolchildren, 1969-2001. *American Journal of Preventive Medicine*, Vol. 32, No. 6, 2007, pp. 509-516.
3. Mitra, R., Papaioannou, E. and Habib, K. M. N. Past and present of active school transportation: An exploration of the built environment effects in Toronto, Canada from 1986 to 2006. *Journal of Transport and Land Use*, Vol. 9, No. 2, 2016, pp. 1-17.
4. van der Ploeg, H. P., Merom, D., Corpuz, G. and Bauman, A. E. Trends in Australian children traveling to school 1971–2003: Burning petrol or carbohydrates? *Preventive Medicine*, Vol. 46, No. 1, 2008, pp. 60-62.
5. ParticipACTION. The ParticipACTION Report Card on Physical Activity for Children and Youth, 2016. 2016, Retrieved from https://www.participaction.com/sites/default/files/downloads/2016%20ParticipACTION%20Report%20Card%20-%20Full%20Report.pdf
6. Tudor-Locke, C., Ainsworth, B. E., Adair, L. S. and Popkin, B.M. Objective physical activity of Filipino youth stratified for commuting mode to school. *Medicine & Science in Sports & Exercise*, Vol. 35, No. 5, 2003, pp. 867-871.
7. Wang, Y., and Lobstein, T. I. M. Worldwide trends in childhood overweight and obesity. *International Journal of Pediatric Obesity*, Vol. 1, No. 1, 2006, pp. 11-25.
8. Guliani, A., Mitra, A., Buliung, R.N., Larsen, K. and Faulkner, G.E.J. Gender-based differences in school travel mode choice behaviour: Examining the relationship between the neighbourhood environment and perceived traffic safety. *Journal of Transport & Health*, Vol. 2, No. 4, 2015, pp. 502-511.
9. Larouche, R., Chaput, J.P., Leduc, G., Boyer, C., Belanger, P., LeBlanc, A.G., Borghese, M.M. and Tremblay, M.S. A cross-sectional examination of socio-demographic and school-level correlates of children's school travel mode in Ottawa, Canada. *Biomed Central Public Health*, Vol. 14, No. 497, 2014.
10. McDonald, N.C. Household interactions and children's school travel: The effect of parental work patterns on walking and biking to school. *Journal of Transport Geography*, Vol. 16, 2008, pp. 324-331.
11. Mitra, R., Faulkner, G.E.J., Buliung, R.N and Stone, M.R. Do parental perceptions of the neighbourhood environment influence children's independent mobility? Evidence from Toronto, Canada. *Urban Studies*, Vol. 51, No. 16, 2014, pp. 3401-3419.
12. Page, A.S., Cooper, A.R., Griew, P., Davis, L. and Hillsdon, M. Independent mobility in relation to weekday and weekend physical activity in children aged 10-11 years: the PEACH Project. *International Journal of Behavioral Nutrition and Physical Activity*, Vol. 6, No. 2, 2009.
13. Omorou, A.Y., Coste, J., Escalon, H. and Vuillemin, A. Patterns of physical activity and sedentary behaviour in the general population in France: Cluster analysis with personal and socioeconomic correlates. *Journal of Public Health Advance Access*, 2015, pp. 1-10.
14. Seghers, J. and Rutten, C. Clustering of multiple lifestyle behaviours and its relationship with weight status and cardiorespiratory fitness in a sample of Flemish 11- to 12-year-olds. *Public Health Nutrition*, Vol. 13, No. 11, 2010, pp. 1838-1846.

15. Veitch, J., Salmon, J. and Ball, K. Individual, social and physical environmental correlates of children's active free-play: A cross-sectional study. *International Journal of Behavioural Nutrition and Physical Activity*, Vol. 7, No. 11, 2010.
16. Canadian Society for Exercise Psychology. 24-hour Movement Guidelines for Children and youth. *Canadian Society for Exercise* Psychology, 2016, Retrieved from http://www.csep.ca/en/guidelines/get-the-guidelines
17. Chaput J.P., Carson V, Gray C.E. and Tremblay M.S. Importance of all movement behaviors in a 24 hour period for overall health. *Int J Environ Res Public Health*, Vol. 11, No. 12, 2014, pp. 12575-12581
18. Gorely, T., Marshall, S. J., Biddle, S. J. H. and Cameron, N. Patterns of sedentary behaviour and physical activity among adolescents in the United Kingdom: Project STIL. *Journal of Behavioural Medicine*, Vol. 30, 2007, pp. 521-531.
19. Nelson, M.C., Gordon-Larsen, P., Adair, L.S. and Popkin, B.M. Adolescent physical activity and sedentary behaviour: Patterning and long-term maintenance. *American Journal of Preventive Medicine*, Vol. 28, No. 3, 2005, pp. 259-266.
