# Prospective Associations Between Play Environments and Pediatric Obesity

Caroline Fitzpatrick, Stephanie Alexander, Mélanie Henderson, Tracie Barnett

American Journal of Health Promotion
2019, Vol. 33(4) 541-548

DOI: 10.1177/0890117118807211
journals.sagepub.com/home/ahp
SAGE

# Prospective Associations Between Play Environments and Pediatric Obesity

**Caroline Fitzpatrick, PhD[1,2,3], Stephanie Alexander, PhD[4], Melanie Henderson, PhD[5,6], and Tracie A. Barnett, PhD[6,7]**


## Abstract

**Purpose:** To identify school typologies based on the availability of play equipment and installations. We also examined the associations between availability of play items and child adiposity.

**Design:** Secondary analysis of longitudinal data.

**Setting:** Elementary schools in Montreal, Canada.

**Participants:** We used data from the Quebec Adipose and Lifestyle Investigation in Youth study (QUALITY), an ongoing investigation of the natural history of obesity and type 2 diabetes in Quebec children of Caucasian descent.

**Measures:** The presence of play items was assessed in each child's school. A trained nurse directly assessed child anthropometric measurements to derive body mass index and waist circumference. Body fat composition was measured using DEXA Prodigy Bone Densitometer System.

**Analyses:** The final analytic sample comprised 512 students clustered in 296 schools (81% response). We used K-cluster analyses to identify school typologies based on the variety of play items on school grounds. Generalized estimation equations were used to estimate associations between school clusters and outcomes.

**Results:** We identified 4 distinct school typologies. Children in schools with the most varied indoor play environments had lower overall body fat, $B = -1.26$ cm (95% confidence interval [CI], $-2.28$ to $-0.24$ cm), and smaller waist circumference, $B = -4.42$ cm (95% CI, $-7.88$ to $-0.96$ cm), compared to children with the least varied indoor play environment.

**Conclusion:** Our results suggest that policies regulating the availability of play items in schools may enrich comprehensive school-based obesity prevention strategies. Extending research in this area to diverse populations is warranted.


**Keywords**
active play, schools, BMI, child adiposity, built environment

## Purpose

According to Active Healthy Kids Canada (2012), active play is fun, freely chosen, self-directed, and spontaneous.[1] This form of play can be distinguished by its vigor and generally involves greater energy expenditure than play but less energy expenditure than exercise.[2] Active play has recently caught the attention of public health scholars as a promising strategy for promoting children's well-being.[3] Indeed, some believe that active play can contribute to cardiovascular health and fitness, motor skills, and bone and muscle development in childhood and adolescence.[3]

Children engage in far less active play today than in previous decades.[4-6] This trend is likely to reflect children's unprecedented access to traditional (televisions, computers) and new (tablets, smart phones) forms of media technology.[7] However, increased demands of formal schooling, parental concerns over child safety from injuries, and the decreased availability of play spaces in children's environments are also believed to have contributed to play disappearing from children's lives.[1,8]

Disadvantaged children may receive fewer opportunities to engage in active play.[9,10] One reason for these disparities may be a perceived lack of neighborhood safety by parents.[11] Some

[1] Department of Social Sciences, Université Sainte-Anne, Church Point, Nova Scotia, Canada
[2] PERFORM center, Concordia University, Montreal, Quebec, Canada
[3] Departement of Childhood Education, University of Johannesburg, Johannesburg, South Africa
[4] Collège d'étude mondiale, Fondation Maison des Sciences de l'Homme, Paris, France
[5] Department of Pediatrics, Université de Montréal, Montreal, Quebec, Canada
[6] Sainte-Justine Children's Hospital Research Centre, Montreal, Quebec, Canada
[7] Epidemiology and Biostatistic Unit, INRS-Institut Armand-Frappier, Laval, Quebec, Canada

**Corresponding Author:**
Tracie A. Barnett, INRS-Institut Armand Frappier Unité d'épidémiologie et de biostatistique Laval, Quebec, Canada.
Email: tracie.Barnett@iaf.inrs.ca

parents appear to be less likely to engage in active outdoor play with daughters. For example, the authors of one study using a nationally representative sample of American families found that parents were 16% less likely to encourage girls to play outdoors than boys.[12]

Differences in the active play environments of center-based child care have also been noted.[13] Bower and colleagues found that preschoolers who attended daycares with greater availability of play installations (climbing structures, swing set) and equipment (jumping rope, hula hoop) were engaged in more moderate to vigorous physical activity (MVPA). These children also spent significantly less time sedentary.

