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Research Article

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Assessing the Influence of the Transition from Primary to Secondary School on the Volume of Active School Transport and Physical Activity: A Prospective Pilot-Study

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Abstract

Objectives: Active school transport (AST, e.g. the use of non-motorized travel modes such as walking and cycling to travel to/from school) is increasingly promoted as a source of physical activity (PA) in children and youth. This prospective pilot-study assessed the: 1) test-retest reliability of a novel measure of the volume of AST; 2) changes in AST and pedometer-determined PA across the transition from primary to secondary school; and 3) associations between AST and PA at both time points.

Methods: 55 grade 6 students were recruited from 4 primary schools in Ottawa (Canada) in May/June, 2012. They were asked to complete a diary indicating their mode of transport to/from school for 1 week, and wear a SC-StepMX pedometer for 8 consecutive days. 48 study packages were returned at baseline and 29 at follow-up (September/October 2012). For the test-retest assessment, a separate sample of 22 participants completed the diary during 2 consecutive weeks.

Results: The weekly volume of AST (e.g. number of active trips X distance) showed high test-retest reliability (ICC=0.87). There were significant decreases in the proportion of children categorized as active travelers (57% to 46%), and in step counts (16,578 ± 3,758 to 14,071 ± 3,680 steps/day) across the school transition. However, in participants reporting at least 1 active trip at both time points (n=11), the volume of AST increased with a moderate effect size (d=0.52), but this change was not statistically significant. While no dose-response association between the volume of AST and PA was evident (probably due to limited statistical power), a gender-adjusted ANOVA indicated that active travelers accumulated an additional 2,207 steps/day at follow-up.

Conclusion: These findings suggest that future research is needed to quantify changes in AST across the school transition, and to determine if AST can attenuate the commonly-observed decline in PA levels from childhood to adolescence.

Keywords: Active travel; Physical activity; Pedometers; Longitudinal study; School transition

Introduction

In the last decade, there has been increased research on the use of modes of transport such as walking and cycling to travel to and from school (e.g. active school transport or AST) [1-3]. A recent systematic review reported that AST was associated with greater physical activity (PA) levels, and the quality of evidence was rated as moderate [4]. This review also found that children who cycled to/from school consistently had greater cardiovascular fitness. Prospective findings from the Danish arm of the European Youth Heart Study indicated that adolescents who cycled to/from school had lower cardiovascular disease risk factors at 15 years of age [5]. Furthermore, substituting motorized trips with active travel has several environmental co-benefits, including reduced greenhouse gases and particulate matter emissions, and reduced traffic congestion [6,7].

Despite these benefits, time trends studies have consistently shown decreases in the rates of AST in many countries, including Australia [8], Canada [9], and the United States [10]. However, longitudinal studies that examined changes in AST from childhood to adolescence have reported mixed findings. Cooper et al. [11] observed that fewer British children walked to/from school in secondary school; however, those who did so travelled greater distances. A Canadian study found that the proportion of children using AST increased with age up to 10 years of age, and then decreased afterwards [12]. In contrast, an Australian study has shown that the number of weekly trips using AST increased between the ages of 12 and 14 [13], and a Belgian study found that the proportion of participants who cycled to school was significantly lower at 10 years of age, compared to 11, 12, 13 and 16 years of age [14].

In parallel, prospective studies have consistently reported decreases in PA levels from childhood to adolescence [15,16]. However, little is known about the potential of AST to prevent or attenuate the decline in PA, following the transition to secondary school. To our knowledge, only Cooper et al. [11] have examined this question. They reported increases in moderate-to-vigorous physical activity (MVPA) in British children, who started to walk to school in secondary school, and in those who walked at both time points. Conversely, they noted a 15.5% decrease in MVPA in children who switched from walking to car riding.

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Although several studies have assessed the relationship between AST and PA levels, almost all of them have used categorical measures of AST (i.e. active vs. inactive travel), and the criteria used for categorizing individuals varied markedly across studies [4]. Another limitation of this approach is that distance traveled can moderate the relationship between AST and PA levels [17,18]. To our knowledge, no previous study has used a continuous measure of the volume of AST; which can be obtained by multiplying the number of active trips to/from school, by the distance between individuals' home and the school that they attend.

