Int J Public Health 54 (2009) 150–157
1661-8556/09/030150-8
DOI 10.1007/s00038-009-7110-0
© Birkhäuser Verlag, Basel, 2009

**Original article**

# School opportunities and physical activity frequency in nine year old children

**Tracie A. Barnett[1,2], Jennifer L. O'Loughlin[2,3,4], Lise Gauvin[2,3], Gilles Paradis[4,5], James Hanley[5], Jennifer J. McGrath[6] and Marie Lambert[1,7]**

[1] *Centre de recherche du CHU Sainte-Justine and Université de Montréal, Montréal, Canada*
[2] *Department of Social and Preventive Medicine, Université de Montréal, Montréal, Canada*
[3] *Centre de Recherche du CHUM, Montréal, Canada*
[4] *Institut National de Santé Publique du Québec, Montréal, Canada*
[5] *Research Institute of the McGill University Health Center and Department of Epidemiology, Biostatistics and Occupational Health, McGill University, Montréal, Canada*
[6] *Department of Psychology, Concordia University, Montreal, Canada*
[7] *Department of Pediatrics, Hôpital Sainte-Justine and Université de Montréal, Montréal, Canada*

Submitted: 28 November 2007; revised: 28 December 2008; accepted: 15 January 2009

Published online first: 21 März 2009

**Abstract**

**Objective:** To examine the association between physical activity (PA) opportunities at school and participation in PA outside of school physical education (PE) classes among 9 year old children.
**Methods:** Data were obtained in a representative sample of 1 267 students nested within 69 schools who completed questionnaires; principals provided data on schools. Students' PA frequency was defined as all reported episodes of past week PA, excluding PE class. Schools were categorized as "high-opportunity" if they provided ≥4 of the following opportunities: PE class ≥2 times/week, extracurricular sports animator, gymnasium, swimming pool, schoolyard equipped for games, and ≥1 outdoor sports playing fields. Multilevel modelling techniques were used to investigate the association between school-level PA opportunity and student-level PA frequency.
**Results:** No main effect of school-level PA opportunities on PA frequency was observed. However, overweight boys attending high-opportunity schools were significantly more active than those attending low-opportunity schools.
**Conclusions:** The association between PA frequency and school-level PA opportunity differs by sex and weight status. Overweight boys in particular may benefit from health promotion strategies providing greater opportunities for school PA.

**Keywords:** Children – Physical activity – Obesity – Multilevel model – School policy – Built environment.

## Introduction

With dramatic increases in obesity in youth[1, 2] and concurrent declines in levels of physical activity,[3–5] identification of the determinants of physical activity in children that are amenable to improvement is a public health priority. In addition to individually-based psychological and behavioural factors that influence health, health promotion research also targets the features of the social and physical environments that are believed to affect individual and collective well-being.[6] In particular, ecologically-based models of health behaviour recognize multiple levels of environmental influences that are hypothesized to determine behaviour, with influences external to the individual seen as constraining or facilitating behavior.[7] For example, the importance of the neighbourhood environment to physical activity involvement was underscored in a recent study showing that fewer physical activity facilities within one's residential area was associated with lower levels of physical activity among youth.[8] The school environment, another key behavioural setting for youth, has long been advocated as an important setting for physical activity promotion, notably by increasing opportunities for physical activity at school.[9, 10] Although it is unknown whether or not access to physical activity opportunities at school influence children's physical activity behaviour, substantial disparities in access to physical activity opportunities have been observed.[11, 12] Studies suggest that improving the quality of the physical education (PE) class can increase school based physical activity

Int J Public Health 54 (2009) 150–157

© Birkhäuser Verlag, Basel, 2009

favourably.[13, 14] In addition, simple environmental measures including marking or painting playgrounds, supplying sports equipment, organizing active games, and increasing access to sports areas are also associated with increases in physical activity at school.[15–18] Although some studies have reported positive associations between frequency of participation in the PE class and recreational[19] or overall[20] physical activity, to our knowledge no studies have examined the association between the school physical activity environment, and children's levels of physical activity outside the PE class in a representative sample of school children. To assess the potential influence of the school physical activity environment on children's overall physical activity behaviour, we investigated the association between school-level opportunity for physical activity, based on measures of physical activity policy and the built environment, and student-level leisure time physical activity, in a large, provincially representative sample of nine year old children. We also examined whether or not the association between school opportunities and student leisure time physical activity was moderated by sex and BMI status.

