

Physical Activity and Parental Attitudes and Beliefs of Children Attending a Nature Preschool

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Submitted January 4, 2019; accepted July 2, 2019

ABSTRACT

Children who spend more time outdoors are more physically active and have fewer behavioral problems than those who spend less time outdoors. No studies to date have evaluated physical activity and behavioral outcomes in an exclusively outdoor nature preschool setting. The aim of this study was to examine differences in objectively measured physical activity and child behavior in children attending a nature preschool compared to waitlisted controls. This cross-sectional pilot study was conducted in Seattle, Washington, in 2016. Children were 3-5 years of age ($n=33$) at the time of enrollment; parents or primary caregivers completed assessments. Children in the intervention group were enrolled at the nature preschool. The comparison group included children that were either waitlisted at the nature preschool, or were participating in a 2-hour nature-based outdoor enrichment class at the same location once per week. All children wore Actigraph accelerometers to measure moderate-to-vigorous physical activity (MVPA; primary outcome) for 5 days; parents completed the Strengths and Difficulties Questionnaire to assess child behavior (secondary outcome). Children in the control group engaged in 16 more minutes/day of MVPA compared to children attending the nature preschool (113 minutes, $SD=24$; 97 minutes, $SD=16$, respectively). No differences were found in MVPA during preschool hours (9 am to 1 pm). Parents of children attending the nature preschool reported wanting their children to engage in more active outdoor playtime compared to controls (206 minutes, $SD=136$; 150 minutes, $SD=87$, respectively). Actual self-reported active outdoor playtime was also higher for nature preschool participants compared to controls (233 minutes, $SD=61$; 67 minutes, $SD=52$, respectively). Parents of nature preschool participants were more comfortable with lower temperatures (21 degrees F, $SD=12$) for their children to play outdoors than control families (30 degrees F, $SD=19$). In summary, both children attending more traditional childcare environments and nature preschools had high levels of MVPA and parents of children in nature preschools were more tolerant of colder conditions for outdoor play.

Keywords: physical activity, early childhood, outdoor preschool, nature preschool, forest preschool

There is increasing evidence of value, and interest in, the benefits of nature contact for human health and well-being (Brussoni et al., 2015; Frumkin et al., 2017; Herrington & Brussoni, 2015; McCurdy, Winterbottom, Mehta, & Roberts, 2010; Tremblay et al., 2015a). Outdoor play for children, particularly in natural environments, is associated with increased physical activity, and other developmental, social/emotional, and health benefits (Gray et al., 2015; D. R. Lubans, Morgan, Cliff, Barnett, & Okely, 2010; D. Lubans et al., 2016; Stephenson, 2003; Taylor, Kuo, & Sullivan, 2002). Nonetheless, total daily outdoor time for children has decreased compared to previous generations (Bassett, John, Conger, Fitzhugh, & Coe, 2015; Gray et al., 2015; Tremblay et al., 2015a). Thus, nature preschools offer a

potential solution to increasing outdoor time, and optimizing physical and behavioral health in early childhood (Kenny, 2013; Larimore, 2016; Sobel, 2015; Sobel, 2014).

In addition, children who spend more time outdoors have been found to be more physically active than those who spent less time outdoors (Hinkley, Crawford, Salmon, Okely, & Hesketh, 2008). Specifically, more time outside is associated with higher moderate-to-vigorous physical activity (MVPA), and fewer minutes of sedentary time (Larouche, Garriguet, Gunnell, Goldfield, & Tremblay, 2016; Tremblay et al., 2015a). Natural settings provide more challenging physical environment (trails, hills, slippery surfaces, etc.) and opportunities for functional play, (Pellegrini & Smith, 1998) which may support motor development by facilitating gross motor activities during a critical development period for these skills (Fjørtoft, 2001, 2004; Little & Wyver, 2008). Spending time outdoors has also been associated with improved Vitamin D levels (Absoud, Cummins, Lim, Wassmer, & Shaw, 2011) necessary for healthy bone development, and prevention of the onset of myopia (Xiong et al., 2017). In addition to physical health benefits, nature contact and outdoor play may promote children's social and emotional development (Burdette & Whitaker, 2005; Burdette, Whitaker, & Daniels, 2004; Heerwagen & Orians, 2002; Kellert, 2012) problem-solving abilities (Kellert, 2012), and creativity (Burdette & Whitaker, 2005; Kellert, 2012; Louv, 2008; Taylor, Wiley, Kuo, & Sullivan, 1998).

