Outdoor Time Is Associated with Physical Activity, Sedentary Time, and Cardiorespiratory Fitness in Youth

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Objective To determine whether time spent outdoors was associated with increased moderate-to-vigorous physical activity (MVPA) and related health benefits in youth.

Study design We performed a cross-sectional study of 306 youth aged 13.6 ± 1.4 years. The exposure of interest was self-reported time spent outdoors after school, stratified into three categories: none, some, and most/all of the time. The main outcome of interest was accelerometer-derived MVPA (Actical: 1500 to >6500 counts/min). Secondary outcomes included sedentary behavior, cardiorespiratory fitness, overweight status, and blood pressure.

Results Among the 306 youth studied, those who reported spending most/all of their after-school time outdoors (n = 120) participated in more MVPA (61.0 ± 24.3 vs 39.9 ± 19.1 min/day; adjusted $P < .001$), were more likely to achieve the recommended minimum 60 min/day of MVPA (aOR 2.8; 95% CI, 1.3-6.4), spent less time in sedentary activities (539 ± 97 min/day vs 610 ± 146 min/day; adjusted $P < .001$), and had higher cardiorespiratory fitness (49 ± 5 vs 45 ± 6 mL/kg/min; adjusted $P < .001$) than youth who reported no time outdoors (n = 52). No differences in overweight/obesity or blood pressure were observed across the groups.

Conclusions Time spent outdoors is positively associated with MVPA and cardiorespiratory fitness in youth and negatively associated with sedentary behavior. Experimental trials are needed to determine whether strategies designed to increase time spent outdoors exert a positive influence on physical activity and fitness levels in youth. *(J Pediatr 2014;165:516-21)*.

Very few youth living in developed countries achieve the recommended minimum of 60 minutes of moderate-to-vigorous physical activity (MVPA) daily.[1] The low levels of physical activity among children and adolescents are attributed to several factors, including changes in the built environment,[2] increased availability of electronic gaming and computers,[3] and possibly reductions in the time spent outdoors.[4] Studies by our group[5] and others[6,7] reveal that youth accumulate the majority of their MVPA during school hours. Specifically, we found that children accumulated ~25% more minutes of MVPA on school days relative to weekend days or holidays.[5,6] In fact, children achieve on average only 10 minutes of MVPA during the after-school period (3:00-5:00 p.m.).[7] Several expert groups have called for increasing outdoor time as one strategy to increase physical activity levels in children during the after-school time period.[8,9] Two key observations have initiated calls for more outdoor activities: (1) children accumulate little MVPA during after-school hours; and (2) levels of outdoor play for children have decreased considerably over the past 20 years.[8,10,11]

Unfortunately, the evidence supporting these calls is lacking and few well-controlled studies have documented a link between time spent outdoors and health behaviors in children.[12,13] The few studies published to date on this topic are generally restricted to younger children, relied on parental report of outdoor activity, and have not adequately addressed possible confounding factors (eg, sex, season, weight status).[8,10,11]

To overcome limitations of previous studies and to determine whether time spent outdoors during the after-school hours was positively associated with MVPA and related health outcomes in youth, we performed a cross-sectional study of youth 9-17 years of age enrolled in the Healthy Hearts Prospective Cohort Study of Physical Activity and Cardiometabolic Health.[14,15] We hypothesized that: (1) time spent outdoors would be positively associated with MVPA;

BMI	Body mass index
MVPA	Moderate-to-vigorous physical activity

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and (2) youth who reported spending most or all of their time outdoors after school would be less sedentary and have greater cardiorespiratory fitness than their peers who spent little or no time outdoors during this period.

Methods

Data from youth who provided valid accelerometer data (minimum of 3 days of wear time with at least 8 hours of registered minutes per day[14]) and completed a questionnaire regarding time spent outdoors from the 2009 wave of the Healthy Hearts Prospective Cohort Study of Physical Activity and Cardiometabolic Health were used in this study.[14,15] The prospective cohort study originally was designed to determine the association between cardiorespiratory fitness and the risk of overweight status in youth. The study involved annual measures of anthropometrics (height, weight, waist-to-hip ratio), cardiorespiratory fitness, and systolic blood pressure in a school-based cohort of children and adolescents (9-17 years of age) attending schools within the Black Gold School District, for 3 years (2008-2010). Data from this study as well as a more in depth description of the methods used have been published previously.[14,15] A convenience sample of 591 youth aged 9-17 wore an accelerometer and completed an online survey (WebSpan)[16] in the 2009 wave of data collection.