Therefore, this pilot study aimed to address these research gaps by 1) assessing the test-retest reliability of a measure of the weekly volume of AST; 2) using this instrument to assess the immediate effects of the transition from primary to secondary school (e.g. from grade 6 to grade 7) on the proportion of children engaging in AST, and the volume of AST and PA; and 3) measuring the changes in the distance between participants' home and the school that they attend, and their level of PA as measured by pedometry. Finally, the strength of the associations between measures of AST and PA was evaluated at both time points.

Methods

Participants

For the test-retest reliability component, a convenience sample of 22 primary and secondary school children (13 girls and 9 boys) aged 10 to 14 years was recruited. Participants were asked to complete a short diary, in which they indicated their mode of transport to and from school for each day of the school week, for two consecutive weeks during the fall season.

Second, 4 K-6 primary schools in the city of Ottawa (Canada) agreed to be involved in the Active Transportation Transition Study. Only students in grade 6 were eligible to participate because the study aimed to assess the immediate influence of the school transition. Parents were asked to indicate their child's prospective secondary school for grade 7, and either their phone number or e-mail address for follow-up purposes. The flow of participants in the study is shown on figure 1. Baseline data were collected in May/June 2012, and the follow-up was conducted in September/October 2012. Primary and secondary schools were respectively given a $100 and $50 honorarium for participation in the study to support physical activity-related initiatives. Ethical approval was obtained from institutional Research Ethics Boards, and from the 2 participating school boards.

Setting

It has been shown that secondary schools generally have larger catchment areas than primary schools [19]. As a result, the average distance between participant's home and the school that they attend should be greater for secondary school students, so the school transition could lead to a decrease in the mode share of AST (e.g. the proportion of children engaging in AST). According to a US study [20], average distance is generally lower in neighborhoods with greater population density; hence, population density of the primary school census tracts was obtained from the 2006 Canadian census [21]. Of the 4 schools, 2 were located in census tracts with high population density (3531-4100 inhabitants/km^2), while the 2 others were located in lower density areas (988-2159 inhabitants/km^2). Participants attending primary schools located in higher density census tracts stayed in the same area for secondary school, while those who attended primary schools located in lower density census tracts went to 7 different secondary schools, most of which were located outside of their neighborhood.

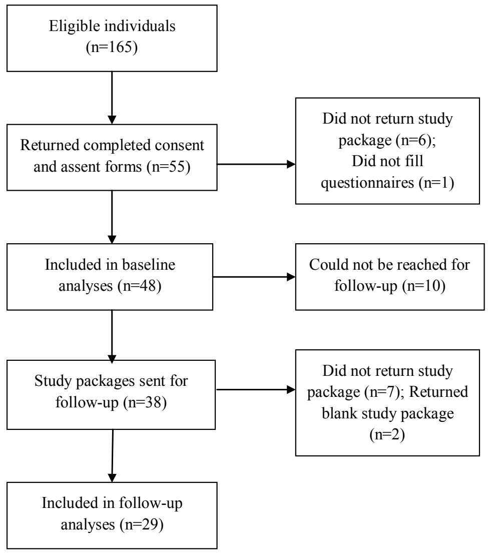

Figure 1: Flow of participants in the active transportation transition study.
Baseline data was collected in May/June 2012 when participants were in primary school (grade 6), and follow-up data was collected in September/October 2012, just after participants had started secondary school (grade 7).

Procedures

Participants involved in the test-retest evaluation were asked to complete a short diary, in which they indicated their mode of transport to and from school for each day of the school week during two consecutive weeks. Participants in the longitudinal assessment were asked to complete this diary, once in the spring and once in the fall. In addition, they were instructed to wear a SC-StepMX^{TM} pedometer (Stepscount, Deep River, ON) on the right hip for 8 consecutive days, and to complete a daily log recording their daily step counts, as well as the time the pedometer was worn during waking hours. This pedometer has demonstrated high validity and reliability [22]. Parents were asked to indicate their postal code and the name of their child's school, to allow for estimation of the distance between home and school.