## Methods

Data from the 1999 Quebec Child and Adolescent Health and Social Survey (QCAHS) were used in this analysis. The methods including details about the sampling frame and procedure have been described previously.[21] Briefly, the sample of nine-year old children was clustered within 71 elementary schools. Schools were randomly selected from the Quebec Ministry of Education listing of all 1 940 elementary schools in Quebec (http://www.mels.gouv.qc.ca/stat/index.htm ), and data collection was conducted in January-May 1999. Within each school sampled, 25 students were randomly selected, while ensuring approximate equal representation of boys and girls.

Data collection instruments included an age-specific self-administered questionnaire for students, questionnaires for parents/guardians, and questionnaires for school principals. In addition, anthropometric measures were taken from children with parental consent. Detailed descriptions of all questionnaire items have been published previously.[21] Approval of the study protocol was obtained from the ethics committees of the Institut de la statistique du Québec/Direction Santé Québec and Sainte-Justine Hospital; signed informed consent was obtained from parents or legal guardians.

*Data collection procedures*

An explanatory letter and a questionnaire to be completed by the parent "who knew the child best" were included with the consent forms sent home to parents. Parents were asked to mail completed questionnaires to the study coordinator in a stamped, preaddressed return envelope. The school principal was asked to complete the questionnaire and return it to the data collection team coordinator in a sealed envelope. All questionnaires are available online at http://www.stat.gouv.qc.ca/publications/sante/enfant-ado_pdf_an.htm.

Data from students were collected during a three-hour visit to each school. Two interviewers assisted nine-year-old participants in completing questionnaires, which were administered during a 45–60 minute class period. One interviewer read each question according to a manual of instructions while standing at the front of the class; the second interviewer circulated among students, ensuring that children were completing the questionnaires according to instructions and responding to queries.

*Anthropometry*

Height was measured to the nearest 0.1 cm using a standard measuring tape (fixed to the wall) and a right angle headpiece. Weight was measured to the nearest 0.2 kg using a spring scale that was calibrated daily. Inter-observer reliability was assessed in sub sample (10 %); intraclass correlations were 0.99 for both height and weight.

*Measure of physical activity*

Physical activity frequency was determined using a seven-day recall, adapted from Sallis' Weekly Activity Checklist.[22] The original instrument correlated with an objective activity measure (Caltrac accelerometer) at $r = 0.34$, $p < 0.001$, and the estimated test-retest reliability with a 3-day interval between administrations was 0.74.[22] The checklist was slightly modified to reflect local activity preferences and climate. In addition to the physical education class, only leisure time physical activities typical of at least moderate intensity were included. For each of 18 physical activities, and up to three volunteered activities, children checked on which day(s) of the preceding week, they participated in each activity for at least 15 consecutive minutes; they also had the option of checking "I didn't do any" for each activity. Children were also asked to indicate on the checklist on which days in the previous week they had participated in PE class.

*Description of variables*

Physical activity frequency was defined as the sum of all reported activities over the previous seven day period, excluding the PE class. Student-reported PE frequency was excluded from the outcome because this item was used to create the school-level measure of physical activity opportunity (described below). Because physical activity frequency was

positively skewed, the variable [physical activity frequency +1] was log transformed.

Body mass index (BMI) was computed as weight/height$^2$ (kg/m$^2$). Children were categorized as overweight according to Cole et al international cut-points (i.e. greater or equal to the age- and sex-specific 85$^{th}$ percentile).[23] Parental influence on student physical activity behaviour was described by 'Frequency mother exercises with child', based on the question included in the parent questionnaire: In the past 3 months, how many times have you engaged in physical activity with your child? Responses were categorized as "at least once per week" vs. "less than once per week". Though available for both parents, there were substantially more missing data for fathers and thus only data on mothers were included in the analyses.

'Family status' was described as a two-parent household (versus other) if the parent completing the questionnaire indicated that their child currently lived with both of his/her biological or adoptive parents, or with one parent and one step-parent. 'Household income' as reported by the responding parent was categorized using three indicator variables; cut-points were meant to reflect approximate groupings of low (less than $20 000), average ($20 000–$59 999) and high income ($60 000 or more) families at the time data were collected.

School-level opportunity for physical activity was based on the availability to students of specific opportunities for engaging in physical activity, based on information provided by school principals (five items) and by students (one item). School principals were required to indicate whether or not each of a number of services and resources were available to students, including five physical activity-related items: a full- or part-time extracurricular sports animator, a gymnasium, a swimming pool, a schoolyard equipped for games, and one or more outdoor sports playing fields, which are typically accessible to students for games and sports year round. In addition, schools were categorized as offering each student either less than two, or two or more PE classes weekly. This sixth item was not included in the principal questionnaire; it was derived from student reports of the frequency of their past week participation in PE. However, not all students within a given school reported the same PE frequency (possibly due to scheduling differences between classes, absences from school, or other circumstances); therefore, schools were categorized as offering PE two or more times if the median value reported for that school was two or more. Schools were then categorized as being "high physical activity opportunity" if four, five, or all six physical activity opportunities were available to students.

