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Seasonal variations and changes in school travel mode from childhood to late adolescence: A prospective study in New Brunswick, Canada

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ABSTRACT

Purpose: Active school transportation (AST) is an important source of physical activity, but it remains unclear how it varies across seasons and over time from childhood to adolescence. In this longitudinal study, we investigated seasonal variations and changes over time in AST and moderate- to vigorous-intensity physical activity (MVPA).

Methods: Children (N = 932; 55.4% female; 10.6 ± 0.7 year olds at study inception) indicated their usual school travel mode and self-reported their MVPA in the fall, winter and spring for six years (18 survey-cycles). We categorized school travel mode as "active", "mixed" (i.e., combination of active and motorized modes) or "motorized". We examined seasonal variations and changes in AST (polynomial logistic regression) and in number of days per week accumulating ≥ 60 min of MVPA (linear regression) using generalized linear mixed models accounting for sex, age at baseline, type of urbanization, school, and the repeated measures design.

Results: Odds of engaging in AST were lower in the winter (OR = 0.48; 95% CI = 0.38, 0.61) compared to the fall, increased over time (OR = 1.08; 1.05, 1.12), and were greater among boys versus girls (OR = 3.41; 2.18, 5.35) and participants living in urban versus rural areas (OR = 2.90; 1.37, 6.14). Boys reported more MVPA than girls (β = 0.30; 95% CI = 0.22, 0.37). Children reported less MVPA in the winter than in the fall (β = −0.27; −0.44, −0.10). MVPA was higher among children using mixed modes than among motorized travelers (β = 0.27; 0.16, 0.39) and among participants living in urban versus rural areas (β = 0.27; 0.14, 0.39). A significant quadratic term ($p < 0.001$) indicated that MVPA increased in the first few cycles and declined afterwards.

Conclusions: The substantial seasonal differences in AST and MVPA suggest that interventions may need to include a particular focus on winter activities. Our findings also highlight the need for effective interventions to prevent the decline in MVPA.

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1. Introduction

Published systematic reviews have concluded that children and youth engaging in active school transport (AST), which represents the use of non-motorized modes of transportation such as walking and cycling to travel to/from school, are more physically active than those using motorized travel modes (Larouche et al., 2014a). Cycling to/from school is also associated with greater cardiovascular fitness and reduced cardiovascular disease risk factors (Andersen et al., 2011; Larouche et al., 2014b). Greater uptake of AST could also help reduce vehicle emissions which are associated with an increased risk of developing cardiovascular diseases and which contribute to accelerate climate change (Patz et al., 2014). Despite these benefits, population-based studies have indicated substantial declines in AST over the last few decades in countries including Canada (Gray et al., 2014), Switzerland (Grize et al., 2010), and the United States (McDonald et al., 2011).

Cooper et al. (2012) reported that, across the transition from primary to secondary school, physical activity (PA) increased among children who switched from motorized travel to AST and decreased in those who switched from AST to motorized travel. These findings suggest that AST could be an important target to prevent the age-related decline in PA that has been reported in many studies (Bélanger et al., 2009a; Dumith et al., 2011; Nader et al., 2008; Sallis, 2000).

Nevertheless, few prospective longitudinal studies have examined how travel behavior changes from childhood to adolescence. Using data from the Canadian National Longitudinal Survey of Children and Youth, Pabayo et al. (2011) noted that the prevalence of AST increases until the age of 10 and decreases markedly thereafter. Similarly, Cooper et al. (2012) observed that fewer British children walked to/from school in secondary school compared to primary school, but those who did travelled longer distances. In contrast, Hume et al. (2009) reported an increase in the number of weekly active trips to/from school between the ages of 12 and 14 years in Australia. Further, Belgian researchers noted that the prevalence of cycling to school was significantly lower at 10 years (46%) than between the ages of 11 and 16, when it ranged between 69 and 83% (Cardon et al., 2012). These conflicting findings underscore a need for further research.