While there is increasing evidence about the benefits of children's outdoor time, opportunities for young children to play outdoors may be limited. The American Academy of Pediatrics recommends that preschool-age children get 60-90 minutes of outdoor time each day (American Academy of Pediatrics & American Public Health Association, 2011). According to a study of a nationally representative US sample, only 51% of preschool age children play outdoors with their parents on a daily basis (Tandon, Zhou, & Christakis, 2012). A recent study of Washington State's child care programs found that most centers provide substantially less than this amount of daily outdoor time for young children (Tandon, Saelens, & Christakis, 2015).

One strategy to increase preschoolers' time in and exposure to natural environments is to enroll them in nature preschools. Nature preschools take various forms, ranging from including nature as a central programming theme and requiring staff have training in both early childhood and environmental education, to what are traditionally called "forest schools" which are generally 70-100% conducted outdoors (Larimore, 2016). Nature preschools have been popular many European countries for decades; in 2014 there were an estimated 1,000 nature preschools in Germany alone (D. Sobel, 2015). Public interest in nature preschools across the US is accelerating rapidly, and programmatic development is following in suit. A 2017 survey of early childhood educators conducted by four national childhood education associations reported approximately 250 nature preschools in the US, an increase of 66% compared to 2016. Nearly 10,000 children attend these programs annually, and 80% of the programs have a waitlist (North American Association for Environmental Education, n.d.).

As interest in nature preschools increases in the US, there is a need to better understand the implications and potential benefits of this model of early childhood education. The aim of this study was to measure physical activity, child behavior, and to describe and compare parents' perception and practices related to outdoor play between children currently enrolled at a nature preschool to those in other more traditional childcare programs.

Methods

Study Population

This cross-sectional observational study included 33 children aged 3-5 years from the greater Seattle area recruited in 2016. Enrollment included children already attending a nature-based, exclusively outdoor preschool (n=20) and a comparison group (n=13). The comparison group consisted of children from families that were either waitlisted at the nature preschool or were participating in a 2-hour nature-based, outdoor enrichment class provided by the same nature preschool once per week. Of the n=13 participants in the comparison group, n=10 attended a traditional indoor preschool, and n=3 received indoor care at home. All participants were recruited by letter (parent letter and study flyers), by phone (participant initiated), or in person (at the preschool or enrichment class). Participants were excluded from participation if they: (1) were foster children (due to the complicated nature of legal guardianship and informed consent), or (2) if parents/guardians were unable to consent in English. Parents of participants

provided written informed consent; children provided verbal assent. The study protocol was approved by the Seattle Children’s Hospital Institutional Review Board.

Setting

The nature preschool occurs exclusively outdoors in a forested park in Seattle, Washington. In alignment with the philosophies of many forest preschools (Kenny, 2013; Larimore, 2016; Sobel, 2015; Warden, 2015), teachers function as guides for learning and do not follow a set curriculum. Instead, teachers focus on free-play and child-initiated exploration and interests; teachers complement with curriculum as needed. Most children attend 5 days per week from 9 am to 1 pm; 2-day and 3-day per week options are available on a limited basis. No full-day options are available. The physical environment consists of dedicated classroom areas that are directly in forested areas. Children use logs and tree stumps to sit; portable canopies are used during inclement weather. While much of the day is spent hiking and exploring the surrounding forest, tables and play stations (e.g., areas for microscopes, coloring, etc.) are present in the classroom areas. No traditional play structures or pre-fabricated playgrounds are utilized.

For control children who enrolled, the 2-hour nature-based outdoor enrichment class was offered once weekly by the same nature preschool the intervention group children attended. All classes included both a caregiver and their child, in addition to a teacher to lead the group. For these classes, the nature preschool prioritizes science-based exploration through outdoor play in a forested park. Classes include circle time, station time (learning stations that emphasize sensory and fine motor skills, creativity, and numerical and literacy skills), short stories, and hikes.

Sociodemographics

Child age (years/months), gender (female/male), race, and ethnicity were determined based on parent report. Socioeconomic status was approximated by parent-reported total annual household income (see Table 1 below).