Relatively simple interventions can increase active play. In one study,[14] intervention schools were equipped with play equipment (such as diabolos or juggling pins) that could be used during recess and lunch. Control schools did not receive additional equipment. No training was provided to teachers in either condition. Assessments conducted 3 months after the introduction of the play equipment showed that children in the intervention group had increased the total proportion of time they spent engaged in moderate physical activity during recess and lunch breaks from 48% to 61%.

Providing children with greater and more diverse active play opportunities in school settings is a particularly appealing health promotion initiative. Foremost, almost all children spend a large proportion of their waking hours at school. In addition, active play is by definition intrinsically motivated and fun for children. Offering students an environment that is conducive to active play as opposed to more competitive forms of physical activity may therefore help promote fitness and well-being in children who tend to avoid other forms of physical activity, due to their perceived lack of athletic ability. As a result, improving the quality of play environments may be a particularly effective option for targeting hard-to-reach children. Finally, unlike structured physical activity, teachers and educators do not require extensive training to facilitate active play with children.

Children are not all exposed to the same types of play environments at school. Some schools may offer a greater variety of indoor installations and equipment, while others may provide a greater variety of outdoor items. Both indoor and outdoor play equipment are likely to promote child health. Their combined contribution remains unclear, however.

Furthermore, there is evidence that engaging in MVPA is associated with reduced adiposity and improved metabolic health.[15] However, it is unknown whether providing children with opportunities to engage in active play specifically promotes cardiometabolic health independently of overall MVPA. That is, children's overall energy expenditure may also contribute to healthy weight outcomes. We hypothesized that children attending schools that offer a greater variety of play equipment and installations would be leaner at the 2-year follow-up, even after considering accelerometer-measured MVPA.

## Methods

### Design

Participating schools were selected from the sampling frame of the Quebec Adipose and Lifestyle Investigation in Youth (QUALITY) study, a longitudinal investigation of the natural history of obesity among at-risk children of Caucasian decent.[16] Eligible children were between 8 and 10 years old, Caucasian, and with at least 1 obese biological parent (ie, body mass index [BMI] $\geq$30 kg/m$^2$ or waist circumference >102 cm in men and >88 cm in women). A total of 1040 primary schools from Montreal, Quebec city, and Sherbrooke agreed to participate, representing an acceptance rate of 89%. In participating schools, flyers were distributed to all students enrolled in grades 2 to 5. Overall, of 3350 interested families, 1320 (49%) met the eligibility criteria and were invited to complete the baseline assessment. From these cases, 48% chose to participate, resulting in a sample of 630 at baseline. Follow-up was completed 2 years later with 564 families (retention rate of 89%), when children were 10 to12 years old. The children in the QUALITY cohort were generally of higher socioeconomic status, more likely to be in intact families, more likely to reside in urban areas, and more likely to be overweight/obese, compared to representative samples of 8- to 10-year-olds from the province of Quebec.[16]

### Sample

The School Environment add-on to the QUALITY study was restricted to the Greater Montreal Area, extending up to 75 km outside city limits, and included the schools of 544 of the 630 participating families. Eight of the 9 regional school boards provided permission to contact school principals. Our final sample consisted of 296 schools attended by 512 children (81% of baseline). The ethics review boards of CHU Sainte-Justine Research Centre approved the School Environment study (2008-179, 2696). More information on the design of the QUALITY cohort study has been published elsewhere.[16]

### Measures

*School play environments.* Data used to characterize school active play environments were obtained at baseline. Trained kinesiologists visited all sports and recreation-oriented locations inside and surrounding the school (school yards, gymnasium, palestres, adjacent parks), identified by the principal as accessible during school hours, to assess the active play environment. Kinesiologists documented the presence and quality of all available equipment and installations. By consensus among members of the broader QUALITY research team, we then selected indoor and outdoor play equipment items used for "fun" or "play" (ie, trampoline, swing set). In contrast, equipment meant for structured sports and exercise (ie, soccer ball, basketball net) were not selected. Sum scores for indoor and outdoor play environments were then created based on whether a piece of equipment was available (scored as 1) or absent (scored as 0).

*Indoor play environment.* Scores were based on the presence of 10 items including skateboards, hula-hoops, trampolines, unicycles, juggling pins, devil sticks, stilts, large cylinders, diabolos, and indoor climbing walls.

*Outdoor environment.* Scores were based on the presence of 13 items including small and large jungle gyms (2 items), pool, skateboard park, skating rink, spider (climbing frames), swing set, and pear ball in the adjacent park. The presence of a swing set, pear ball, small and large jungle gym (2 items), and climbing spider in the school yard was also considered. Both sum scores ranged between 0 and 10, with higher scores reflecting a greater variety of play equipment/installations.

