Relationship Between Active School Transport and Body Mass Index in Grades-4-to-6 Children

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The current investigation assessed the impact of active school transportation (AST) on average daily step counts, body mass index (BMI) and waist circumference in 315 children in Grades 4–6 who participated to Cycle 2 of the Canadian Assessment of Physical Literacy (CAPL) pilot testing. T-tests revealed a significant association between AST and lower BMI values (18.7 ± 3.3 vs. 19.9 ± 3.8 kg/m²). The active commuters accumulated an average of 662 more steps per day, and their waist circumference was lower by an average of 3.1 cm, but these differences were not statistically significant. ANCOVA analyses controlling for age and step counts, found trends toward lower BMI and waist circumference values among the active commuters. These results suggest that AST may be a valid strategy to prevent childhood obesity; further research is needed to determine more precisely the impact of AST on body composition, and the direction of the relationship.

The prevalence of childhood overweight and obesity has increased rapidly in many countries and it is now considered a pandemic (43). Recent data from the Canadian Health Measures Survey illustrate that the rising prevalence of obesity occurred in conjunction with a sevenfold increase in the prevalence of elevated waist circumference in Canadian youth between 1981 and 2007–2009 (25). Further, according to the 2010 Active Healthy Kids Canada report card on physical activity for children and youth (2), only a small proportion of Canadian children and adolescents meet either the 60 or the 90 min of daily moderate to vigorous physical activity (MVPA) guidelines (22,36). Insufficient physical activity among children and youth has been linked to several health problems such as impaired glucose tolerance and cardiovascular disease risk factors (4,24).

To alleviate these societal trends, researchers have traditionally focused on increasing leisure-time physical activity as a form of intervention. However, emerging evidence suggests that, in isolation, increasing leisure-time physical activity may be an insufficient approach to prevent and/or treat obesity and its complica-
Such observations have led to the emergence of research focusing on the concept of “active living”, within which active school transportation (AST) represents a key component for children (34,35).

In a recent systematic review, Faulkner and colleagues (20) reported that in 11 of 13 studies, children who engaged in AST had higher levels of objectively measured physical activity on a daily basis. However, based on the existing data, these authors could not draw a strong conclusion on the relationship between AST and body weight. The purpose of the current study was to examine the relationship between AST, daily physical activity and body composition variables (e.g., body mass index [BMI] and waist circumference) among Eastern Ontario children in grades 4–6 who participated in pilot testing of the Canadian Assessment of Physical Literacy (CAPL; 27,38).

Methods

The CAPL is a contemporary assessment tool that is still in the development process. It is being developed with the goal of being a valid, reliable, feasible and informative tool to assist in the assessment of physical literacy in children. The CAPL assesses the four domains of physical literacy: fundamental motor skills, physical activity behavior, physical fitness, and knowledge, awareness and understanding (26,38).

Participants

Research ethics approval was obtained from the researchers’ institution as well as two local participating school boards (1 urban, 1 rural). Participation was completely voluntary and written informed consent was obtained from all parents/guardians. In addition written assent was obtained from each participant. Data for the current study are from the second cycle of pilot testing (cycle 1 was primarily feasibility testing). In cycle 2, 364 children from grades 4–6 participated and were asked to report their primary mode(s) of transportation to and from school in both the Fall/Winter and the Spring/Summer seasons as part of the knowledge, awareness and understanding assessment module. Specifically, the children were asked “Please circle how you get to school most of the time in the Fall/Winter (during cold or snowy weather)” and “in the Spring/Summer (during nice weather)?”

Forty-nine participants did not answer the questionnaire and/or the question related to AST. Thus, the data from 315 children with a mean age of 10.1 ± 0.9 years were included in the current analyses. T-tests revealed no difference between these children and those that did not report their mode of transportation for age, sex, BMI and waist circumference. However, the excluded participants accumulated an average of 1346 less steps per day (t = 2.06; p = .04).

Procedure

The participants were instructed to wear a pedometer (Digi-Walker SW200) for 7 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. The same pedometer and data collection procedures were used by the Canadian Fitness and
Lifestyle Research Institute in the annual nationally representative CANPLAY study (15). The assessment of body composition was conducted by a Certified Exercise Physiologist (details of this certification can be found at http://www.csep.ca/english/view.asp?x=739), according to the Canadian Physical Activity, Fitness & Lifestyle Approach protocol (9). Height was measured to the nearest 0.1 cm and without footwear using a portable stadiometer (SECA: Hamburg, Germany). Weight was measured wearing light clothing and without footwear and to the nearest 0.1 kg with a digital scale (A&D Medical: Milpitas, CA.). Waist circumference was measured to the nearest 0.5 cm at the top of the iliac crest, and at the end of a normal expiration. Data collection was performed during the Fall of 2009 and Winter 2010.