Table 1
Participant characteristics by preschool type

| Category | Nature Preschool n=20 | Controls n=13 |
|--|--------------------------------------|--------------------------|
| Female, N (%) | 9 (45%) | 4 (33%) |
| Age, months (SD) | 54 (6) | 47 (8) |
| Race and ethnicity, N (%) | | |
| White | 13 (65%) | 9 (75%) |
| Asian | 1 (5%) | 2 (17%) |
| Hispanic, Mexican, or Latina/Latino | 1 (5%) | 0 (0%) |
| Mixed race (≥1 race selected) | 5 (25%) | 1 (8%) |
| Parental age, years (SD) | 38 (4) | 39 (4) |
| Highest Parent Education, N (%) | | |
| Completed College | 5 (25%) | 3 (25%) |
| Completed Graduate | 15 (75%) | 9 (75%) |
| Household Annual Income, N (%) | | |
| \$29,000 or less | 0 (0%) | 1 (8%) |
| \$30,000-\$49,000 | 0 (0%) | 1 (8%) |
| \$50,000-\$69,000 | 0 (0%) | 0 (0%) |

| | | |
|-------------------|----------|---------|
| \$70,000-\$89,000 | 2 (10%) | 2 (17%) |
| \$90,000 or more | 18 (90%) | 8 (67%) |

Note: Percentages may not add up to 100% based on rounded estimates.

Measurements

Physical Activity. Physical activity was objectively measured using a GT3X+ Actigraph accelerometer (*ActiGraph*, n.d.; Puyau, Adolph, Vohra, & Butte, 2002); all participants wore the accelerometers between April and June of 2016 for a minimum of 5 days (one weekend included in wear period). A 5-day consecutive wear time has been shown to accurately estimate objectively measured physical activity data in preschool-aged children (Addy, Trilk, Dowda, Byun, & Pate, 2014; Pate, O'Neill, & Mitchell, 2010). Children wore the devices on their right hip attached to an elastic belt. Accelerometers were initialized at 40 hertz to begin sampling and storing activity counts starting at 0100 Pacific Standard Time on the first day of wear. To take into account the impact of weather conditions on physical activity, we categorized weather for each day of accelerometer wear time by National Oceanic and Atmospheric Administration thresholds for precipitation: no rain, and greater than or equal to trace rain (a small amount of precipitation below the rain gauge measuring limit of 0.01 inch) (National Oceanic and Atmospheric Administration, n.d.). Each 'intervention' child was matched with a 'control' child by date to ensure that accelerometer data were present for both groups under any given weather condition. We used a 1:N matching strategy; participants were included in the analysis if they had greater than or equal to one match in the comparison group.

Data Processing and Cut Points. Physical activity counts were downloaded in 15 second epochs using a common method established by Pate and colleagues (Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006). Participants with 3+ valid days of accelerometer data were included if ≥ 8 hours of wear time were detected; any time period greater than 20 minutes with consecutive zeros was considered non-wear. Accelerometer activity level data were downloaded and analyzed using ActiLife (*ActiGraph ActiLife*, n.d.). Accelerometer data were scored using MeterPlus software (*MeterPlus*, n.d.); time filters were created to reflect on/off times. Physical activity cut points were determined using previously published guidelines: sedentary: 0 - 799 counts per minute (CPM); light: 800 - 1679 CPM; moderate-to-vigorous: 1680 - 3368+ CPM (Pate et al., 2006). In addition, we examined characteristics of sedentary bouts during wear time - sustained periods of inactivity which were defined as being a minimum of 10 minutes in length, and ≤ 199 activity counts per epoch for the entirety of the bout (1 epoch of ≥ 200 activity counts would reset the clock for bout time) (Healy et al., 2008; Saunders et al., 2013).

Child Behavior and Parental Beliefs. Strengths and Difficulties Questionnaire (SDQ). The SDQ was used as a brief behavioral screening tool for each participant (Goodman, 1997; Mellor, 2004). The SDQ is a 25-item parent-reported psychological assessment of children to evaluate psychological attributes in 5 domains (5 items in each domain; score range in each domain: 0-10): emotional problems, conduct problems, hyperactivity/inattention, peer relationship problems, and prosocial behavior. We used a modified informant-related version of the SDQ that was developed for preschool-aged children. Parents were asked to rate their child on a scale of 0 to 2 for each question (0=not true; 1=somewhat true; 2=certainly true). A general difficulties score was also calculated using SDQ pre-specified instructions (sum of all domain scores except prosocial behavior; overall score range: 0-40) ([Strengths and Difficulties Questionnaire: Scoring Website., n.d.](#)).