Whereas it is often assumed that AST is subject to seasonal variations in regions with important seasonal climatic variations, the evidence largely stems from studies using repeated cross-sectional designs. In such studies, different participants were questioned in different seasons; thus it is possible that the observed seasonal variations are due to differences in samples across seasons. Furthermore, previous studies examining seasonal variations in school travel mode have obtained inconsistent findings (Børrestad et al., 2011; Kallio et al., 2016; Mitra and Faulkner, 2012; Robertson-Wilson et al., 2008). Kallio et al. (2016) reported that the prevalence of AST was about 15 percentage points lower in the winter compared to the spring and fall among Finnish children whereas Børrestad et al. (2011) reported that the decrease in cycling among Norwegian children was compensated by an increase in walking. In contrast, two studies have shown no seasonal differences in the prevalence of AST in Ontario (Robertson-Wilson et al., 2008) and in the City of Toronto (Mitra and Faulkner, 2012).

In this analysis, we aimed to describe seasonal variations and changes over time in AST and moderate-to-vigorous intensity physical activity (MVPA) using data from a prospective cohort study. As a secondary objective, we investigated the relationship between changes in school travel mode and MVPA over 6 years covering the transition from childhood to adolescence.

2. Methods

2.1. Participants

Monitoring Activities of Teenagers to Comprehend their Habits (MATCH) is a prospective study for which Grades 5 or 6 students were recruited in 17 schools in 2011 across the province of New Brunswick, Canada (Bélanger et al., 2013). Schools were purposefully sampled to include a mix of French and English schools in low, moderate and high socioeconomic neighbourhoods and in rural and urban areas. There are no noteworthy differences in the education system of French- and English-speaking students in New Brunswick. At Time 1, there were 806 participants aged 10.3 ± 0.6 years. Other students from participating schools were allowed to join the study after Time 1 (39 joined in year 2, and 92 joined in year 4). In total, 937 children (55.2% female) took part in at least one survey cycle of the study. Ethical approval was obtained from the Comité d'Éthique de la Recherche du Centre Hospitalier de l'Université de Sherbrooke. Both participants and their parents provided active informed consent.

2.2. Setting

In New Brunswick, school bus transportation is provided for students attending public schools and living beyond 2.4 km away from school (or beyond 1.5 km for those living on side roads). This distance threshold can be lowered for students with special needs (Government of New Brunswick, 2018). Normal temperature at the Greater Moncton International Airport vary from an average low of -14.0 °C in January to an average high of 24.7 °C in July (Environment Canada, 2018). In the New Brunswick school system, the transition from primary to secondary school does not occur at a single point in time. Some of our participants transitioned to secondary school after grade 6, others after grade 8.

2.3. Protocol

Study participants completed self-report questionnaires tri-annually (fall, winter, and spring). At the time of analyses, 18 survey cycles with data on school travel mode and PA participation were available (i.e., from the fall of 2011 to the spring of 2017). One item was used to assess school travel mode at each time point: "Over the course of the last 7 days, how did you usually get to and from school?" Response options provided in survey cycles 1 to 6 were "actively (e.g., walk, bike, skateboard)", "inactively (e.g., car, bus, public transit)", or "mixed (e.g., actively and inactively)". From survey cycle 7 to 16, participants could specify their mode of active transportation such that the response options were "walking", "biking", "by skateboard or scooter", "inactively (e.g., car, bus, public transit)", or "mixed (e.g., actively and inactively – e.g., walking and bus"). For analyses, responses from all cycles were coded as active ("walking", "biking", "skateboard or scooter"), "mixed" (combination of active and motorized modes of transportation) or "motorized".

Rural or urban status of participants' municipality of residence was obtained based on postal codes reported by participants. Participants were considered to live in a rural setting if the municipality of residence included less than 10,000 residents or in an urban setting if it included 10,000 residents or more (Government of Canada, 2011).