Data Treatment and Analysis

The raw pedometry data were screened based on established criteria including 1) Between 1000 and 30000 steps/day (31,40); 2) At least 10 hr of data/day (12,19) and 3) At least three days of valid data (e.g., meeting the daily wear threshold values; 40). The days where these criteria were not met were removed and replaced by the average daily step counts for each participant, as recommended by Rowe and colleagues (32). Application of these criteria resulted in the removal of 13 person-days for outlying number of steps/day and 84 person-days for insufficient wear time. The pedometry data from five participants was excluded because they had less than three days of valid measurement. In total, acceptable pedometry data were available for 262 participants for a total of 1642 person-days.

Based on their self-reported modes of transportation to and from school, the participants were classified into three groups: passive commuters, active commuters, and multiple modes (i.e., a combination of active and passive modes of transportation such as walking and being driven). ANOVAs were performed to assess differences between groups for average daily step counts, BMI and waist circumference. The Bonferroni post hoc test was used given the differences in the number of participants in each group.

As illustrated in Table 1, only 27 participants (8.6% of the total sample) reported multiple modes of transportation and variability between subjects was very high among this subgroup for the outcome variables. In addition, the ANOVAs revealed no significant differences between those who reported multiple modes of transportation and the other subgroups. Thus, subsequent analyses were performed only between the active and passive commuters using t tests. Chi-square analyses were also used to compare the rates of overweight and obesity based on the International Obesity Task Force (IOTF) classification (11). Finally, ANCOVAs were performed to compare the mean values for BMI and waist circumference while controlling for physical activity level (average daily step counts) and age. The statistical analyses were performed with the PASW Statistics 18 software (SPSS inc., Chicago, Il.) and the level of significance was set at $p < .05$. For the ANCOVAs, the estimated marginal means are presented with 95% confidence intervals (CI). Normal distribution of the outcome variables (BMI, waist circumference and steps/day) could not be rejected based on the skewness and kurtosis of the distribution. Levene’s test for equality of variance was performed with the t tests and all $p$ values were $\geq 0.05$. 

The prevalence of AST in this sample was 21.0% and 30.9% in the Fall/Winter and Spring/Summer seasons respectively. A Spearman correlation of 0.75 ($p < .01$) indicates a high stability in mode of transportation throughout the year. Therefore, because the data on the outcome variables (physical activity and anthropometric measures) were collected in the Fall, only the mode of transportation reported for the Fall/Winter seasons was included in the analyses.

T-test results indicate that the active commuters had significantly lower BMI values ($18.7 \pm 3.3$ vs. $19.9 \pm 3.8$ kg/m²; $p = .04$) and they had a lower prevalence of overweight and obesity than the passive commuters ($30.5$ vs. $44.6\%$; $X^2 = 3.75; p = .05$). Moreover, the prevalence of obesity was more than two times lower among the active commuters, although this difference is not statistically significant ($6.8\%$ vs. $14.2\%$; $X^2 = 2.31; p = .13$). The active commuters accumulated an average of 662 more steps per day, but this difference was not significant ($11,924$ vs. $11,261$ steps; $p = .23$). In addition, the average waist circumference was lower by 3.1 cm in the active commuters in comparison with the passive commuters ($69.1 \pm 9.6$ vs. $72.2 \pm 11.9$ cm; $p = .10$).