Parent Supervision Attributes Profile Questionnaire (PSAPQ). The PSAPQ was to assess potential differences in parental value systems that may play a role in whether parents feel comfortable with their child attending a nature preschool. The PSAPQ is a 29-item self-report questionnaire, to assess beliefs/behaviors about parent supervision (Morrongiello & Corbett, 2006). Participants were asked to rate their child on a scale of 1 to 5 for each question (1=never; 2=some of the time; 3=half of the time; 4=most of the time; 5=all of the time; score range in each domain: 0-5). Mean scores were calculated in 4 domains: protectiveness (9 items), supervision beliefs (9 items), risk tolerance (8 items), and belief that fate controls child's health (3 items).

Author-developed questionnaires. In addition, parents were asked to complete two additional questionnaires about: 1) perceived level of importance of activities thought to prepare their child for kindergarten (1=least important; 3=somewhat important; 5=most important) (Jayasuriya, Williams, Edwards, & Tandon, 2016), and 2) limits of comfort with inclement weather conditions (type, frequency [minutes/hours], duration, and temperature [Fahrenheit; F]) for their child's active outdoor playtime activities.

Statistical Analysis

Descriptive statistics were generated for participants using means (SD) for continuous variables and frequencies (percentages) for categorical variables, with results stratified by preschool type. Results are presented as point estimates with 95% confidence intervals, with no inferential statistical testing given the small sample sizes. Physical activity data were analyzed for the entire wear time and were additionally categorized as follows: 1) weekend/weekday, and 2) preschool hours (9 am – 1 pm); all units of physical activity are reported as minutes per day. For the weather analysis, the unit of the analysis was the day, with General Estimating Equations (GEE) models used to account for within-person correlation; GEE model specifications included an exchangeable working correlation matrix and a robust standard variance estimator. All analyses were performed using Stata version 14.1 (or later) and R (R Core Team, 2017; Stata Corp, 2015).

Results

Of the 33 participants included in our analysis, nature preschool participants were more likely to be female, older, and live in households with higher annual incomes. The overall study sample was highly educated; 75% of responding parents had completed some form of graduate school in both groups. Although children attending nature preschool were more likely to be mixed race (25% vs. 8% in controls), both preschool types were predominantly white (65% vs. 75% in nature preschool and controls, respectively). Annual household income was higher in children attending nature preschool; 90% of nature preschool families and 67% of control families reported earning \$90,000 or more annually (Table 1).

Control preschoolers engaged in nearly 16 more minutes/day of MVPA on average compared to nature preschool preschoolers (113 minutes, SD=24; 97 minutes, SD=16, respectively). No differences in MVPA were found during preschool hours (9 am to 1 pm) between children attending the nature preschool and those in the control group. Similar differences by preschool type were seen when comparing weekends and weekdays (see Table 2). While the frequency of sedentary bouts did not differ between groups, average sedentary bout length was 3 minutes lower in nature preschool preschoolers (13 minutes, SD=5) than in children in the control group (16 minutes, SD=3) (see Table 2).

Parents reported both the ideal amount of active outdoor playtime they would like their children to have at school, in addition to the actual amount of active outdoor playtime their children receive at school. Parents of children attending the nature preschool reported wanting their children to engage in more active outdoor playtime (206 minutes, SD=136) compared to controls (150 minutes, SD=87). Actual active outdoor playtime was also higher for nature preschool participants (233 minutes, SD=61) compared to controls (67 minutes, SD=52). Thus, children attending the nature preschool have: 1) more active outdoor playtime at school than their control counterparts, and 2) parents that want them to have more total time spent in active outdoor play at school on a daily basis. No differences in total accelerometer wear time were observed between groups (see Table 2).

The PSAPQ scores in each domain appeared similar between children in different preschool types; no differences were found between groups for SDQ scores (see Table 3). No differences were found between groups for self-reported importance of activities to prepare a child for kindergarten; outside play time ranked highly in both groups (4.5, SD=0.95; 4.8, SD=0.39 in nature preschool and controls, respectively) (see Table 4). Parents of nature preschool participants were more comfortable with all inclement weather conditions; high temperature preferences were similar between groups but nature preschool parents were more comfortable with lower temperatures (21 degrees F, SD=12) for their children to play outdoors than control families (30 degrees F, SD=19) (see Table 5). No differences in physical activity or sedentary activity time were found between groups by weather condition.