*Student measures.* Trained nurses measured child height, weight, and waist circumference. Measurements were taken according to a standardized protocol.[17] Body fat composition was measured using DEXA Prodigy Bone Densitometer System, DF+14664 (GE Lunar Corporation, Madison, Wisconsin). No reagents or chemicals were used. Fat mass index (FMI) was computed using the following formula: FMI = (Total body fat mass [g]/100)/(height/100)$^2$. Age- and sex-specific BMI *z*-scores were computed based on child height and weight according to the US Centers for Disease Control and Prevention growth charts. Waist circumference was measured midway between the lowest rib and the iliac crest using a measuring tape and was used as an index of central adiposity ($ICC_{V1andV2} = 0.909$).[18]

*Control variables.* Minutes of physical education per school cycle was reported by school principals during a structured interview with a trained research assistant. Child daily MVPA was objectively measured using an actigraph activity monitor (accelerometer) over the course of 1 week. Participants were required to wear an accelerometer during their waking hours, except while bathing or during aquatic activities. Data collected from accelerometry were downloaded as 1-minute intervals. Data were considered to be valid if the child wore the device for at least 10 hours per day for a minimum of 4 days. Average counts per minute (total counts/wear time) was computed for participants at both time points. This measure of physical activity has been validated for use with children.[19] Finally, parents completed the questionnaires at baseline to gather demographic information including highest educational level of the parents (high school, preuniversity level, technical or trade school, or university) and total annual family income in Can$.

## Data Analytic Strategy

We used K-cluster analyses to identify types of schools that differed in terms of the variety of the combined indoor and outdoor play environments. The concept of active play typology was exploratory in nature; therefore, our intention was to examine and compare solutions with up to 10 clusters using K-means clustering technique. We subsequently examined associations with child adiposity outcomes.

Analyses were conducted with generalized estimation equations with school as the within-subject factor to account for the nesting of children within schools. All models included child MVPA, sex, and age as well as parental education and family income as control variables. In total, 11% of participants were lost to follow-up. To reduce bias due to nonrandom sample attrition, we followed recommendations on the treatment of missing data in longitudinal research and performed multiple imputations with NORM software version 2.03.[20] NORM employs an iterative method based on an expectation maximization algorithm to estimate values for missing data, depending on the available and valid observations in the original data set. Results using imputed data and nonimputed data were similar. As a result, we only report based on the imputed data.

**Table 1.** Socioeconomic Characteristics of School Neighborhoods.[a,b]

| | Mean (SD) | Minimum | Maximum |
|---|---|---|---|
| Mean income (Can$) | 82 106 (20 777) | 51 332 | 194 481 |
| Median income (Can$) | 73 524 | 45 627 | 143 753 |
| 25th percentile | 62 810 | - | - |
| 75th percentile | 82 994 | - | - |
| Parental education | | | |
| Mean % without diploma | 15.06 (7.04) | 1.15 | 47.40 |
| Family configuration | | | |
| Mean % single parent | 17.41 (5.74) | 4.50 | 33.34 |

[a]N = 296 schools.
[b]Characteristics of school neighborhoods (eg, the mean proportion of single-parent households in the school neighborhood) represent area-level average rates measured within a 750-m circular buffer of sampled schools. Average income reflects the mean income before taxes for households containing one couple. Without diploma reflects the proportion of people between the ages of 24 and 64 with no degree. Single parent reflects the proportion of single-parent-headed households.

# Results

## Descriptive Statistics

Socioeconomic characteristics of school neighborhoods are presented in Table 1. Schools were in economically diverse neighborhoods with mean income levels ranging from Can$51 332 to Can$194 481 per 2-person households. These income levels remain above the poverty line cutoffs. Sampled schools also varied in neighborhood average educational attainment and proportion of single-parent families (see Table 1).

In terms of demographics for our sample of children, boys and girls were equally represented (54% vs 46%, respectively). The mean age was 9.6 years old (115 months) at the first visit. Finally, mean household income was Can$42 360 per year, and 8% of the children had 1 or 2 parents without a high school diploma.