Data treatment

The volume of AST was calculated by multiplying the frequency of AST by the distance between participants' home and the school that they attend. Frequency was defined as the number of trips using active travel modes (i.e. walk, bike, skateboard, non-motorized scooter, etc.), with values ranging from 0 to 10. Distance (in kilometers) was estimated with Google Maps, using the shortest walking route option, acknowledging that some participants may take longer routes due to safety concerns, and others may take shortcuts outside of the road and sidewalks network [23]. The postal code provided by the parent was used as a proxy for residential address [24]. Because the volume of AST was skewed, it was transformed into its natural logarithm (ln) to achieve quasi-normal distribution (non-transformed descriptive data are provided in the results section for ease of interpretation). Hence, the formula was: volume=ln (1+frequency×distance), with the constant (1) added to ensure that no volume was below 0. To enable comparison of the findings with other studies, a dichotomous measure of participant's primary mode of transport (e.g. active vs. inactive) was also used, based on the information from the diaries. Participants were classified as active travelers, if they used AST for at least 50% of school trips.

The raw pedometry data were screened based on established criteria, including 1) between 1000 and 30000 steps/day [25,26]; 2) at least 10 hours of data/day [27], and 3) at least three days of valid data (e.g. meeting the daily wear threshold values) [26]. Application of these thresholds led to the exclusion of pedometer data from 2 participants at baseline, and none at follow-up. The main PA measure used in the analyses was average daily steps counts, but average weekday and weekend step counts are also reported.

Statistical analyses

The test-retest reliability for the measures of primary travel mode and volume of AST were assessed with the kappa statistic and Intraclass Correlation Coefficients (ICC), respectively. Subsequently, a series of analyses were performed. First, changes in the volume of AST distance between home and school and average daily step counts were assessed with paired-samples t-tests, while changes in the mode share of AST were examined with a chi-square test. Second, the association of participants' primary mode of transportation with distance and PA at both time points were assessed with independent-samples t-tests and two-way (gender by travel mode) ANOVAs, respectively. Third, among participants who reported at least one active trip, associations between the volumes of AST and PA were assessed with linear regression analyses adjusted for gender. Effect sizes were determined with Cohen's d for the t-tests, and with the partial eta-squared (η^2) statistic for the ANOVAs, using Cohen's Statistical Power Analysis [28] cut-points. All analyses were performed with IBM SPSS 20 and α were set at 0.05.

Results

Based on the diary, the ICC for the volume of AST was 0.87 (95% CI=0.71-0.94). The proportion of participants classified as active travelers (e.g. who did ≥ 50% of their school trips using AST) was 22.7% in week 1 and 31.8% in week 2. The kappa value was 0.77. Descriptive characteristics of the participants at baseline and follow-up are provided in table 1. At baseline, 30 participants did at least one active trip, accumulating an average volume of 6.9 ± 4.5 km/week. Of the 27 participants classified as active travelers, 11 walked, 10 cycled, 2 used non-motorized scooters, 1 skateboarded, and 3 used a combination of active modes. At follow-up, the average volume of AST among the 13 participants who did at least one active trip was 11.1 ± 10.9 km/week. Similarly, 13 participants were classified as active travelers (9 walked, 3 cycled and 1 used a non-motorized scooter).

The subsample of participants included in longitudinal analyses (e.g. on the basis that they provided valid data at baseline and follow-up) varied by outcome (Table 2). Active travelers tended to accumulate greater volumes of AST at follow-up, but this difference was not statistically significant (t=1.08; p=0.31), despite a moderate effect size (d=0.52). It is worth noting that there was large between-individual variability in the volume of AST, especially at follow-up. In contrast, the mode share of AST significantly decreased from 57% to 46% (X^2=3.88; p=0.05), while average distance between home and school increased from 2.6 ± 2.7 to 3.9 ± 3.4 km (t=-3.12; p=0.004). Average daily step counts also decreased from 16,578 ± 3,758 to 14,071 ± 3,680 steps/day (t=4.43; p<0.001). Similar declines in step counts were found for weekday and weekend days steps.