Table 2

Objectively measured physical activity and parent-reported preferences for physical activity of participant by preschool type

| Category | Nature Preschool n=20 | Controls n=13 | Difference (95% CI) |
|---|--------------------------|------------------|----------------------|
| Objectively measured physical activity (Actigraph accelerometer), minutes per day (SD)¹ | | | |
| General physical activity | | | |
| Sedentary | 467 (60) | 453 (51) | 14.4 (-29.1, 58.0) |
| Light | 91.6 (13) | 102 (10) | -10.1 (-19.2, -1.0) |
| MVPA | 97.4 (16) | 113 (24) | -15.5 (-31.9, 0.87) |
| Total Wear Time | 656 (59) | 667 (59) | -11.1 (-57.9, 35.6) |
| Weekday physical activity | | | |
| Sedentary | 468 (66) | 461 (54) | 6.9 (-40.1, 54.0) |
| Light | 93.5 (18) | 101 (15) | -7.3 (-20.1, 5.4) |
| MVPA | 97.1 (21) | 112 (30) | -14.9 (-36.3, 6.5) |
| Weekend physical activity | | | |
| Sedentary | 486 (65) | 453 (51) | 33.0 (-14.8, 80.9) |
| Light | 88.7 (14) | 103 (15) | -14.2 (-25.9, -2.4) |
| MVPA | 95.8 (16) | 113 (22) | -17.7 (-33.8, -1.5) |
| General physical activity (9 am to 1 pm) | | | |
| Sedentary | 153 (19) | 166 (13) | -13.5 (63.3, 54.2) |
| Light | 31.8 (11) | 32.7 (5) | -0.9 (-2.1, 0.64) |
| MVPA | 33.2 (15) | 34.7 (7) | -1.5 (-2.8, 1.2) |
| Sedentary bouts (9am to 1pm)² | | | |
| Bout, total number | 6.3 (3) | 6.4 (4) | -0.05 (-2.9, 2.8) |
| Bouts, number per day | 1.9 (1) | 2.0 (1) | -0.11 (-0.94, 0.73) |
| Bouts, total length | 88.9 (47) | 100 (59) | -11.3 (-54.4, 31.7) |
| Bout, average length | 12.8 (5) | 16.1 (3) | -3.3 (-6.7, 0.13) |
| Parent-reported preferences for physical activity, minutes per day (SD)³ | | | |
| Outdoor time preferences | | | |
| Ideal active outdoor playtime at school | 206 (136) | 150 (87) | 55.5 [-32.0, 143.0] |
| Actual active outdoor playtime at school | 233 (61) | 67.3 (52) | 165.2 [117.6, 212.9] |
| On a typical school day... | | | |
| Time spent outdoors: from waking to school | 12.0 (27) | 5 (10) | 7.0 [-8.3, 22.3] |
| Time spent outdoors: after school until bed | 105 (63) | 76.3 (55) | 28.8 [-17.8, 75.3] |
| Time spent outdoors as a family | 68.3 (52) | 51.3 (51) | 17.0 [-24.0, 58.0] |
| On a typical non-school day... | | | |
| Time spent outdoors | 188 (71) | 166 (79) | 21.5 [-42.5, 85.5] |
| Time spent outside active as a family | 121 (75) | 128 (81) | -7.4 [-73.6, 58.8] |

Percentages may not add up to 100% based on rounded estimates.

Abbreviations: standard deviation, SD; moderate-to-vigorous physical activity, MVPA; confidence interval, CI.

¹Objectively measured using ActiGraph accelerometer device.

² Sedentary bout defined as a minimum of 10 minutes in length, and ≤199 activity counts per epoch for the entirety of the bout (1 epoch of ≥200 activity counts would reset the clock for bout time).

³ Parent-reported outdoor time preferences for child.