An indicator of 'average school-area income' was obtained from the 1996 Census conducted by Statistics Canada. School-area income was defined as the average income among households occupied by a married or common-law couple, in the census district in which the school was located (http://www12.statcan.ca/english/census01/info/census96.cfm). It was categorized into approximate tertiles using three indicator variables: low (less than $48 000), average ($48 000 to $55 000) and high (greater than $55 000), with the highest category used as the referent in the analyses. Schools were categorized as located in **'**Urban' areas if they were located in areas inhabited by at least 1000 persons with a population density of at least 400 people per square kilometre; otherwise they were categorized as 'Non-urban', based on Census Dictionary terms ( http://www.statcan.ca/english/census06/reference/dictionary/geo049.cfm). Finally, timing (i.e. season) of data collection was coded as 'Spring' if data collection occurred in April or May, and 'Winter' if it occurred in February or March.

*Analysis*

Multilevel modeling techniques were used to investigate the association between school-level physical activity opportunity and student-level physical activity frequency. Multi level analyses are well suited for this purpose because the likelihood of making inferential errors is reduced[24, 25] and because inherent selection biases can be addressed.[24, 26, 27]

The dependent variable was analyzed as a continuous outcome. There is evidence that determinants of physical activity[28, 29] and those related to the school environment in particular[16] are modified by weight status and sex of students. Therefore, we included terms to examine cross-level interactions (i.e., to assess the association between school-level physical activity opportunity and student physical activity frequency within each sex-weight category).

A step-up approach was adopted.[25] First, the null model was estimated, in order to decompose the variance in physical activity frequency into between- and within- school sources of variation. Then, subsequent models were developed by sequentially adding all student-level variables (including sex, overweight, a sex-by-overweight interaction term, frequency mother exercises with child, household income, and family status) followed by all school-level variables (including school physical activity opportunity, average school-area income, season, and location). Analyses were performed with one random effect on the intercept. Variables significant at the 0.05-level were retained for further analyses; all variables not retained were added to the final model one-by-one to test for confounding. The final model tested the association of school physical activity opportunity with student physical activity frequency, while allowing for differential effects according to students' sex-

Int J Public Health 54 (2009) 150–157
© Birkhäuser Verlag, Basel, 2009


**Table 1.** Student-level and school-level characteristics. Quebec Child and Adolescent Health and Social Survey (1999).

| Characteristic | N[a] (%) |
|---|---|
| **STUDENT-LEVEL** | |
| All | 1267 (100) |
| Sex | |
| Males | 627 (49.5) |
| Females | 640 (50.5) |
| Overweight status | |
| Body Mass Index ≤85$^{th}$ percentile) | 973 (76,8) |
| Body Mass Index >85$^{th}$ percentile) | 294 (23.2) |
| Family status | |
| Two-parent household | 769 (72.6) |
| Other | 498 (17.4) |
| Household income | |
| $20000 or less | 148 (14.5) |
| $20000–59 9999 | 570 (55.9) |
| $60000 or more | 301 (29.5) |
| Frequency mother exercises with child | |
| 1/week or more | 327 (31.8) |
| <1/week | 702 (68.2) |
| **SCHOOL-LEVEL** | |
| All | 69 (100) |
| Physical activity opportunity level | |
| High | 26 (37.7) |
| Low | 43 (62.3) |
| School location | |
| Urban area | 39 (56.5) |
| Non-urban area | 30 (43.5) |
| Average school-area income | |
| <$48000 | 19 (27.5) |
| $48000–$55000 | 30 (43.5) |
| >$55000 | 20 (29.0) |
| Timing of data collection | |
| Spring | 16 (23.2) |
| Winter | 53 (76.8) |

Note: a: Percentages exclude missing data

weight category, and adjusting for potential student-level confounders. All analyses were performed using SAS version 9.0 and HLM version 6.0.

## Results

*Response*

Of the 71 elementary schools sampled, 69 agreed to participate. A total of 1 564 nine-year-old children were sampled, of which 1 520 were eligible to participate (non-eligible children were no longer registered at the school). Among all eligible children, 1 267 (83.4 %) completed questionnaires and had their height and weight measured. From these, a total of 1 065 also returned parent questionnaires. Complete data were available for 1 029 children. Compared with those retained for regression analysis, children who were excluded due to missing data were slightly more active, more likely to have participated in the spring than in the winter, and less likely to have attended a high physical activity opportunity school.