Two ANCOVA analyses controlling for age and average daily step counts were performed to further assess the relationship between AST, BMI and waist circumference. The results are summarized in Table 2. In both ANCOVA models, the relationships did not differ according to gender. In model 1, the relationship between AST and BMI fell at the significance threshold ($F = 3.75; p = .05$). The estimated marginal means for BMI were $18.6$ kg/m² (95% CI = 17.5–19.8) for the active commuters and $19.9$ kg/m² (95% CI = 19.3–20.5) for the passive commuters. Step counts were associated with BMI, but not age (respectively $F = 4.27; p = .04$ and $F = 2.41; p = .12$). According to the second ANCOVA model, the active commuters had lower mean waist circumferences, but the difference was not significant ($F = 2.79; p = .10$). The estimated marginal means for waist circumference were

### Table 1 Descriptive Characteristics of the Sample

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Active commuters</th>
<th>Passive commuters</th>
<th>Multiple modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of participants</td>
<td>66</td>
<td>222</td>
<td>27</td>
</tr>
<tr>
<td>Age (years)</td>
<td>$10.2 \pm 0.9$</td>
<td>$10.1 \pm 0.8$</td>
<td>$10.3 \pm 0.8$</td>
</tr>
<tr>
<td>% Girls</td>
<td>48.5</td>
<td>48.6</td>
<td>40.7</td>
</tr>
<tr>
<td>Step counts (steps per day)</td>
<td>$11,924 \pm 3,776$</td>
<td>$11,261 \pm 3,107$</td>
<td>$10,641 \pm 3,664$</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>$18.7 \pm 3.3$</td>
<td>$19.9 \pm 3.8^*$</td>
<td>$19.6 \pm 4.4$</td>
</tr>
<tr>
<td>% Overweight</td>
<td>30.5</td>
<td>44.6*</td>
<td>33.0</td>
</tr>
<tr>
<td>% Obese</td>
<td>6.8</td>
<td>14.2</td>
<td>12.5</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>$69.1 \pm 9.6$</td>
<td>$72.2 \pm 11.9$</td>
<td>$74.1 \pm 13.3$</td>
</tr>
</tbody>
</table>

N.B. Data are presented based on Fall/Winter modes of transportation. The prevalence of overweight and obesity is based on the International Obesity Task Force’s thresholds (11). Asterisks illustrate significant differences between active and passive commuters ($p < .05$).

### Results

The prevalence of AST in this sample was 21.0% and 30.9% in the Fall/Winter and Spring/Summer seasons respectively. A Spearman correlation of 0.75 ($p < .01$) indicates a high stability in mode of transportation throughout the year. Therefore, because the data on the outcome variables (physical activity and anthropometric measures) were collected in the Fall, only the mode of transportation reported for the Fall/Winter seasons was included in the analyses.

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69.0 cm (95% CI = 65.2–72.8) and 72.6 cm (95% CI = 70.7–74.4) for the active and passive commuters respectively. The second model also revealed that both step counts and age were significantly associated with waist circumference (respectively $F = 8.24; p < .01$ and $F = 5.44; p = .02$).

**Discussion**

The purpose of our investigation was to assess the relationship between AST, physical activity levels and body composition. The most important finding was that BMI was significantly lower among the active commuters, when compared with the passive commuters (a mean difference of 1.2 kg/m²), even when controlling for age and daily step counts. The combined prevalence of overweight and obesity was approximately 46% lower among the active commuters. Moreover, for a 10 year old child, the mean BMI observed in the passive commuters (19.9 kg/m²) correspond to the threshold for overweight according to the IOTF classification (11). These differences are clinically relevant given the wide range of medical and psychosocial complications associated with childhood obesity (21,28).

It is of great concern that a decline in the prevalence of AST has been observed among Canadian (8), American (29) and Australian (42) children and adolescents during the last decades. These trends occurred in parallel with rapid increases of childhood obesity. For example, Tremblay and colleagues (39) compared the results of the children and adolescents who participated in the 1981 Canada Fitness Survey and the 2007–2009 Canadian Health Measure Survey. They found that the later had a 1.1 kg/m² higher BMI, and the combined prevalence of overweight and obesity doubled (39). However, the potential contribution of the reduction in the prevalence of AST on the increase of body weight has not been evaluated empirically.

Our results are in contrast with the findings of a systematic review on the topic (20), where most studies did not report a relationship between AST and BMI, but the authors noted that the existing evidence was too weak to draw a strong conclusion. It was also argued that the absence of significant differences could result from

<table>
<thead>
<tr>
<th>Source</th>
<th>Body mass index</th>
<th>Waist circumference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$F$ value</td>
<td>$p$ value</td>
</tr>
<tr>
<td>Corrected model</td>
<td>2.08</td>
<td>0.07</td>
</tr>
<tr>
<td>Steps per day</td>
<td>4.27</td>
<td>0.04</td>
</tr>
<tr>
<td>Age</td>
<td>2.41</td>
<td>0.12</td>
</tr>
<tr>
<td>Mode of transportation</td>
<td>3.75</td>
<td>0.05</td>
</tr>
<tr>
<td>Gender</td>
<td>0.01</td>
<td>0.94</td>
</tr>
<tr>
<td>Transport * Gender</td>
<td>0.04</td>
<td>0.84</td>
</tr>
</tbody>
</table>