Table 3

Parent-reported Parent Supervision Attributes Profile Questionnaire and Strengths and Difficulties Questionnaire by preschool type¹

| | Nature Preschool n=19 | Controls n=12 | Difference (95% CI) |
|--|--------------------------|------------------|---------------------|
| Parent Supervision Attributes Profile Questionnaire, score (SD)² | | | |
| Protectiveness | 3.26 (0.52) | 3.27 (0.58) | 0.01 (-0.45, 0.45) |
| Supervision Beliefs | 2.85 (0.45) | 2.94 (0.6) | -0.09 (-0.53, 0.35) |
| Risk Tolerance | 3.98 (0.4) | 3.94 (0.49) | 0.04 (-0.33, 0.4) |
| Belief that Fate Controls Child's Health | 2.21 (0.59) | 2.11 (0.92) | 0.1 (-0.56, 0.76) |
| Strengths and Difficulties Questionnaire, score (SD)³ | | | |
| Overall Score ⁴ | 6.55 (4.35) | 7.51 (4.23) | -0.95 (-4.39, 2.49) |
| Emotional problems | 1.20 (1.67) | 1.00 (0.95) | 0.2 (-0.82, 1.22) |
| Conduct problems | 1.63 (1.54) | 1.83 (1.59) | -0.23 (-1.49, 1.03) |
| Hyperactivity/inattention | 2.74 (2.27) | 3.58 (2.27) | -0.88 (-2.71, 0.94) |
| Peer relationship problems | 1.05 (0.94) | 1.08 (1.24) | -0.03 (-0.95, 0.88) |
| Prosocial behavior | 8.15 (1.57) | 7.83 (1.59) | 0.32 (-0.95, 1.59) |

Abbreviations: standard deviation, SD; confidence interval, CI.

¹ All self-reported by parents

² Scores calculated as a mean for each domain on a scale of 1 (never) to 5 (all of time time); score range in each domain: 1-5. Higher is more protective (protectiveness) and values closer supervision (supervision beliefs); higher greater tolerance for risk (risk tolerance); higher is stronger belief that fate impacts future events (belief that faith controls child's health).

³ Individual domain scores calculated as a sum for each domain on a scale of 0 (not true) to 2 (certainly true); score range in emotional problems, conduct problems, hyperactivity/inattention, peer relationship problems: 0-10 (lower is better); score range for prosocial behavior: 0-10 (higher is better);

⁴ Overall score calculated by summing individual scores of all domains except prosocial behavior (scored separately). Overall score range: 0-40 (lower is better).

Table 4

Parent-reported importance of activities to prepare child for kindergarten by preschool type¹

| | Nature Preschool n=20 | Controls n=12 | Difference (95% CI) |
|---|--------------------------|------------------|---------------------|
| Importance of Activity to Prepare for Kindergarten, score (SD)² | | | |
| Social and emotional learning | 4.9 (0.31) | 4.9 (0.29) | -0.02 (-0.25, 0.22) |
| Make believe play | 4.7 (0.59) | 4.7 (0.49) | -0.02 (-0.44, 0.41) |
| Outside play time | 4.5 (0.95) | 4.8 (0.39) | -0.33 (-0.86, 0.19) |
| Story time | 4.2 (1.06) | 4.0 (0.89) | 0.20 (-0.6, 1.0) |
| Music | 3.9 (0.85) | 3.8 (0.98) | 0.08 (-0.7, 0.87) |
| Science activities | 3.8 (1.08) | 3.8 (0.87) | -0.03 (-0.84, 0.78) |
| Lunch time/snack time | 3.8 (1.21) | 3.4 (1.29) | 0.48 (-0.59, 1.54) |
| Arts and crafts | 3.7 (0.93) | 3.7 (1.01) | 0.01 (-0.82, 0.84) |
| Learning ABC's and numbers | 3.2 (1.06) | 3.4 (1.43) | -0.16 (-1.26, 0.93) |
| Inside play time | 3.0 (1.23) | 3.8 (1.11) | -0.88 (-1.82, 0.05) |
| Nap time | 2.8 (1.44) | 2.7 (1.42) | 0.07 (-1.12, 1.27) |

Abbreviations: standard deviation, SD; confidence interval, CI.

¹ All self-reported by parents.

² Scores calculated as a mean for each item on a scale of 1 (least important) to 5 (most important).

Table 5

Parent-reported limits of comfort with inclement weather conditions by preschool type¹

| | Nature Preschool n=20 | Controls n=12 | Difference, 95% CI |
|--|--------------------------|------------------|--------------------|
| Weather condition preferences, N (%)² | | | |
| Wet ground/puddles on the playground | 20 (100%) | 10 (91%) | 0.09 (-0.1, 0.3) |
| Light rain/mist/drizzle | 20 (100%) | 11 (92%) | 0.08 (-0.09, 0.26) |
| Steady rain/showers | 14 (70%) | 5 (46%) | 0.25 (-0.16, 0.65) |
| Heavy rain | 7 (35%) | 1 (8%) | 0.27 (-0.03, 0.56) |
| Light snow or snow on the ground | 20 (100%) | 12 (100%) | 0 (0, 0) |
| Heavy snow | 18 (90%) | 10 (83%) | 0.07 (-0.21, 0.35) |
| Temperature preferences for outdoor play, degrees Fahrenheit (SD) | n=20 | n=10 | |
| Lowest temperature | 21.0 (12) | 30.0 (19) | -9 (-24.2, 6.2) |
| Highest temperature | 93.5 (5) | 92.7 (10) | 0.8 (-7.0, 8.6) |

Abbreviations: standard deviation, SD; confidence interval, CI.