The 2-item screening tool developed by Prochaska et al. (2001) was used to assess MVPA. Participants were asked to indicate how many days they engaged in MVPA for at least 60 min on a (1) typical week and (2) this past week. Response options ranged from 0 (*days*) to 7 (*days*). The following preamble was used to define MVPA to the participants: "Physical activity is any activity that increases your heart rate and makes you get out of breath some of the time. Physical activity can be done in sports, playing with friends, or walking to school. Some examples of physical activity are running, brisk walking, rollerblading, biking, dancing, skateboarding, swimming, soccer, basketball, hockey, and skiing." An average of the two items was taken to create an overall MVPA score. This measure has substantial test-retest reliability (ICC = 0.77) and is moderately associated with accelerometer-measured MVPA (r = 0.40) among 12 year olds (Prochaska et al., 2001).

2.4. Data analysis

Descriptive statistics and examination of outliers for MVPA within our sample, defined as z-scores above $|3.29|$ (which normally include 99.9% of observations) were performed in SPSS Version 25 (IBM Corporation, Armonk, NY). Odds ratios were computed using polynomial logistic regression within a generalized linear mixed model framework (GLIMMIX procedure in SAS version 9.4, Cary, NC, USA) to identify whether season, time, and sex were associated with school travel mode, while accounting for clustering of the repeated measures for each child as a random effect. Models were also adjusted for school attended, type of urbanization (i.e., urban vs. rural), and age at cycle 1 (for participants that joined the study later, we estimated their age at cycle 1 based on their age at the first cycle in which they participated). In this model, motorized transportation was used as the reference category because it was the most prevalent mode. An interaction term was also tested to verify if the effect of survey cycle on school travel mode differed across seasons. Results are reported as odds ratios with 95% confidence intervals.

Linear regressions within the generalized linear mixed models framework were used to examine the relationship between school travel mode and MVPA (GENLINMIXED procedure in IBM SPSS version 25, Armonk, NY). Specifically, these models examined the number of days where participants accumulated at least 60 min of MVPA as a function of school travel mode, sex, survey cycle, and season, while also accounting for clustering of the repeated measures for each child as a random effect. Models were also adjusted for school attended, type of urbanization, and age at cycle 1. A quadratic term was used for survey cycle based on visual inspection of the data, which indicated that the rate of change in MVPA was not following a linear pattern. We also tested an interaction term between survey cycle and season. Results are reported as unstandardized regression coefficients with 95% confidence intervals. For continuous dependent variables, the coefficients represent the changes in the outcome per unit of the dependent variable, whereas for categorical variables, they represent the differences in the outcome between the categories compared. Although participants with missing data were retained in analyses through full information maximum likelihood, cycles for which they did not provide data were deleted listwise.

3. Results

Descriptive statistics for school travel mode and MVPA at each time point are presented in Supplementary File 1. At any survey cycle, between 5.5 and 16.3% of participants were categorized as active travelers and between 7.4 and 17.6% were "mixed" travelers. Participants completed a median of 11 cycles (interquartile range = 7–16). No outliers for MVPA were identified (all $z < |2.42|$) and between 11.7 to 21.4% of participants reported ≥ 60 min of daily MVPA at each survey cycle. Seasonal variations and longitudinal trends in school travel modes are illustrated in Fig. 1. Missing data ranged from 28.2–61.0% for AST and from 21.6–61.0% for MVPA across cycles. Characteristics of participants at cycle 1 are shown in Table 1.

The interaction term assessing if the effect of survey cycle on school travel mode differed across seasons was not significant ($p = 0.37$) and was not retained for the model presented herein. Season, time (survey cycles), type of urbanization, and participants' sex were statistically significant predictors of school travel mode (Table 2). The odds of using AST compared to motorized modes were considerably lower during winter than fall survey cycles (OR = 0.48; 95% CI = 0.38, 0.61). Over the 18 cycles of follow-up, there was an increase in odds of engaging in AST compared to motorized modes (OR = 1.08; 95% CI = 1.05, 1.12); in other words, the odds of AST increased by an average of 8% per cycle. Odds of using active (OR = 2.90; 95% CI = 1.37–6.14) and mixed (OR = 3.61; 95% CI = 2.16–6.03) modes rather than motorized modes were higher among participants living in urban compared to rural areas. Finally, boys were over three times more likely than girls to use AST (OR = 3.41; 95% CI = 2.18, 5.35) compared to motorized modes.