*Description of the sample*

Characteristics for the 1 267 students and schools are described in Table 1. Twenty-three percent of the sample was overweight. Almost 75 % of children resided in two-parent households. Thirty-one percent of mothers reported doing physical activity with their child at least once per week. Of the 69 participating schools, 26 (37 %) were categorized as 'high physical activity opportunity'. Specifically, among all 69 participating schools, 67 had gymnasiums, 62 had a schoolyard equipped for games, 26 had one or more outdoor sports playing fields, 22 offered PE at least twice weekly, 11 employed a full- or part-time extracurricular sports animator, and 2 had a swimming pool. Most participating schools were located in urban areas, and approximately 75 % of the data were collected over the winter months. The median values of physical activity frequency (excluding PE class), for all, by sex and weight status, and by school physical activity opportunity level, are shown in Table 2. Although median physical activity frequency did not vary by school physical activity opportunity overall, overweight boys reported substantially more physical activity in high- than in low-opportunity schools (W statistic for two sample Mann-Whitney median test = 2.4, p = 0.016, unadjusted for multiple testing).

*Multilevel analyses*

The intra-class correlation was 0.088 (i. e., 8.8 % of the variance in children's physical activity behaviour was attributable to between-school variation). In the model including all student level variables (i. e. sex, weight status, sex-by-weight interaction, mother's physical activity, household income, and family status), only sex, the sex-by-weight interaction term, and frequency mother exercises with child variables were associated with the student's physical activity. Children whose mothers reported exercising with their child at least once per week (compared with those exercising less than once per week with their child) reported a significantly higher physical activity frequency.

All school-level variables were then added to the model, including spring, school-area income, urban location and high

| Subjects | n | Median (IQR) number of reported weekly physical activities | | |
|---|---|---|---|---|
| | | All | High PA school | Low PA school |
| All | 1267 | 6 (3–11) | 6 (3–12) | 6 (3–10) |
| Boys, all | 627 | 7 (3–12) | 7 (4–12) | 7 (3–12) |
| Boys, non-overweight | 476 | 7 (4–12) | 6 (4–11) | 7 (4–13) |
| Boys, overweight | 151 | 6 (3–10) | 8 (4–14) | 5 (2–9) |
| Girls, all | 640 | 6 (3–10) | 6 (2v12) | 6 (3–9) |
| Girls, non-overweight | 497 | 6 (3–10) | 6 (2–11) | 5 (3–9) |
| Girls, overweight | 143 | 6 (3–12) | 6 (3–12) | 6 (3–10) |

**Table 2.** Median physical activity frequency by sex and overweight status, for all and by level of school physical activity (PA) opportunity. Quebec Child and Adolescent Health and Social Survey (1999).

Notes: IQR = Interquartile range; PA = physical activity; children were categorized as overweight if they were at or above the 85$^{th}$ age and sex-specific percentile for BMI according to international cut points described by Cole et al.Two sample median tests for comparing medians between high and low opportunity schools showed a significant difference among OW boys only (W statistic for two sample Mann-Whitney mediant test = 2.4, 2-sided p-value = 0.016, unadjusted for multiple comparisons)

physical activity opportunity. School-area income and location were not associated with student physical activity, but season was a significant main effect. The final model is illustrated in Table 3. The intercept $\gamma_{00}$ is the estimated overall mean (of the transformed dependent variable) when all other parameters are set to zero, i.e. for non-overweight girls during the winter. For all children, the mean physical activity frequency was significantly higher during the spring season than during the winter season. The parameter $\gamma_{02}$ represents the main effect of 'Season'. Although there was no main effect of attending a high physical activity opportunity school, a significant cross-level interaction with weight-sex category was identified. In particular, overweight boys reported significantly more episodes of physical activity if they attended high physical activity opportunity schools, compared with overweight boys who did not attend high physical activity opportunity schools. Because of the presence of interaction, $\gamma_{01}$ is interpreted as the effect of being in a 'high-opportunity-school' when interaction terms are set to zero, i.e. for non-overweight girls. The parameter $\gamma_{30}$ corresponds to the value in the dependent variable associated with being overweight, being male, and attending a low-opportunity school; $\gamma_{31}$ corresponds to the change in the dependent variable among overweight boys associated with attendance in a high-opportunity school. Because the dependent variable was log-transformed, the parameter is interpreted as a percent increase rather than an increase. Thus, among overweight boys attending high- (vs. low) opportunity schools, PA frequency was 52.3% greater, at reference categories of other variables in the model (i.e. winter, mother exercises with child <1/week). The significant 3-way interaction involving sex, weight status and school PA opportunity is illustrated in Figure 1.