20. Voulgaris, C.T., Taylor, B.D. and Smart, M.J. Long routes to school? School travel and activity participation among students. *The 95th Meeting of the Transportation Research Board of the National Academics*, Washington, D. C., January 2016.
21. Cooper, A.R., Page, A.S., Lucy, J.F. and Qahwaji, D. Commuting to school Are children who walk more physically active? *American Journal of Preventive Medicine*, Vol. 25, No. 4, 2003, pp. 273-276.
22. Mitra, R. Independent mobility and mode choice for school transportation: a review and framework for future research. *Transportation Review*, Vol. 33, No. 1, 2013, pp. 21–43.
23. Faulkner, G. E. J., Mitra, R., Buliung, R., Stone, M. R. and Fusco, C. Children's outdoor play time, physical activity and parental perceptions of the neighbourhood environment. *International Journal of Play*, Vol. 4, No. 1, 2015, pp. 84-97.
24. Nicaise, V., Kahan, D. and Sallis, J.F. Correlates of moderate-to-vigorous physical activity among preschoolers during unstructured outdoor play periods. *Preventive Medicine*, Vol. 53, 2011, pp. 300-315.
25. Tremblay, M.S., LeBlanc, A.G., Kho, M.E., Saunders, T.J., Larouche, R., Colley, R.C., Goldfield, G. and Gorber, S.C. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, Vol. 8, No. 98, 2011.
26. Mitchell, J.A. and Byun, W. Sedentary behavior and health outcomes in children and adolescents. *American Journal of Lifestyle Medicine*, Vol. 8, No. 3, 2013, pp. 173-199.
27. Glanz, K., Rimer, B. K. and Viswanath, K. (Eds.) (2008) Health *Behavior and Health Education: Theory, Research, and Practice, 4th edition*. Jossey-Bass, Inc., San Francisco, 2013.
28. Statistics Canada. Canadian Census Data, 2011. Government of Canada, 2016, Retrieved from http://www12.statcan.gc.ca/census-recensement/2011/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CSD&Code1=3520005&Geo2=CD&Code2=3520&Data=Count&SearchText=toronto&SearchType=Begins&SearchPR=01&B1=All&Custom=&TABID=1
29. Stone, M.R., Faulkner, G.E. and Buliung, R.N. How active are children in Toronto? A comparison with accelerometry data from the Canadian Health Measures Survey. *Chronic Diseases and Injuries in Canada*, Vol. 33, No. 2, 2013, pp. 61-68.

30. Stone, M. R., Rowlands, A. V. and Eston, R. G. Relationships between accelerometer-assessed physical activity and health in children: impact of the activity-intensity classification method. *Journal of Sport Science in Medicine*, Vol. 8, 2009, pp.136-143.
31. Lattin, J.M., Carroll, J.D. and Green, P.E. *Analyzing Multivariate Data.* Brooks/Cole, Inc., Canada, 2003.
32. Neff, J. and Dickens, M. *Public Transportation Fact Book, 64th ed.* American Public Transportation Association, Washington, D.C., 2013.
33. HDR Corporation. *Costs of road congestion in the Greater Toronto and Hamilton Area: Impact and cost benefit analysis of the Metrolinx draft regional transportation plan*. Greater Toronto Transportation Authority, Toronto, ON, 2008.
34. Thompson, D. C., Rebolledon, V., Thompson, R. S., Kaufman, A. and Rivara, F. P. Bike speed mesaurements in a recreational population: validity of self reported speed. *Injury Prevention*, Vol. 3, No. 1, 1997, pp. 34-45.
35. Sarstedt, M. and Mooi, E. *A Concise Guide to Market Research*. Springer, Berlin, 2014.
36. Stone, M. R., Faulkner, G. E. J., Mitra, R. and Buliung, R. Physical activity patterns of children in Toronto: The relative role of neighbourhood types and socioeconomic status. *Canadian Journal of Public* Health, Vol. 103, Suppl. 3, 2012, pp. S9-S14.
37. Larouche, R., Saunders, T. J., Faulkner, G. E. J., Colley, R. and Tremblay, M. Associations between active school transport and physical activity, body composition, and cardiovascular fitness: A systematic review of 68 studies. *Journal of Physical Activity and Health*, Vol. 11, 2014, pp. 206-227.
38. Biddle, S.J.H., Gorely, T., Marshall, S.J. and Cameron, N. The prevalence of sedentary behavior and physical activity in leisure study of Scottish adolescents using ecological momentary assessment. *Preventive Medicine*, Vol. 48, No. 2, 2009, pp. 151-155.