There was no statistically significant difference in MVPA between children who reported using active and motorized modes of transportation (Table 3). However, mixed travelers reported at least 60 min of MVPA more often than their counterparts using

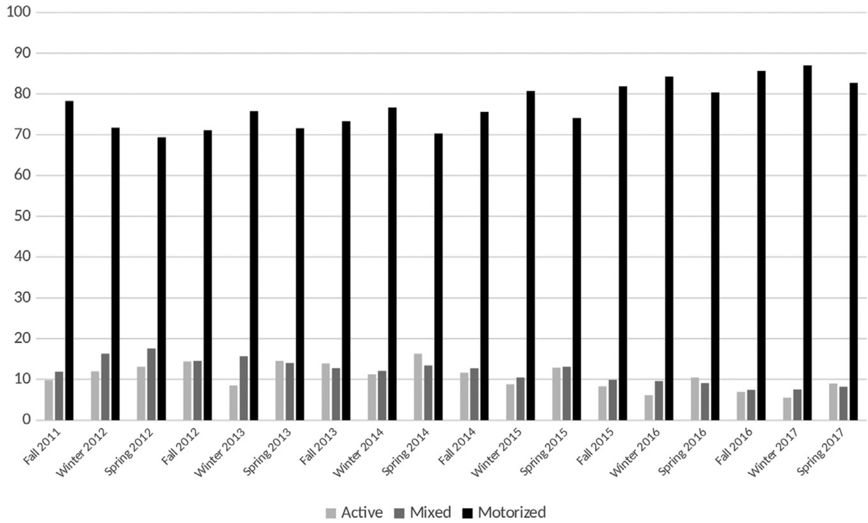

Fig. 1. Percentage of participants using active, mixed, and motorized school travel modes at each time point in the MATCH study Note: MATCH: Monitoring Activities of Teenagers to Comprehend their Habits.

Table 1
Descriptive characteristics of the participants at cycle 1 in the MATCH study.

Variable	n	%	Mean ± SD
Sex	932	–	–
Female	516	55.4	–
Male	416	44.6	–
Language	932	–	–
English	298	32.0	–
French	634	68.0	–
Type of urbanization	931	–	–
Rural	487	52.3	–
Urban	444	47.7	–
Age	932	–	10.6 ± 0.7

MATCH: Monitoring Activities of Teenagers to Comprehend their Habits. MVPA: moderate- to vigorous-intensity physical activity.

Table 2
Odds ratios (OR) and 95% confidence intervals (CI) for potential predictors of mode of school transportation over 6 years in the MATCH study.

Predictor	School travel mode		
	Motorized[b] OR	Active OR (95% CI)	Mixed OR (95% CI)
Season			
Fall[b]	–	–	–
Winter	–	0.48 (0.38–0.61)[c]	0.94 (0.79–1.13)
Spring	–	1.01 (0.82–1.26)	1.19 (0.99–1.44)
Survey cycle (approx. 4 months)	–	1.08 (1.05–1.12)[c]	0.97 (0.94–0.99)
Sex			
Girls[b]	–	–	–
Boys	–	3.41 (2.18–5.35)[c]	1.17 (0.87–1.58)
Type of urbanization			
Rural[b]	–	–	–
Urban	–	2.90 (1.37–6.14)[c]	3.61 (2.16–6.03)[c]
Age at cycle 1	–	0.97 (0.67–1.39)	1.06 (0.84–1.35)

MATCH: Monitoring Activities of Teenagers to Comprehend their Habits. Results are based on 932 participants and 9681 observations.
[a]From polynomial logistic regression adjusting for all variables in the table, school attended and for the repeated measures design;
[b] Represents reference category.
[c] Represents odds ratio with $p < 0.05$.