## Cluster Analyses

A K-means cluster analysis was conducted on all 296 schools based on indoor and outdoor play environment scores. The unit

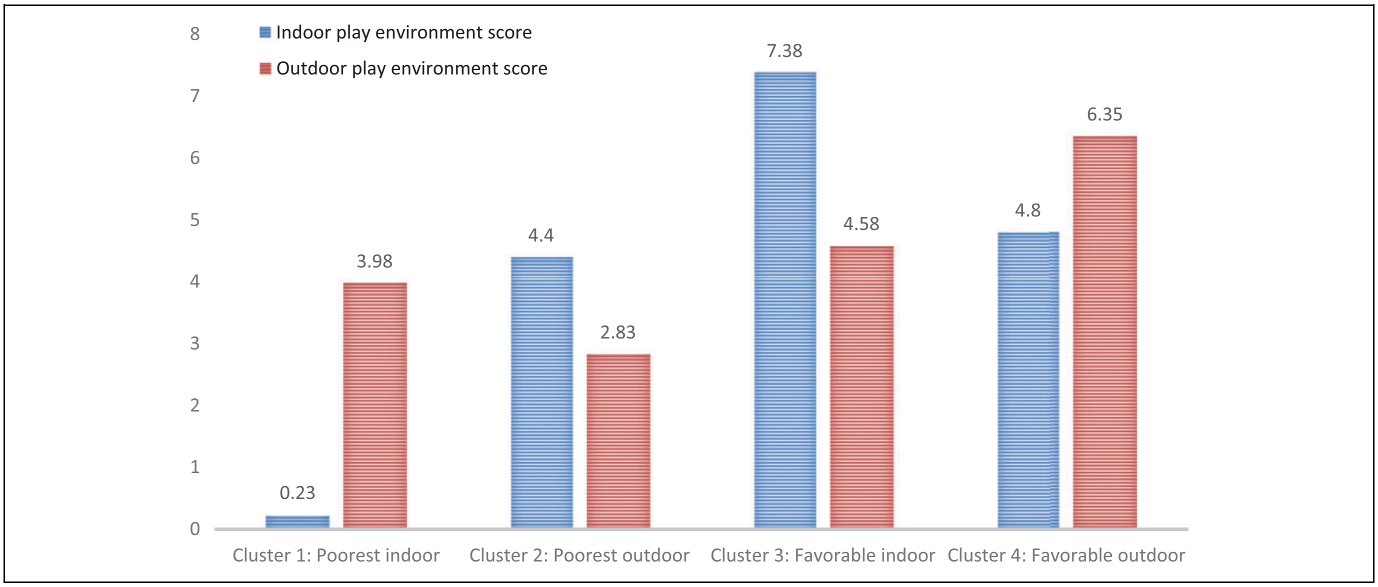


**Figure 1.** Sum scores for indoor and outdoor play environments according to school cluster.

of analysis was the school. A 4-cluster solution in which both variables contributed significantly to differentiating school types was selected. Analysis of variance revealed significant cluster differences, $F_{3,\ 292} = 460.58$, $P < .0001$ and $F_{3,\ 292} = 94.12$ $P < .0001$, on the indoor and outdoor play environment variables, respectively. This solution also met the requirements for number of cases per cluster. A 5-cluster solution did not provide a better fit; therefore, we did not further examine solutions with more than 5 clusters.

The four clusters were characterized by the contrasts in their combined indoor and outdoor play environments. Clusters are depicted in Figure 1. To orient comparisons, a first school cluster (type 1, N = 57) is referred to as the poorest indoor play environment. These schools received the lowest scores for their indoor play environment and moderate scores for their outdoor play environment. A second school cluster (type 2, N = 91) is referred to as the poorest outdoor play environment. These schools received the lowest scores for their outdoor play environment and moderate scores for their indoor play environment. A third school cluster (type 3, N = 66) comprises schools with a favorable indoor play environment. These schools had the highest scores on the indoor play environment and moderate scores for their outdoor play environment. Finally, a fourth school cluster (type 4, N = 82) scored the highest on the outdoor play environment and moderately on the indoor play environment. School and student characteristics according to clusters are presented in Tables 2 and 3, respectively. Children attending type 1 schools had the largest waist circumferences and highest body fat measures using body scan technology compared to the other school clusters. Type 1 schools also tended to offer fewer hours of physical education, although this difference was not statistically significant.

### *Regression Analyses*

Table 4 shows covariate-adjusted associations between school types and child adiposity outcomes. Data were analyzed using generalized estimation equation, with school entered as a within-subject factor. In all models, cluster 1, reflecting the poorest overall play environment, is used as the reference group.

We estimated regression equations while adjusting for child and family control variables. Relative to children in schools with the poorest indoor play environments (type 1), children with the most favorable indoor play environment (type 3) had lower overall body fat, $B = -1.26$ (95% CI, −2.26 to −.24), $P < .05$, and smaller waistlines, $B = -4.42$ cm (95% CI, −7.88 to −0.96 cm), $P < .05$, after 2 years. Attending schools with more varied indoor play environments did not predict BMI *z*-scores 2 years later. There were no significant differences between type 1 schools and type 2 (poorest outdoor environment) or type 4 (most favorable outdoor environment) schools in predicting any of the adiposity outcomes.