¹ All self-reported by parents.

² Percent of parents reporting that they would take their child outside in the specific weather conditions.

Discussion

In this study, we examined objectively measured physical activity, children's behavioral strengths and difficulties, and parents' perception and practices around outdoor play in children attending a nature preschool compared to children not enrolled in such a preschool. To the best of our knowledge, this is the first study to examine children's physical activity and their behavioral strengths and difficulties in an exclusively nature preschool model. Overall, we found that physical activity levels were high in both groups, with children attaining over the 180 minutes per day of total activity recommended by many international groups (Australia's Physical Activity and Sedentary Behaviour Guidelines, 2014; United Kingdom Physical Activity Guidelines, n.d.; Lipnowski, Leblanc, & Canadian Paediatric Society, Healthy Active Living and Sports Medicine Committee, 2012), and greater than the 60-90 minutes of MVPA recommended for school age children in the US (American Academy of Pediatrics & American Public Health Association, 2011). Unexpectedly, there was no indication that the children enrolled in nature preschool were engaged in more physical activity, despite spending considerably more outdoor time at school. In addition, parents of nature preschool preschoolers reported (a) wanting their children to spend more time outside at school, (b) that their children do spend more time outside at school, and (c) a higher tolerance for their children to be outside in wetter and colder weather conditions. There were no other observed differences in actual child behavior or parent protectiveness or preferences between children in the nature preschool versus those not enrolled in this type of preschool. Thus, both children attending a nature preschool and children in more traditional indoor childcare settings have ample opportunities for MVPA. While we can be certain that all activity was outdoors in the children attending a nature preschool, we do not know where the MVPA was occurring in the control group. Thus, children in the indoor childcare setting may have active play opportunities, but the frequency to engage in these opportunities outdoors in a natural environment is uncertain. Because parents in the overall study sample were highly educated (25% had a college degree and 75% had a graduate degree in both groups), it is possible that families in both groups appreciate the importance of outdoor play and provide these opportunities to their children independent of type of childcare environment.

Evidence suggests that children who spend more time outdoors are more physically active than those who spend more time indoors (Cleland et al., 2008; Hinkley et al., 2008; Kneeshaw-Price et al., 2013; K Lachowycz & Jones, 2011; Kate Lachowycz, Jones, Page, Wheeler, & Cooper, 2012; Schaefer et al., 2014; Tandon et al., 2015). One recent study found that Swedish children in preschools with high quality outdoor play environments were less likely to be overweight, slept for longer periods of time, and had more daily steps per minute than their peers with lower quality outdoor preschool environments (Söderström et al., 2013). Our findings are inconsistent with the literature examining the impact of outdoor time on physical activity. There may be unanticipated differences between nature preschools and indoor childcare settings that offer high quality outdoor play opportunities. Recent studies examining outdoor time in children suggest that outdoor environments provide more diverse spaces and opportunities for different types of play, and provide an environment for children to be more engaged for longer periods of time (Drown & Christensen, 2014; Herrington & Brussoni, 2015). It is possible that children attending a nature preschool, while engaging in high levels of overall physical activity, had lower total MVPA compared to the other group due to being more engaged with the outdoor learning environment or that the natural outside environment was less conducive to active play than say a playground might be. A study examining movement patterns in children before and after installation of a more natural outdoor play space at two preschools in Canada found that children were more likely to "channel surf" – walk back and forth or engage in repetitive motions indicating boredom – before the installation (Herrington & Brussoni, 2015). Post-installation, there were more pauses in movement to interface with the environment, and movement patterns were more spatially complex. The authors concluded that children were more engaged in their play after the installation of natural elements (Coombes, van Sluijs, & Jones, 2013; Herrington & Brussoni, 2015). Children attending nature preschools may be more engaged in their learning environments even if such activities are outdoors but mostly sedentary. It could be that the novelty or change in context to going outdoors for children in traditional preschools who spend most of their time indoors is what encourages more physical activity. In contrast, nature preschoolers are always outdoors and would not be expected to be active the whole time they are attending preschool.