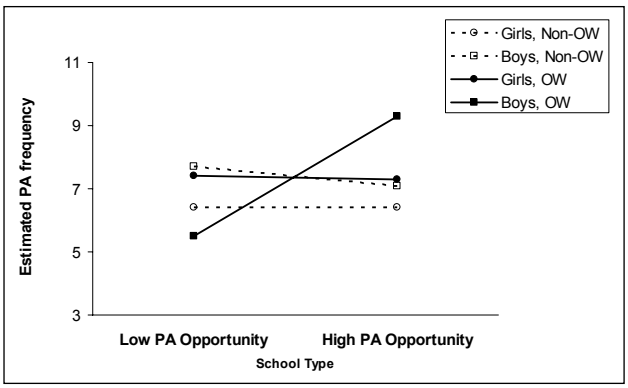


**Figure 1.** Estimated physical activity frequency in elementary schools, by sex and weight status, according to school level of physical activity opportunity. Values illustrated for each sex-weight-school type category were computed at reference values for all other variables in Table 3. Quebec Child and Adolescent Health and Social Survey (1999). PA = physical activity; OW = overweight.

## Discussion

The purpose of this study was to examine the independent association between physical activity frequency (excluding the PE class) and level of physical activity opportunity in elementary schools among 9 year old school children, as well as to investigate whether or not this association was modified by sex and BMI status. Although no main effect on mean physical activity frequency for school physical activity opportunity was observed, specific sub-groups of students (i.e. overweight boys) attending schools that offered more physical activity opportunities reported significantly greater physical activity frequency. Previous studies have observed that policy driven measures such as frequency of offering PE are effective for increasing levels of physical activity during the PE class,[13, 14, 20]

Int J Public Health 54 (2009) 150–157
© Birkhäuser Verlag, Basel, 2009


**Table 3.** Estimated parameters of the multilevel regression model of student- and school-level correlates of children's reported physical activity. Quebec Child and Adolescent Health and Social Survey (1999).

| Fixed effects | Parameter | Relative difference | d.f. | p-value |
|---|---|---|---|---|
| **Intercept (corresponds to non-overweight girls)** | | | | |
| | $\text{Exp}(\beta_0)$ | | | |
| Intercept | $\text{Exp}(\gamma_{00})$ | 6.42 (reference) | 66 | <0.001 |
| High *(Vs. Low)* PA Opp | $\text{Exp}(\gamma_{01})$ | 0.01 | 66 | n.s. |
| Spring *(Vs Winter)* | $\text{Exp}(\gamma_{02})$ | 0.27 | 66 | 0.010 |
| **Male Sex *(Vs. female)*** | $\text{Exp}(\beta_1)$ | | | |
| Intercept | $\text{Exp}(\gamma_{10})$ | 0.21 | 1019 | 0.012 |
| High *(Vs. Low)* PA Opp | $\text{Exp}(\gamma_{11})$ | –0.082 | 1019 | n.s. |
| **Overweight *(Vs non-overweight)*** | $\text{Exp}(\beta_2)$ | | | |
| Intercept | $\text{Exp}(\gamma_{20})$ | 0.148 | 1019 | n.s. |
| High PA Opp | $\text{Exp}(\gamma_{21})$ | –0.019 | 1019 | n.s. |
| **Male Sex*Overweight** | $\text{Exp}(\beta_3)$ | | | |
| Intercept | $\text{Exp}(\gamma_{30})$ | –0.492 | 1019 | 0.002 |
| High PA Opp | $\text{Exp}(\gamma_{31})$ | 0.523 | 1019 | 0.031 |
| **Mother exercises with child ≥1/week** *(Vs. <1/week)* | $\text{Exp}(\beta_4)$ | 0.148 | 1019 | 0.008 |

Final model: Level 1: $\ln[\text{Physical activity freq}+1] = \beta_0+\beta_1\text{Sex}+\beta_2\text{Overweight}+\beta_3\text{Sex*Overweight}+\beta_4\text{Mother-child PA}+\varepsilon_0$