Two way ANOVAs examined the association between participant's primary mode of transport and step counts at both time points (Table 3). At baseline, active travelers accumulated 1,118 more steps/day than passive travelers, but this difference was not significant (F=2.17; p=0.15), and effect size was small (η^2=0.05). At follow-up, the difference in step counts was 2,207 steps/day, and effect size was large (F=5.48; p=0.03; η^2=0.20). Although the gender by mode share interactions were not statistically significant (p>0.22), the strength of the association between AST and step counts was greater in girls than in boys at baseline, while the opposite trend was noted at follow-up. Independent-samples t-tests indicated that active travelers lived significantly closer to their school than inactive travelers at baseline (t=-7.04; p<0.001) and follow-up (t=-5.84; p<0.001). However, linear regression analyses demonstrated no dose-response associations between the volume of AST and steps counts at baseline (F=0.45; p=0.51) and follow-up (F=0.17; p=0.69).

Discussion

The present study had three main objectives: 1) to develop a measure of the volume of AST and assess its test-retest reliability; 2) to measure the changes in AST, PA and distance between home and school, resulting from the transition from primary to secondary school; and 3) to assess the strength of the relationship between AST and PA, at the end of primary school and the beginning of secondary school.

Test-retest reliability

High test-retest reliability coefficients were found for the participants' volume of AST and primary travel mode dichotomized as active vs. inactive. To our knowledge, no peer-reviewed study has reported the reliability of a continuous measure that combines both the frequency of AST trips, and the distance between home and school. However, high reliability coefficients have been reported for questions on habitual travel mode and "hands-up" classroom surveys [29-31].

The potential advantages of using a continuous measure may include: 1) a more precise quantification of the relationship between AST and health-related outcomes; 2) the possibility of examining dose-response relationships; and 3) using a consistent measure of AST would facilitate the inclusion of studies in meta-analyses. Indeed, meta-analyses could not be performed in earlier systematic reviews due to

Variable	Categories	Baseline	Follow-up
Gender	Girls	24	16
	Boys	24	13
Travel mode	Active	27 (14G,13B)	13 (8G,5B)
	Inactive	19 (9G,10B)	15 (7G,8B)
	Missing	2 (1G,1B)	1 (1G)
Volume of AST (km)	Overall	6.9 ± 4.5	11.1 ± 10.9
	Girls	6.4 ± 3.2	8.9 ± 4.2
	Boys	7.4 ± 5.4	14.6 ± 17.4
Distance (km)	Overall	2.3 ± 2.4	3.9 ± 3.4
	Girls	2.2 ± 2.3	3.0 ± 2.9
	Boys	2.5 ± 2.6	4.9 ± 2.7
Average steps/day	Overall	16,805 ± 3,744*	14,071 ± 3,680
	Girls	15,235 ± 2,973	12,728 ± 3,301
	Boys	18,447 ± 3,820	15,415 ± 3,662
Weekday steps/day	Overall	17,501 ± 3,872*	14,743 ± 3,701
	Girls	16,025 ± 3,093	13,368 ± 3,455
	Boys	19,045 ± 4,064	16,117 ± 3,537
Weekend steps/day	Overall	15,424 ± 6,165	12,206 ± 4,409
	Girls	14,017 ± 6,361	10,828 ± 3,159
	Boys	16,981 ± 5,704	13,372 ± 5,072

AST=Active School Transport; G=Girls; B=Boys. Statistics are presented as mean ± SD. Differences between boys and girls were assessed with independent-samples t-tests and X^2 tests, where appropriate. Weekly volume of AST was computed only for participants reporting at least 1 active trip. *denotes statistical significance (p<0.05).

Table 1: Descriptive characteristics of the sample at baseline and follow-up.

important discrepancies in the classification of participants as active and passive travelers [2,4]. Other studies also suggest that the criterion distances for walking and cycling (e.g. the distance that one would be willing to walk or cycle) vary between countries and between age groups [32-34]. While the present study was likely underpowered for the purpose of detecting a dose-response association, it is noteworthy that British researchers have reported that distance moderates the association between AST and PA [17,18]. In these 2 studies, distance was treated as a categorical variable.