Table 3
Association between school travel mode, season and moderate- to vigorous-intensity physical activity over 6 years from childhood to adolescence[a].

Variable	β	95% CI
Intercept	4.56	3.84, 5.28
School travel mode		
Motorized[b]	–	–
Active	0.02	-0.11, 0.15
Mixed	0.27[c]	0.16, 0.39
Season		
Fall[b]	–	–
Winter	−0.27[c]	−0.44, −0.10
Spring	0.09	−0.09, 0.28
Survey cycle - linear term (approx. 4 months)	0.12[c]	0.08, 0.15
Survey cycle - quadratic term (approx. 4 months)	−0.01[c]	−0.01, −0.01
Sex		
Girls[b]	–	–
Boys	0.30[c]	0.22, 0.37
Cycle by season (interaction)		
Fall[b]	–	–
Winter	0.02[c]	0.00, 0.04
Spring	−0.01	−0.03, 0.01
Age at cycle 1	−0.06	−0.12, 0.01
Type of urbanization		
Rural[b]	–	–
Urban	0.27[c]	0.14, 0.39

Note: results are reported as the number of days where participants accumulated at least 60 min of moderate- to vigorous-intensity physical activity based on generalized linear mixed models adjusting for all variables in the table, for school attended, and the repeated measures design. Results are based on 932 participants and 9690 observations.
[a] Data are from the MATCH study (Monitoring Activities of Teenagers to Comprehend their Habits)
[b] Represents reference category;
[c] Represents coefficient with $p < 0.05$.

motorized modes (β = 0.27 days/week; 95% CI = 0.16, 0.39). Boys reported at least 60 min of MVPA on more days per week than girls (β = 0.30 days/week; 95% CI = 0.22, 0.37). Compared to the fall survey cycles, participants reported less MVPA in the winter (β = -0.27 days/week; 95% CI = -0.44, -0.10). Participants living in urban areas reported more MVPA than those living in rural areas (β = 0.27; 0.14, 0.39). The quadratic term for survey cycle was statistically significant ($p < 0.001$) and inspection of the mean MVPA data (Appendix 1) indicates that MVPA increased in the first few cycles and declined afterwards. The interaction term between survey cycle and season was also significant ($p = 0.010$). Specifically, it indicated that although participants reported less MVPA during the winter than the fall, there was an attenuation of differences between seasons over time (β = 0.02; 95% CI = 0.00, 0.04).

4. Discussion

Using a unique longitudinal dataset that included triannual follow-ups over a 6-year period from the same children and youth over time, the present analyses extend previous research examining seasonal variations and temporal changes in AST and MVPA. Our results provide evidence of considerable seasonal variations in these behaviors with the prevalence of AST and the frequency of accumulating ≥ 60 min of MVPA/day being significantly lower in the winter compared to the fall.

These results are consistent with those of Kallio et al. (2016) among Finnish children; however, they are in contrast with two other Canadian studies conducted in the province of Ontario (Mitra and Faulkner, 2012; Robertson-Wilson et al., 2008). An important difference between these studies and ours is that previous studies were limited by the use of repeated cross-sectional designs with only two survey cycles, whereas our study benefited from following up the same participants over many cycles. Our findings support the need for additional efforts to promote AST, especially during the winter months. Nevertheless, it is worth emphasizing that the rates of AST were low throughout all seasons. This is in agreement with results from the nationally-representative Physical Activity Monitor study which indicated that only 9% of school-aged children in New Brunswick regularly engage in AST (Gray et al., 2014).

Our observation that participants reported less MVPA during winter is consistent with previous research on the seasonal differences in PA (Bélanger et al., 2009b; Tucker and Gilliland, 2007). Recent analyses using the International Children's Accelerometry Database also suggest that better visibility and additional daylight is associated with higher PA (Goodman et al., 2014; Harrison et al., 2017). Furthermore, other researchers have shown that many parents do not allow their child out without supervision when it is dark outside until they reach a certain age (Shaw et al., 2015), which might reduce opportunities for AST in the darkest months of the year. Presumably, the inconvenience of exposure to cold temperature and the time needed to put on warmer clothes may also be viewed as deterrents to AST and MVPA in the winter.