Level 2:
$\beta_0 = \gamma_{00} + \gamma_{01}$ (High PA Opp)$+ \gamma_{02}$ (Spring)$+ \mu_0$
$\beta_1 = \gamma_{10} + \gamma_{11}$ (High PA Opp)
$\beta_2 = \gamma_{20} + \gamma_{21}$ (High PA Opp)
$\beta_3 = \gamma_{30} + \gamma_{31}$ (High PA Opp)
$\beta_4 = \gamma_{40}$

Notes:
Dependent variable = ln[physical activity frequency excluding PE class, +1]. Because the dependent variable was log-transformed, the parameter is interpreted as a percent increase. Thus, among overweight boys attending high (Vs. low) opportunity schools, PA frequency is greater by 52.3 %, at reference categories of other variables in the model (i. e. winter, mother-child physical activity < 1/week).
Variance components (within/between school): null model: 0.64/0.062; final model: 0.63/0.05;
Abbreviations: n.s. = not significant; PA = physical activity; OW = overweight; Opp = Opportunity
$\gamma_{01}$ is the effect of being in a 'high-opportunity school' when interaction terms are set to zero, i. e. for non-overweight girls. The parameter $\gamma_{30}$ corresponds to the value in the dependent variable associated with being OW, being male, and attending a low PA Opp schools; $\gamma_{31}$ corresponds to change in the dependent variable among OW boys associated with attendance to a high PA Opp school. This 3 way interaction is illustrated in Figure 1.

while features of the built environment such as access to sports fields and play areas are associated with higher physical activity levels at school among middle school students.[30] Our findings provide some evidence that a greater number of opportunities for physical activity, including amenities, policies, physical structures, and human resources, may be a promising health promotion strategy for increasing overall physical activity, at least for some elementary school children.

Higher physical activity opportunity was not related to physical activity frequency among non-overweight boys, but this subgroup was the most active, suggesting that non-overweight boys attending low-opportunity schools may 'compensate' to some extent through physical activity opportunities outside the school setting. Possibly because of greater barriers outside the school setting, overweight boys may be more susceptible to universal interventions (i. e. interventions targeting all students) in the school setting. It is of concern that school physical activity opportunity was not related to girls' levels of physical activity; it is possible that the nature of physical activities promoted in schools may be valued to a greater extent by boys. More research is needed to identify potential targets for the promotion of physical activity in schools that can benefit girls, and to identify which factors in the school environment are most effective in helping all children increase and maintain recommended levels of physical activity.

Similar to others,[31–33] we observed higher frequency of physical activity in spring than in winter, and this seasonal effect was responsible for some of the variation between schools. However, between-school variation remained significant after including potential explanatory variables at both the student and school-levels. School-level variation in average physical activity frequency is of concern because it may partly reflect significant disparities in determinants of health behaviours, and may eventually lead to disparities in health-related outcomes. Clearly, other factors that contribute to school-level variation need to be identified, including possibly the availability of intra- and extra-mural sports teams, the quality of the PE class, and indicators of school culture, such as the per-

ceived importance of physical activity relative to academic pursuits. In addition, it is likely that children's response to cues in the school environment depends on other factors, such as community-based opportunities and parental awareness of school opportunities for physical activity. Future investigations could work towards the development of a theoretical model in which social processes at the school-level interact with those at the individual, family and community levels.

*Limitations*

We investigated the influence of school opportunities on student physical activity frequency in a cross-sectional analysis. It is possible that students (or their parents), especially in the presence of overweight, 'selected' schools on the basis of the physical activity opportunities available. A longitudinal study investigating change in behaviour following change in physical activity environment is required to establish the causal relationship between school opportunity for physical activity and student behaviour.

Self-report questionnaires are frequently used in assessing physical activity in children and adolescents because of ease of administration, low cost, unobtrusiveness, and versatility.[34, 35] The degree of validity depends not only on the developmental stage of respondents but also on the degree of complexity of the questionnaire.[36] Reliability of recall is generally higher in older children compared to younger children.[37–39] Self-administered questionnaires are susceptible to several sources of bias, including inaccurate recall, misinterpretations, and perceived social desirability.[36] Although questionnaires eliciting detailed responses (such as estimates of duration or exertion) are generally not recommended for children under the age of ten years,[38, 40] simpler versions can be adapted for use in children as young as eight years.[35] Specifically, the accuracy of recall can be enhanced by using structured questionnaires that conform to the children's developmental stage, by providing the appropriate cues and prompts, and by supplementing the questionnaire with clear instructions and close supervision. Thus, although students in the current study were probably among the youngest for whom valid data can be self-reported, every effort was made to adhere to these recommendations in order to assure that the questionnaires were age-appropriate. Any misclassification due to incorrect reports (even systematic over-reporting) would not result in associations that are spurious.