## Discussion

Research has challenged the notion that children are naturally inclined to engage in sufficient amounts of physical activity.[9,12] Nevertheless, when physical activity opportunities are fun, children may be more inclined to engage in them and as a result be more physically active.[21] The aim of the present study was to identify contrasting active play environments across a large number of urban schools. We also examined whether school types were associated with child adiposity outcomes 2 years later. We identified 4 types of schools that appear to offer qualitatively and quantitatively different active play environments. Moreover, students attending

**Table 2.** Characteristics of Schools and School Neighborhoods, by School Cluster.[a,b]

| | Type 1 (N = 57): Poorest Indoor Play Environment | | Type 2 (N = 91): Poorest Outdoor Play Environment | | Type 3 (N = 66): Favorable Indoor Play Environment | | Type 4 (N = 82): Favorable Outdoor Play Environment | | |
|---|---|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | M | SD | M | SD | *P* Value |
| Outdoor play environment | 3.98 | 2.01 | 2.83 | 1.16 | 4.58 | 1.18 | 6.35 | 1.26 | <.0001 |
| Indoor play environment | 0.23 | 0.60 | 4.40 | 1.12 | 7.38 | 1.22 | 4.80 | 1.14 | <.0001 |
| Physical education, minutes | 119.00 | 18.54 | 124.56 | 33.37 | 121.10 | 18.84 | 114.27 | 18.20 | .071 |
| MVPA (accelerometer) | 561.85 | 172.89 | 594.08 | 178.86 | 581.70 | 215.84 | 562.71 | 146.71 | .667 |
| Mean income, Can$ | 79 617 | 19 913 | 83 834 | 23 672 | 83 289 | 20 484 | 82 346 | 19 330 | .570 |
| Median income, Can$ | 74 963 | 14 879 | 71 125 | 15 164 | 74 946 | 18 283 | 73 952 | 15 396 | .376 |
| 25th percentile | 65 740 | | 59 704 | | 64 539 | | 64,204 | | |
| 75th percentile | 81 243 | | 83 085 | | 82 661 | | 84 308 | | |
| Without diploma, % | 15.52 | 7.78 | 14.96 | 6.60 | 14.36 | 7.22 | 15.48 | 6.33 | .708 |
| Single parent, % | 18.29 | 6.22 | 17.05 | 5.55 | 16.60 | 5.66 | 17.62 | 5.25 | .253 |

Abbreviations: M, mean; MVPA, moderate to vigorous physical activity; SD, standard deviation.
[a]N=296 schools.
[b]Outdoor and indoor play environment are sum scores reflecting the average number of outdoor and indoor play items available to children. Physical education reflects the number of minutes of physical education offered at schools. Average income reflects the area-level average income of family units living in the school neighborhood. Without diploma reflects the area-level proportion of families without a diploma. Single parent reflects the area-level proportion of single-parent-headed households.

**Table 3.** Characteristics of Students, by School Cluster.[a]

| | Type 1 (N = 89): Poorest Indoor Play Environment | | Type 2 (N = 141): Poorest Outdoor Play Environment | | Type 3 (N = 134): Favorable Indoor Play Environment | | Type 4 (N = 148): Favorable Outdoor Play Environment | | *P* Value |
|---|---|---|---|---|---|---|---|---|---|
| Sex (% males) | 48 | | 45 | | 46 | | 43 | | .848 |
| | M | SD | M | SD | M | SD | M | SD | |
| Age, months | 115.44 | 9.73 | 115.39 | 10.98 | 115.18 | 11.41 | 114.95 | 11.41 | .983 |
| Waist circumference, cm | 75.92 | 14.54 | 73.37 | 14.48 | 70.66 | 12.30 | 71.89 | 12.22 | .049 |
| Fat mass index | 7.42 | 4.19 | 6.56 | 4.03 | 5.90 | 3.59 | 6.20 | 3.53 | .039 |
| BMI (z-score) | 0.93 | 1.14 | 0.67 | 1.09 | 0.58 | 1.08 | 0.69 | 0.99 | .175 |

Abbreviations: BMI, body mass index; M, mean; SD, standard deviation.
[a]N=296 schools.

schools with more varied indoor play environments had lower overall body fat and smaller waistlines. These observed effect sizes were small to moderate and are likely to add up to meaningful clinical risks, given that both overall body fat and waist circumference represent important indicators of metabolic health.[22,23]

We did not observe any associations between school play environment and later BMI *z*-score, although associations were in the predicted direction. Moderate to vigorous physical activity, however, was a significant predictor of later BMI *z*-scores. One possibility is that waist circumference and body fatness measures obtained via Prodigy Bone Densitometer System may be better able to detect relatively smaller changes in child body fat than BMI assessments which do not differentiate between lean and fatty body mass.