Data for exposure and outcome variables were not available for a sufficient number of youth in all 3 waves; therefore, the data presented here are restricted to the wave with the largest sample size that provided complete data. Data-collection procedures for the larger cohort study have previously been described.[14] All parents and youth provided written informed consent and assent, respectively, before initiation of the study, in accordance with the Declaration of Helsinki. This study was approved by the Human Research Ethics Board at the University of Alberta (Edmonton, Alberta, Canada).

During class time, youth completed a validated web-based questionnaire of health behaviors that included a self-reported measure of time spent outdoors.[16,17] This measure was meant to encompass all time spent out of doors, after the school period, whether taking part in organized activities or free play. Students were asked to recall the amount of time spent outdoors during the afterschool period over the past 7 days with 4 possible responses: (1) none of the time; (2) some of the time; (3) most of the time; and (4) all of the time. As there were few responses for the fourth option, we collapsed answers for option 3 and 4 into a single exposure of "most/all of the time." The exact time period that makes up the after-school period was not specified in this question.

The primary outcome measure (MVPA) was determined from 15-second epochs using waist-mounted accelerometers worn over a period of 7 days (Actical, serial nos. B101270-B101375; Respironics, Bend, Oregon) in the winter and spring terms of the 2008/2009 academic calendar year. Raw physical activity counts were converted into minutes of physical activity with the Kinesoft software program (KineSoft, Saskatoon, Saskatchewan, Canada).[18,19] Participants who failed to obtain a minimum of 3 days of wear with at least 480 registered minutes (8 hours) per day and the absence of consecutive zero counts >60 minutes were excluded from analyses. Similar criteria have been used in previous studies by our group and others to estimate habitual physical activity from accelerometer-derived data.[14,20-22] Standardized thresholds were used to classify raw counts per minute (cpm) into intensities of physical activity: (1) sedentary time (<100 cpm); (2) light-intensity (100-1499 cpm); (3) moderate-intensity (1500-6499 cpm); and (4) vigorous-intensity (>6500 cpm).[1,23] Secondary outcomes included: (1) sedentary behavior derived from accelerometry; (2) cardiorespiratory fitness determined using the Leger shuttle run[15,24]; and (3) systolic blood pressure assessed in triplicate using an automated machine after 5 minutes of quiet sitting,[15] and overweight status determined from age- and sex-specific thresholds for absolute body mass index (BMI) values to classify youth as "healthy weight," "overweight," or "obese" according to the International Obesity Task Force guidelines.[25] Blood pressure also was treated as a categorical variable with youth stratified as high normal if systolic blood pressure was >90th percentile for age, sex, and height.

Age,[26] sex,[5] weight status,[7] and season[27] (cold season: November-March; warm season: April-October) when physical activity was undertaken were considered potential confounders. Body weight was measured to the nearest 0.1 kg in duplicate using a digital scale (Seca 882 Digital Floor scale; Seca, Hamburg, Germany), and height was measured in duplicate to the nearest 0.1 cm using a medical standard stadiometer (Seca Portable Model 214). Absolute BMI (kg/m^2) was converted to an age- and sex-specific Z-score using EpiInfo.[28] Waist circumference was measured using a flexible tape at the top of the iliac crest as previously reported.

Statistical Analyses

Independent *t* tests were used to test for group-wise differences in characteristics between youth who were included in the analysis and those who were excluded for lack of sufficient accelerometer data to test for potential sampling bias. Normally distributed variables were compared across levels of outdoor time using ANOVA. Non-normally distributed variables were compared across levels of outdoor time using Kruskal-Wallis tests. Pearson χ^2 tests were used to determine differences in categorical variables across levels of outdoor time. Any significant differences in outcome measures in unadjusted tests were repeated with multivariable general linear or logistic regression models, adjusting for wear time, sex, age, BMI Z-score, and time of year.

In an effort to improve precision of the association, we conducted a second series of analyses where the outcome variable (MVPA) was restricted to the window of time when they were queried about the time they spent outdoors (3:30-11:59 p.m.). A multivariable linear regression model was used to determine whether the time spent outdoors was associated with MVPA and secondary outcome measures independent of confounding variables. The odds of achieving