The observation that AST increased over time is consistent with studies conducted in Australia (Hume et al., 2009) and Belgium (Cardon et al., 2012), which reported an increase in the frequency of AST and an increase in cycling to/from school respectively. However, it is in contrast with many North American studies indicating lower rates of active transportation among high school students compared to their primary school counterparts (Evenson et al., 2003; Fulton et al., 2005; Gropp et al., 2012). Such findings are commonly attributed to increasing distance between home and school, which has been identified as the most consistent correlate of AST (Wong et al., 2011). Another Canadian multi-year longitudinal study documented that the relationship between age and the prevalence of AST was curvilinear, with a peak at 10 years of age followed by a substantial decline (Pabayo et al., 2011). Independent mobility (e.g., children's freedom to move around in public space without adult supervision) typically increases with age (Hillman et al., 1990; Shaw et al., 2015), and when children travel without parental accompaniment, they are more likely to use active modes (Mitra, 2013). This may partly explain the increase in AST over time. Collectively, these findings suggest that the relationship between age and school travel mode may be more complex than commonly thought.

Although distance was not measured in the current study, one would expect that, on average, children living in urban areas would live closer to school than their counterparts in rural areas. In line with our findings, previous North American studies have consistently reported higher rates of AST in urban areas (Gray et al., 2014; Pabayo and Gauvin, 2008; Robertson-Wilson et al., 2008). The observation that children living in urban areas were more active than their rural counterparts is also consistent with previous research (Liu et al., 2008; Rainham et al., 2012).

In accordance with previous North American studies (Gropp et al., 2012; McMillan et al., 2006; Pabayo and Gauvin, 2008; Robertson-Wilson et al., 2008), we observed that boys were much more likely to engage in AST than girls. It is possible that parents are more inclined to restrict independent mobility among girls than boys, in part because girls are perceived to be more vulnerable (Brown et al., 2008). Nevertheless, studies in Northern European countries, where AST (especially cycling) is more prevalent, typically do not show such gender differences (McDonald, 2012). Moreover, previous research suggests that, by traveling in groups, girls can enjoy as much independent mobility as boys (Brown et al., 2008). Collectively, this body of evidence suggests that it is possible to resolve the sex difference in terms of participation in AST. Efforts to promote AST among girls could help bridge the gap we also noted between boys and girls with regards to participation in MVPA and which is consistent with previous studies (Colley et al., 2017; Hallal et al., 2012).

We observed that the frequency of accumulating at least 60 min of MVPA per day followed a curvilinear pattern over time with an increase in the first few survey cycles followed by a decrease. Whereas some research supports our findings that PA peaks in early adolescence and declines afterwards (Allison et al., 2007; Telama and Yang, 2000), other studies suggest that PA may start to decline as early as the age of school entry (Farooq et al., 2018; Reilly, 2016). Collectively, this body of evidence emphasizes the need for promotion of PA across the life course. Furthermore, we also noted that at each time point, less than a quarter of participants accumulated at least 60 min of daily MVPA. These results are consistent with self-reported data from 105 countries compiled by Hallal et al. (2012). In their pooled analyses, 80.3% of 13- and 15-year-olds did not meet MVPA recommendations.

There was no difference in the frequency of accumulating at least 60 min of MVPA between active and motorized travelers; yet, participants using mixed modes reported greater levels of MVPA than those using motorized modes. These counter-intuitive findings might reflect differences in distance between home and school between active and “mixed” travelers. Perhaps the latter lived further away from school on average. Alternatively, it is plausible that many highly active youth participated in organized sports after school, and active travel to such venues and/or to go back home may be impractical. It is worth noting that our findings are inconsistent with two previous longitudinal studies indicating that switching from motorized to active school travel was associated with increases in accelerometer-measured MVPA (Cooper et al., 2012; Smith et al., 2012). Our crude self-reported measure of MVPA may have failed to capture transport-related PA. For example, participants may have considered walking to/from school as light-intensity PA rather than MVPA. The low prevalence of AST in our sample may also have limited our ability to detect a relationship with MVPA.