Although physical activity represents a natural mediator of the associations in the present study, this was not born out in our analyses. Indeed, the effect of play environment was observed above and beyond the effect of MVPA, which suggests that active play may foster health benefits by increasing milder forms of activity and movement. Active play equipment may also benefit child health by reducing sedentary time (sitting time, screen time) and increasing light physical activity through social interaction. As described previously, active play generally involves shorter bursts of intense physical activity as well as lower intensity recovery periods. This form of physical activity may be especially efficient in helping children maintain a healthy weight. For example, high-intensity intermittent activity is more effective in reducing body fat in young women than similar amounts of time spent engaged in steady state exercise.[24] Furthermore, increased active play may reduce caloric intake by reducing time available for eating or snacking. Future research could examine the extent to which these variables mediate associations between active play and health.

Our study is the first to suggest that the availability of equipment and installations, which children can have fun with

**Table 4.** Regression Coefficients Estimating Associations Between School Cluster and Later Child Adiposity.[a]

| | Waist Circumference, cm | | Fat Mass Index | | BMI z-Score | |
|---|---|---|---|---|---|---|
| | *B* (95% CI) | *P* Value | *B* (95% CI) | *P* Value | *B* (95% CI) | *P* Value |
| Poorest indoor play environment (reference group) | - | - | - | - | - | - |
| Poorest outdoor play environment | −2.09 (−5.84 to 1.66) | .274 | −0.67 (−1.76 to 0.42) | .226 | −0.21 (−0.51 to 0.08) | .160 |
| Favorable indoor play environment | −4.42 (−7.88 to −0.96)[d] | .012 | −1.26 (−2.28 to −0.24) | .015 | −0.28 (−0.57 to 0.004) | .053 |
| Favorable outdoor play environment | −3.30 (−6.80 to 0.19) | .064 | −0.93 (−1.96 to 0.09) | .075 | −0.20 (−0.47 to 0.08) | .168 |
| Physical education, min | −0.01 (−0.10 to 0.09) | .872 | 0.00 (−0.03 to 0.03) | .982 | −0.001 (−0.01 to 0.01) | .826 |
| MVPA (accelerometer) | −0.01 (−0.02 to 0.003)[c] | .004 | −0.003 (−0.005 to −0.001) | .016 | −0.01 (−0.01 to −9.32E-5)[d] | .024 |
| Sex (girl = 1, boy = 2) | −1.70 (−0.55 to 3.95) | .138 | −0.71 (−1.36 to −0.06) | .034 | 0.10 (−0.09 to 0.28) | .321 |
| Age, months | 0.21 (0.11 to 0.32)[b] | .000 | −0.003 (−0.01 to 0.01) | .559 | −0.003 (−0.01 to 0.01) | .559 |
| Parents education | −2.53 (−4.44 to −0.61)[d] | .010 | −0.19 (−0.35 to −0.03) | .018 | −0.19 (−0.35 to −0.03)[d] | .018 |
| Income (in 1000 CND) | −0.04 (−0.10 to 0.03) | .248 | −0.004 (−0.01 to 0.001) | .134 | −0.004 (−0.01 to 0.01) | .134 |

Abbreviations: BMI, body mass index; CI, confidence interval; MVPA, moderate to vigorous physical activity.
[a]Fat mass index reflects (Total body fat mass [g]/100)/(height/100)$^2$. Parental education was scored as 1 = high school, 2 = preuniversity level, 3 = technical or trade school, or 4 = university.
[b]$P < .001$, significant.
[c]$P < .01$, significant.
[d]$P < .05$, significant.

inside the school premises, may be important for the prevention of child obesity. In many areas, weather limits the possibilities for outdoor play, as was the case in this study (conducted in Montreal, Canada). Other schools may be located in neighborhoods characterized by more disadvantage, pollution, noise, or crime. Consequently, providing opportunities to play indoors may be a strategic intervention for promoting active play and child health outcomes in schools.