Immediate effects of the transition from primary to secondary school on AST and PA levels

A moderate-size increase in the volume of AST was observed among active travelers; however, this difference was not statistically significant, likely owing to the large variability in the volume of AST and the small sample size. *A posteriori* sample size calculations based on the observed effect size indicate that 32 participants would have been necessary for a paired-samples t-test to achieve a power of 0.8, with a two-tailed α of 0.05. However, only 11 participants did at least 1 active trip at both time points. Because no earlier study has reported changes in the weekly volume of AST across the transition from primary to secondary school, there is a need for future studies with larger sample sizes.

In contrast, an 11% decrease in the mode share of AST was observed using the dichotomous measure. The lower mode share in secondary school students is consistent with findings from the Canadian National Longitudinal Survey of Children and Youth [12], although this report did not specifically assess the effect of the school transition. In line with the present study, Cooper et al. [11] reported a decrease in the proportion of children walking to school (from 77.0% to 60.7%), that was mirrored by an increase in bus riding (from 0.7 to 18.6%). Because secondary schools generally have much larger catchment areas, the proportion of students living within a "walkable" distance is likely to be lower, thereby leading to a decrease in AST [19]. A systematic review has found that distance between home and school was the most consistent environmental correlate of AST, as measured by geographic information systems [23]. In the present study, the average distance increased by almost 50% across the school transition. At both time points, active travelers lived significantly closer to their school than passive travelers. Together, these findings suggest that although fewer participants used AST at follow-up, those who did so tended to travel greater distances, and to accumulate greater volumes of AST.

Levels of PA decreased by about 15% across the school transition; this finding is consistent with earlier reviews [15,16]. For instance, in their meta-analysis of 26 tracking studies, Dumith et al. [15] found a 7% annual decline in PA during adolescence, and only one study reporting an increase. In a life course perspective, studies have found that the age-related decline in PA is not linear; it tends to be faster upon key transition periods in the lifespan (such as the school transition, entry into the labour market, etc.), and slower between these major life events [35-37]. Hence, these authors argued that such major life events are critical periods for the promotion of PA.

Variable	n*	Primary school	Secondary school	Test statistic	*p*	d
AST mode share	28	57.1%	46.4%	3.88	0.049	N/A
Volume of AST†	11	1.8 ± 0.7	2.2 ± 0.8	1.08	0.306	0.52
Distance	28	2.6 ± 2.7	3.9 ± 3.4	-3.12	0.004	0.41
Average steps/day	26	16,578 ± 3,758	14,071 ± 3,680	4.43	<0.001	0.67

Changes in the mode share of AST were assessed with X^2 test; changes in all other variables were assessed with paired-sample t-tests. *n refers to the sub-samples of participants who provided valid data at baseline and follow-up for each variable. AST=Active School Transport. †the log-transformed volume of AST was obtained with the following formula: ln (1+frequency×distance).

Table 2: Changes in active school transport, distance between home and school, and average daily step counts upon the transition from primary to secondary school.

Period	Gender (n)	AT steps ± SD	IT steps ± SD	F	*p*	η^2
Baseline	Overall (43)	17,300 ± 3,389	16,182 ± 4,367	2.17	0.15	0.05
	Girls (22)	16,037 ± 2,931	13,545 ± 2,555	4.02	0.06	0.17
	Boys (21)	18,908 ± 3,365	18,291 ± 4,452	0.13	0.72	0.01
Follow-up	Overall (26)	15,175 ± 3,995	12,968 ± 3,101	5.48	0.03	0.20
	Girls (13)	13,250 ± 3,246	11,893 ± 3,584	0.50	0.50	0.04
	Boys (13)	18,256 ± 3,189	13,639 ± 2,794	7.57	0.02	0.41

Two-way ANOVA models (e.g. travel mode by gender) were used for the "overall" models and one-way ANOVA were used for the gender-specific models. AT=Active Travelers; IT=Inactive Travelers. η^2 indicates the independent effect size of travel mode within the models.

Table 3: Differences in average daily step counts between active and inactive travelers.