N.B. For BMI, the $R^2 = .05$ (Adjusted $R^2 = .026$) and for waist circumference, $R^2 = .092$ (Adjusted $R^2 = .065$)
rather short distances between home and school among most active commuters (20). More recently, German researchers observed an inverse association between AST and obesity when objectively measured distance to school was taken into account, suggesting a dose-response relationship (26). Similarly, prospective data from the Québec Longitudinal Study of Child Development found that sustained AST over two years in young children predicted lower BMI values (31).

The current study reveals a trend toward smaller waist circumferences among the active commuters. As reflected by the large standard deviation, it can be hypothesized that the variability between participants precluded the observation of a significant difference. To our knowledge, earlier publications did not assess the association between AST and waist circumference. This is surprising given the strength of the association between waist circumference and health risks such as insulin resistance, elevated cholesterol and blood pressure in youth (44,45). Some pedometry-based studies have shown that children who did not meet the step recommendations were more likely to have an elevated waist circumference or a higher body fat percentage (17,19). Moreover, Eisenmann and colleagues’ (19) demonstrated a dose-response relationship between step counts categories, BMI and waist circumference.

The current findings highlight the need for further investigation on the impact of AST on body composition variables. To date, most published studies have: 1) used a cross-sectional methodology (20); 2) relied only on BMI as an indicator of obesity, which may not accurately reflect body composition (44); 3) did not distinguish between modes of AST such as walking and cycling (7); and 4) did not take into account the volume of AST (20,31). In addition, experimental trials (or quasi-experimental studies with a control group) would be needed to establish the direction of the relationship between both variables.

With respect to physical activity levels, the active commuters accumulated 662 more steps/day, but the difference was not significant. In contrast, other researchers who examined the impact of AST on daily step counts have found larger differences between groups (1,18,23). In addition, most studies in which physical activity was measured with accelerometry have shown that active commuters were significantly more active on a daily basis (16,20), especially during the hour preceding and following the school day (13).

The main limitation of the current study is the relatively small sample size, which may explain the lack of significant differences between groups for waist circumference and average daily step counts. With respect to step counts, there could be a discrepancy between the mode of transport reported by the participants and the mode they used during the monitoring period. In addition, the number of active commuters was too low to assess the impact of walking and cycling separately. Despite the inclusion of schools in urban and rural areas and with various socioeconomic levels, the sample may not be representative of the population, which limits the generalizability of the findings. In addition, given the cross-sectional design, it is not possible to confirm that children were leaner because they engaged in AST. All data were collected in the fall and early winter, and transportation behaviors may be subject to seasonal variations like overall physical activity level (10).

It seems unlikely that participant reactivity had a major impact on the results. The average step count values were relatively low (11,924 and 11,262 for the active and passive commuters respectively), but similar to those obtained in the
CANPLAY study with a population sample of 19,789 children and adolescents aged 5–19 (12,259 for boys and 10,906 for girls; 15) and to other North American studies, as reported in a recent systematic review (6). Furthermore, there is no reason to believe that potential participant reactivity would be different among active or passive commuter groups. Finally, researchers who compared step counts obtained from sealed vs. unsealed pedometers reported no evidence of a reactivity bias (30,33,41).

The strengths of this study include the objective measurement of physical activity which, unlike questionnaires, is not subject to recall bias (3); b) the utilization of previously validated thresholds for the step count data; c) the measurement of both BMI and waist circumference and d) the control for daily step counts in the assessment of the relationship between AST and body composition variables.

**Conclusion**

In the current study, the children who reported using active modes of transportation had lower BMI values, and were less likely to be overweight and obese. When controlling for age and daily step counts, this relationship remains significant. This difference is clinically relevant given the wide range of complications associated to childhood obesity. Lack of statistical power and high variability between participants may have prevented the observation of significant differences for outcome variables such as waist circumference and physical activity level. In conclusion, these findings emphasize the need for further research on the outcomes of AST, as well as interventions to promote AST.

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**References**