Our investigation presents limitations and strengths. First, our study described naturally existing differences between schools in a large sample of Canadian children. Therefore, using this design, it is not possible to determine with certainty whether school typologies were causally associated with later child adiposity. For example, an underlying characteristic of children's families could have influenced both the type of school they attended and their adiposity 2 years later. To take this possibility into account, we controlled for family income and parental education in our analyses. Although it is possible that parents may have chosen schools for their academic or sports programs, we believe it is unlikely that they might have chosen schools based on their play environment. Nevertheless, experimental research can help strengthen the potential usefulness of increasing the quality of active play environments in elementary schools. Second, the QUALITY study included only Caucasian youth with a parental history of obesity. As a result, the generalizability of our findings to other populations is unknown. Nevertheless, our description of school play environments was based on a large sample of urban Montreal schools from diverse neighborhoods that varied in terms of socioeconomic status. Consequently, the diversity present in our sample helps increase confidence in the potential generalizability of the findings to other urban schools. Although we implemented rigorous quality control measures and used only a trained kinesiologist to complete audits, the play environment scores remain exploratory in nature. Hence, measurement properties remain to be established, and replication in different settings and populations is warranted. Finally, our study was strengthened by the use of direct observation of school grounds and objective assessments of child adiposity outcomes.

Over the past several decades, there has been an increased tendency toward reducing play opportunities in schools to allow more time for academic subjects. Although academic learning should remain a key priority, neglecting the importance of active play may be counterproductive. In addition to fostering healthy physical development, active play in school can also benefit the development of important social skills, creativity, and self-control.[21,23-26] These skills in turn are important for academic success, persistence to high school completion, success in the adult work place, and lifelong health.[27,28]

The current epidemic of childhood obesity demands that cost-effective and easily implemented preventive interventions be applied as early as possible. The present results suggest that some children experience inequity in their opportunities to engage in active play at their elementary school. There are currently no existing policies regulating children's access to active play environments during school hours. Our findings warrant further research and could be considered in the context of comprehensive child obesity prevention efforts.

## SO WHAT? Implications for Health Promotion Practitioners and Researchers

### *What is already known?*

Children today spend less time engaged in active play then children from previous generations.

### *What does this article add?*

Attending schools that provide a variety of opportunities for active free play is associated with lower adiposity in children.

### *What are the implications for health promotion practice or research?*

Schools represent an ideal setting for the promotion of child health as nearly all children spend a large proportion of their time attending school. The present study suggests that increasing access to play equipment, as an added component in school health initiatives, may represent a promising strategy for decreasing pediatric obesity and sedentariness.

## Authors' Note

Caroline Fitzpatrick wrote the first draft of this manuscript and has received no honorarium, grant, or form of payment. Tracie A. Barnett, Melanie Henderson, Stephanie Alexander, and Caroline Fitzpatrick all take entire responsibility for this manuscript. Barnett, Henderson, and Alexander have each significantly contributed to the design, data analysis and interpretation, and critical editing of the manuscript. The cohort integrates members of TEAM PRODIGY, an interuniversity research team including Université de Montréal, Concordia University, INRS-Institute-Armand Frappier, Université Laval, and McGill University.

## Acknowledgments

Dr Marie Lambert (July 1952 to February 2012), pediatric geneticist and researcher initiated the QUALITY cohort. Her leadership and devotion to QUALITY will always be remembered and appreciated. Finally, we are grateful to all the families that participate in the QUALITY cohort. The research team is grateful to all the children and their families who took part in this study, as well as the technicians, research assistants, and coordinators involved in the QUALITY cohort project.

## Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Mélanie Henderson holds a Diabetes Junior Investigator Award from the Canadian Society of Endocrinology and Metabolism—AstraZeneca and a Fonds de Recherche du Québec—Santé Junior 1 salary award, and Tracie A. Barnett holds a Senior salary award from the Fonds de la Recherche du Québec—Santé.

## Funding

The author(s) disclosed receipt of the following financial support for the research and/or authorship of this article: The QUALITY cohort was funded by the Canadian Institutes of Health Research (#OHF-69442, #NMD-94067, #MOP-97853 and #MOP-119512), the Heart and Stroke Foundation of Canada (#PG-040291), and Fonds de recherche du Québec—Santé (FRQS).