*Conclusion*

There was substantial variation between schools in student physical activity frequency. Higher school physical activity opportunity was associated with significantly higher physical activity frequency among overweight boys, and possible avenues for intervention are suggested. In practice, however, it is unlikely that any one physical activity opportunity would appeal to a majority of students; therefore, strategies designed to promote volitional physical activity may only be effective in part of the target population. In order to increase population levels of physical activity in youth, program planners will need to provide comprehensive strategies that target multiple aspects of children's lives, using a variety of approaches that are tailored to specific sub-groups of children.

*Acknowledgements*

This research was funded by the Ministère de la Santé et des Services Sociaux, the Ministère de l'Éducation du Québec, and the Bureau of Nutritional Sciences, Health Canada. Tracie A. Barnett was funded by a Canadian Institutes of Health Research fellowship and is currently a Fonds de la Recherche en Santé du Québec research scholar. Jennifer L. O'Loughlin holds a Canada Research Chair in the Childhood Determinants of Adult Chronic Disease. Lise Gauvin holds a Canadian Institutes for Health Research /Centre de Recherche en Prévention de l'Obésité Applied Public Health Chair in Neighbourhoods, Lifestyle and Healthy Body Weight. The authors are grateful for the contributions of Claudette Lavallée, Jacinthe Aubin, Daniel Tremblay, and Paul Berthiaume.

## References

**1.** Strauss RS, Pollack HA. Epidemic increase in childhood overweight, 1986–1998. JAMA 2001; 286:2845–8.

**2.** Troiano RP, Flegal KM, Kuczmarski RJ, Campbell SM, Johnson CL. Overweight prevalence and trends for children and adolescents. The National Health and Nutrition Examination Surveys, 1963 to 1991. Arch Pediatr Adolesc Med 1995;149:1085–91.

**3.** Tremblay MS, Willms JD. Is the Canadian childhood obesity epidemic related to physical inactivity? Int J Obes Relat Metab Disord 2003; 27:1100–5.

**4.** Dollman J, Norton K, Norton L. Evidence for secular trends in children's physical activity behaviour. Br J Sports Med 2005;39:892–7.

**5.** Anderssen N, Jacobs DR, Jr., Sidney S, et al. Change and secular trends in physical activity patterns in young adults: a seven-year longitudinal follow-up in the Coronary Artery Risk Development in Young Adults Study (CARDIA). Amer J Epidemiol 1996;143:351–62.

**6.** Stokols D. Establishing and maintaining healthy environments. Toward a social ecology of health promotion. Am Psychol 1992;47:6–22.

**7.** Sallis JF, Owen N. Ecological models. In: Glanz K, Lewis FM, Rimer BK, eds. Health behavior and health educaiton: Theory, research and practice. San Francisco: Jossey-Bass, Inc; 1997:403–24.

**8.** Gordon-Larsen P, Nelson MC, Page P, Popkin BM. Inequality in the built environment underlies key health disparities in physical activity and obesity. Pediatrics 2006;117:417–24.

**9.** Guidelines for school and community programs to promote lifelong physical activity among young people. National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and prevention. J Sch Health 1997;67:202–19.

**10.** Wechsler H, Devereaux R. Using the school environment to promote healthy eating and physical activity. Prev Med 2001;31(Supplement):S121–S37.

**11.** Allison KR, Adlaf EM. Structured opportunities for student physical activity in Ontario elementary and secondary schools. Can J Public Health 2000;91:371–5.

**12.** Barnett TA, O'Loughlin J, Gauvin L, Paradis G, Hanley J. Opportunities for student physical activity in elementary schools: a cross-sectional survey of frequency and correlates. Health Educ Behav 2006;33:215–32.

**13.** Luepker RV, Perry CL, McKinlay SM, et al. Outcomes of a field trial to improve children's dietary patterns and physical activity. The Child and Adolescent Trial for Cardiovascular Health. CATCH collaborative group. JAMA 1996;275: 768–76.

**14.** McKenzie TL, Nader PR, Strikmiller PK, et al. School physical education: effect of the Child and Adolescent Trial for Cardiovascular Health. Prev Med 1996;25:423–31.

**15.** Connolly P, McKenzie TJ. Effects of a games intervention on the physical activity levels of children at recess. Res Q Exerc Sport 1995;66 (Supplement):A60.

**16.** Sallis JF, McKenzie TL, Conway TL, et al. Environmental interventions for eating and physical activity: a randomized controlled trial in middle schools. Amer J Prev Med 2003;24:209–17.