Association between AST and PA levels

The third objective of the study was to examine the strength of the association between AST and PA levels at both time points. Linear regression analyses found no evidence of an association between the volume of AST and PA levels at any time points. However, as stated previously, this might be explained by the large variability of the volume of AST, and the small sample size. Hence, further research is needed to determine whether there is a dose-response relationship between the volume of AST and PA level.

Two-way ANOVAs indicated that active travelers accumulated 2,217 additional steps per day on weekdays, at follow-up with a large effect size. However, daily step counts did not significantly differ between active and inactive travelers at baseline. This finding could be partly explained by shorter distances between home and school, and by the limited ability of pedometers to measure PA during cycling [38], given that 10 participants cycled to/from school at baseline. Furthermore, primary school children using AST may have "compensated" by being less active in the remainder of the day [39]. This potential explanation is supported by the observation that active travelers accumulated only 132 more steps/day on weekdays during primary school. It is also noteworthy that inconsistencies between genders were observed with respect to the strength of the association between AST and PA. Other studies have found similar inconsistencies [40-42].

British researchers recently examined the relationship between AST and PA level in primary and secondary school students, using a combination of accelerometers and global positioning systems in two separate cross-sectional studies [43-44]. In line with the present study, they observed that the relationship between AST and daily MVPA was stronger in secondary school students than in primary school students. Cooper et al. [11] also found an increase in PA across the school transition in participants who started walking. Together, these studies provide preliminary evidence, suggesting that promoting AST during adolescence may be a key strategy to attenuate the age-related decline in PA levels. How best to do this remains to be seen given that the majority of school travel intervention research has been done in the elementary school context [45]. Barriers and facilitators to AST may be very different for adolescents.

Limitations and strengths

The small sample size should be considered when interpreting the findings for the following reasons. First, limited statistical power may have reduced the likelihood of observing significant associations; thus caution is needed in making a distinction between a lack of evidence of effect and evidence of no effect. Second, the sample may not be representative of the population, especially given the low participation rate. The longitudinal study design, and the school board requirement that incentives cannot be offered to participants, may have contributed to the low participation rate. Third, the volume of AST was calculated irrespective of active travel mode, although it is known that pedometers underestimate PA during cycling [38]. Because cyclists generally traveled longer distances, combining active travel modes in the analyses may have reduced the likelihood of observing significant relationships. Thus, whenever possible, future studies should examine active travel modes separately, as recommended by Shephard [3]. In addition, the observed decline in PA may be partially explained by seasonal variations [46,47]. However, the follow-up was done as early as possible in the school year, in order to minimize this potential bias. Alternatively, conducting the follow-up in the following spring would have avoided seasonal bias, but at the expense of less accurately measuring the immediate effects of the school transition, which was the main study objective. Interestingly, no seasonal differences in travel modes were observed among 11-12 years old children in Toronto [48]. Finally, the use of postal codes rather than actual street addresses limits the precision of the distance estimation, but there is no reason to believe that it has systematically biased the findings in one direction or another. A study in Calgary (Canada) found that 87.9% of postal code locations were within 200 meters of the true address location [24].

On the other hand, the prospective study design is an important strength of the study. Second, while the school transition had repeatedly been shown to be associated with a major decrease in PA [15], only one study had previously examined changes in AST upon this important transition period [11]. Third, PA was assessed with an objective measure, rather than a self-report instrument prone to recall bias [49]. Furthermore, the present study confirms the test-retest reliability of a new approach to quantify the volume of AST, which can be included in future studies with minimal cost.

Conclusion

This pilot-study found that one week measurement of the volume of AST is very reliable, providing a new strategy for researchers interested in quantifying the relationship between AST and health-related outcomes. Consistent with previous studies, an important decline in PA was observed upon the transition from primary to secondary school. The mode share of AST also decreased significantly during this transition, but active travelers tended to accumulate greater volumes of AST in secondary school. Furthermore, the difference in step counts between active and inactive travelers was about twice as large in secondary school. Together, these findings suggest that AST may account for a greater proportion of PA among adolescents than in children. However, these findings must be interpreted with caution, given the small sample size; thus, there is a need for the replication of this study design with larger samples. Nevertheless, the present findings provide a rationale for future studies to determine whether the promotion of AST during adolescence could attenuate the commonly observed age-related decline in PA.

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