## References

1. Alexander S, Barnett TA, Fitzpatrick C. Are inequalities produced through the differential access to play opportunities at school? A call to level the playing field. *Can J Public Health*. 2017;107(6):e583-e585.
2. Canadian kids need to move more to boost their brain health. 2018. https://www.participaction.com/sites/default/files/downloads/the_participaction_report_card_on_physical_activity_for_children_and_youth_-_2018.pdf. Accessed June 21, 2018
3. Pellegrini AD. The development and function of locomotor play. In: Pellegrini AD ed. *The Oxford Handbook of the Development of Play*; 2011. Oxford, UK: Oxford University Press.
4. Gray P. The decline of play and the rise of psycopathology in children and adolescents. *Am J Play*. 2011;3(4):443-463.
5. Singer DG, Singer JL, D'Agostino H, DeLong R. Children's pastimes and play in sixteen nations: is free-play declining?. *Amer J Play*. 2009;1(3):283-312.
6. Hofferth SL, Sandberg JF. Changes in American children's time, 1981–1997. In: Owens T, Hofferth SL, eds. *Children at the Millennium: Where Have We Come From? Where Are We Going? Advances in Life Course Research*. Bingley, UK: JAI Press; 2001: 193-229.
7. Bleakley A, Vaala S, Jordan AB, Romer D. The Annenberg Media Environment Survey. Media and the well-being of children and adolescents. 2014. Oxford, UK: Oxford.
8. ParticipACTION. *The Brain + Body Equation: Canadian Kids Need Active Bodies to Build Their Best Brains. The 2018 ParticipACTION Report Card on Physical Activity for Children and Youth*. Toronto, Ontario, Canada: ParticipACTION; 2018.
9. Barth P.Time out: is recess in danger. Center for Public Education. 2008. http://www.centerforpubliceducation.org/Main-Menu/Organizing-a-school/Time-out-Is-recess-in-danger. Accessed 2016.
10. Anderson SE, Economos CD, Must A. Active play and screen time in US children aged 4 to 11 years in relation to sociodemographic and weight status characteristics: a nationally representative cross-sectional analysis. *BMC Public Health*. 2008;8(1): 309-311.
11. Milteer RM, Ginsburg KR, Mulligan DA, et al. The importance of play in promoting healthy child development and maintaining strong parent-child bond: focus on children in poverty. *Pediatrics*. 2012;129(1):e204-e213.
12. Tandon PS, Zhou C, Christakis DA. Frequency of parent-supervised outdoor play of US preschool-aged children outdoor play and preschool-aged children. *Arch Ped Adol Med*. 2012; 166(8):707-712.

13. Bower JK, Hales DP, Tate DF, Rubin DA, Benjamin SE, Ward DS. The childcare environment and children's physical activity. *Am J Prev Med*. 2008;34(1):23-29.
14. Verstraete SJM, Cardon GM, De Clercq DLR, De Bourdeaudhuij IMM. Increasing children's physical activity levels during recess periods in elementary schools: the effects of providing game equipment. *Eur J Public Health*. 2006; 16(4):415-419.
15. Ho M, Garnett SP, Baur L, et al. Effectiveness of lifestyle interventions in child obesity: systematic review with meta-analysis. *Pediatrics*. 2012;130(6):e1647-e1671.
16. Lambert M, Van Hulst A, O'Loughlin J, et al. Cohort profile: the Quebec adipose and lifestyle investigation in youth cohort. *Int J Epi*. 2012;41(6):1533-1544.
17. 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(5):523-531.
18. Lohman TG, Roche AF, Martorell R, eds. *Anthropometric Standardization Reference Manual*. Champaign, IL: Human Kinetics; 1988.
19. Colley R, Gorber SC, Tremblay MS. Quality control and data reduction procedures for accelerometry-derived measures of physical activity. *Health Rep*. 2010;21(1):63-69.
20. Cummings P. Missing data and multiple imputation. *JAMA Pediatrics*. 2013;167(7):656-661.
21. Burdette HL, Whitaker RC. Resurrecting free play in young children: looking beyond fitness and fatness to attention, affiliation, and affect. *Arch Ped Adol Med* 2005;159(1):46-50.
22. Meininger JC, Brosnan CA, Eissa MA, et al. Overweight and central adiposity in school-age children and links with hypertension. *J Ped Nursing*. 2010;25(2):119-125.
23. Arnberg K, Larnkjær A, Michaelsen KF, Mølgaard C. Central adiposity and protein intake are associated with arterial stiffness in overweight children. *J Nutrition*. 2012;142(5):878-885.
24. Trapp EG, Chisholm DJ, Freund J, Boutcher SH. The effects of high-intensity intermittent exercise training on fat loss and fasting insulin levels of young women. *Int J Obesity*. 2008;32(4):684-691.
25. Diamond A, Lee K. Interventions shown to aid executive function development in children 4 to 12 years old. *Science*. 2011; 333(6045):959-964.
26. Lillard A, Else-Quest N. The early years: evaluating montessori education. *Science*. 2006;313(5795):1893-1894.
27. Duckworth AL. The significance of self-control. *Proc Nat Acad Science*. 2011;108(7): 2639-2640.
28. Moffitt TE, Arseneault L, Belsky D, et al. A gradient of childhood self-control predicts health, wealth, and public safety. *Proc Nat Acad Science*. 2011;108(7):2693-2698.