**17.** Stratton G. Promoting children's physical activity in primary schools: an intervention study using playground markings. . Ergonomics 2000; 43:1538–46.

**18.** Stratton G, Mullan E. The effect of multicolor playground markings on children's physical activity level during recess. Prev Med 2005;41:828–33.

**19.** Sullivan SO. The physical activity of children: a study of 1,602 Irish schoolchildren aged 11–12 years. Ir Med J 2002;95:78–81.

**20.** Myers L, Strikmiller PK, Webber LS, Berenson GS. Physical and sedentary activity in school children grades 5–8: the Bogalusa Heart Study. Med Sci Sports Exerc 1996;28:852–9.

**21.** Paradis G, Lambert M, O'Loughlin J, et al. The Quebec Child and Adolescent Health and Social Survey: design and methods of a cardiovascular risk factor survey for youth. Can J Cardiol 2003;19:523–31.

**22.** Sallis JF, Condon SA, Goggin KJ, Roby JJ, Kolody B, Alcaraz JE. The development of self-administered physical activity surveys for 4th grade students. Res Q Exerc Sport 1993;64:25–31.

**23.** Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ 2000;320:1240–3.

**24.** Diez-Roux AV. Multilevel analysis in public health research. Annu Rev Public Health 2000; 21:171–92.

**25.** Raudenbush SW, Bryk AS. Hierarchical linear models: applications and data analysis methods 2nd ed. Thousand Oaks, CA: Sage Publications; 2002.

**26.** Greenland S. Principles of multilevel modelling. Int J Epidemiol 2000;29:158–67.

**27.** Sellstrom E, Bremberg S. Is there a «school effect» on pupil outcomes? A review of multilevel studies. J Epidemiol Community Health 2006;60:149–55.

**28.** Sallis JF, Alcaraz JE, McKenzie TL, Hovell MF. Predictors of change in children's physical activity over 20 months. Variations by gender and level of adiposity. Am J Prev Med 1999;16: 222–9.

**29.** Sallis JF, Zakarian JM, Hovell MF, Hofstetter CR. Ethnic, socioeconomic, and sex differences in physical activity among adolescents. J Clin Epidemiol 1996;49:125–34.

**30.** Sallis JF, Conway TL, Prochaska JJ, McKenzie TL, Marshall SJ, Brown M. The association of school environments with youth physical activity. Am J Public Health 2001;91:618–20.

**31.** Baranowski T, Thompson WO, DuRant RH, Baranowski J, Puhl J. Observations on physical activity in physical locations: age, gender, ethnicity, and month effects. Res Q Exerc Sport 1993; 64:127–33.

**32.** Ridgers ND, Stratton G, Clark E, Fairclough SJ, Richardson DJ. Day-to-day and seasonal variability of physical activity during school recess. Prev Med 2006;42:372–4.

**33.** Rifas-Shiman SL, Gillman MW, Field AE, et al. Comparing physical activity questionnaires for youth: seasonal vs annual format. Am J Prev Med 2001;20(4):282–5.

**34.** Pate RR. Physical activity assessment in children and adolescents. Crit Rev Food Sci Nutr 1993;33:321–6.

**35.** Baranowski T. Methodologic issues in self-report of health behavior. J Sch Health 1985;55: 179–82.

**36.** Kohl H, Fulton JE, Caspersen CJ. Assessment of physical activity among children and adolescents: a review and synthesis. Prev Med 2000;31 (Supplement):S54–S76.

**37.** Sallis JF, Buono MJ, Roby JJ, Micale FG, Nelson JA. Seven-day recall and other physical activity self-reports in children and adolescents. Med Sci Sports Exerc 1993;25:99–108.

**38.** Welk GJ, Corbin CB, Dale D. Measurement issues in the assessment of physical activity in children. Res Q Exerc Sport 2000;71(Supplement):S59–73.

**39.** Welk GJ, Wickel E, Peterson M, Heitzler CD, Fulton JE, Potter LD. Reliability and validity of questions on the youth media campaign longitudinal survey. Med Sci Sports Exerc 2007;39: 612–21.

**40.** Saris WH. The assessment and evaluation of daily physical activity in children. A review. Acta Paediatr Scand Suppl 1985;318:37–48.

**Address for correspondence**

**Tracie A. Barnett, Ph.D.**
**Centre de recherche du CHU**
**Sainte-Justine Hospital Research Center**
**3175 Côte Sainte-Catherine**
**Montréal, Québec, H3T 1C5**
**Canada**
**Tel.: 514-345-4931 ext. 5461**
**E-mail: ta.barnett@umontreal.ca**