Our findings have implications for policy-makers and practitioners. They highlight a need for interventions to counteract the decline in MVPA and the low prevalence of AST across survey cycles. Interventions such as walking school buses and school travel planning may help increase AST and MVPA (Larouche et al., 2014, 2018). In the United States, school travel accounts for 10–14% of private vehicles on the road during the morning peak period; hence, AST interventions could help reduce traffic congestion and minimize the costs of school travel (McDonald et al., 2011, 2016). However, according to a recent systematic review (Larouche et al., 2018), previous AST interventions have focussed almost exclusively on primary school children. Our results suggest a need for researchers, practitioners, and decision-makers to collaborate to develop and implement interventions to promote AST in secondary schools.

It is also important to emphasize that all previous studies investigating seasonal variations in AST used repeated cross-sectional designs. In other words, different samples were recruited in different seasons; hence, observed changes could be at least partly due to differences between samples rather than true differences between seasons. Understanding seasonal variations in AST is important for researchers interested in PA and public health and for practitioners involved in AST interventions, which could be less successful in the winter. To this end, our results suggest that additional efforts may be needed to promote AST and MVPA in the winter. Multicomponent school-based interventions show promise in increasing PA among children and adolescents (Kriemler et al., 2011). Notably, Comprehensive School Health interventions have resulted in improvements in PA and eating habits, and reductions in the likelihood of obesity in the Canadian context (Veugelers and Schwartz, 2010). Practitioners could tailor school-based interventions to promote winter activities.

4.1. Limitations and strengths

The main limitation of our study relates to the use of self-reported measures of MVPA and school travel mode, which may be subject to social desirability and recall bias (Shephard, 2003). Second, while the 2-item MVPA measure has been shown to be reliable and significantly correlated with accelerometer-measured PA (Prochaska et al., 2011), it may have failed to capture PA during AST. Third, the psychometric properties of our measure of travel behaviors is unknown; however, researchers using similar questions have shown substantial test-retest reliability and convergent validity between child and parent reports (Larouche et al., 2014c). Fourth, data on distance between home and school were not collected in the MATCH study. Fifth, there was a substantial amount of missing data present across all survey cycles which is notably due to two schools interrupting their participation in the study early, to student absenteeism on data collection days and to loss to follow-up. The use of generalized linear models allowed us to make full use of data from all participants while attributing proportionally more weight to those with more data points. Sixth, the loss to follow-up may affect generalizability of the study. Seventh, we cannot tell how much walking was accrued by the students reporting mixed modes.

Conversely, the prospective study design with multiple data collection cycles over many years is a major strength of this study. To our knowledge, no previous study has examined PA and school travel mode on a triannual basis from childhood to adolescence. This has allowed us to more precisely examine seasonal variations in AST compared to previous studies which used repeated cross-sectional designs.

5. Conclusions

Our prospective cohort study has shown that the likelihood of engaging in AST varies substantially by season among New Brunswick students, with lower odds in the winter compared to the fall. Similar seasonal patterns were noted for MVPA. These observations suggest that additional efforts are needed to promote AST and MVPA in the fall and winter. Consistent with previous research (e.g., Dumith et al., 2011), we also observed a decline in MVPA over time, which underscores a need for PA interventions focusing on the transition from childhood to adolescence. Interventions may be particularly needed in rural areas where participants were substantially less active and less likely to engage in AST. Finally, we have observed that boys were over three times more likely to engage in AST compared to girls. Given that travelling in groups seems to enable girls to develop their independent mobility (Brown et al., 2008), parents and practitioners could encourage young girls to engage in AST with their peers. Social marketing campaigns may also help counteract the negative attitudes toward AST that often develop in adolescence, particularly among girls (Underwood et al., 2014).

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Conflict of interest

The authors report that they have no conflicts of interest.

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.jth.2018.08.012.

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