During childhood, natural outdoor environments can improve mental health (Amoly et al., 2014b; JACKSON, TESTER, & Henderson, 2008; Kuo & Taylor, 2004; Wells & Evans, 2003), behavioral problems (Balseviciene et al., 2014; Markevych et al., 2014), motor development (Fjørtoft, 2001, 2004; Little & Wyver, 2008), and social and emotional development (JACKSON et al., 2008; Wells & Evans, 2003). Though in the present study both nature preschool and control preschoolers' average scores fell within the normal range on the Strengths and Difficulties Questionnaire, control preschoolers had somewhat higher hyperactivity/inattention scores than children attending nature preschool (Table 3). While we cannot discern directionality of this relationship, it could be that children who are more hyperactive are more likely to be enrolled in a nature preschool perhaps because their families felt they would do better in this environment compared to a more traditional preschool setting. The use of waitlist controls mitigates this concern because if families with children who were more hyperactive/inattentive were more likely to want to enroll in a nature preschool, we would expect that they would be non-differentially distributed based on their enrollment status (enrolled vs. on the waitlist). Alternatively, our finding could be consistent with other literature that reports time in nature reduces attention deficit/ hyperactivity disorder symptoms in children (Amoly et al., 2014a; Faber Taylor & Kuo, 2011; Kuo & Taylor, 2004; van den Berg & van den Berg, 2011). For parent-reported preferences for outdoor time, both total desired and actual active outdoor play time at preschool were higher for nature preschool families. These findings suggest that having a child enrolled in a nature preschool may magnify attitudes and beliefs about how much time parents want their children to be active outdoors during the school day. While nature preschool families reported higher actual active outdoor time than desired outdoor time at school, control families reported lower actual outdoor time than desired. This suggests that while families in the control group valued outside time – their current childcare arrangement may not be providing them the amount of time they would like their children to be outside (Table 5). On both typical school days and on non-school days, nature preschool families reported spending more time being outside while children were not in preschool. This may be due to strengthened attitudes and beliefs that occur as a result of having a child enrolled in a nature preschool. For example, families may become more tolerant of less favorable weather conditions after habituating to a nature preschool environment or develop social relationships and engage in outdoor activities with other families that have children attending the nature preschool.

Strengths of this study include objectively measured physical activity using accelerometry, a robust control group of preschool children who were waitlisted at the nature preschool but in a different childcare setting, and additional assessment of parental supervision attributes, domains of child behavior, parental values and beliefs, and preferences for outdoor activities and weather conditions. In addition, this is the first study evaluating physical activity in an exclusively nature-based outdoor preschool. Given that enthusiasm and legislation for outdoor educational opportunities has accelerated in recent years (North American Association for Environmental Education, n.d.; Washington State Legislature, 2017), evidence regarding the health and behavioral implications of nature-based outdoor preschools could be beneficial for future programs and policies (McCurdy et al., 2010; Tremblay et al., 2015b). There are a number of limitations to this study. First, it was cross-sectional, thus limiting the ability to establish temporality of the relationship between outdoor time and physical activity. Second, the sample size was small, and thus results are exploratory and hypothesis-generating in nature. Third, the study population was highly educated, with approximately 75% of parents in each group completing graduate school. It is possible that more highly educated families prioritize physical activity as part of a healthy family lifestyle. Fourth, we did not track how many of the children in the comparison group were attending the 2-hour outdoor enrichment class offered once per week. It is possible that these children had higher levels of physical activity than they would have if they had been indoors. Nonetheless, given that accelerometers were worn for five consecutive days, it is unlikely that a single 2-hour program dramatically impacted their mean physical activity. Fifth, although our control group was chosen as a mechanism to compare families with similar beliefs and values towards outdoor time, it may be that both groups – independent of preschool enrollment – were highly motivated to engage in outdoor time and thus the reason why MVPA was high in both groups. Lastly, physical activity in children is known to be impacted by seasonality (Shen, Alexander, Milberger, & Jen, 2013; Tucker & Gilliland, 2007). This study was conducted in 2016 from April through June, months that can be more inviting for children to want to be outside. These months were unusually dry compared to historical averages in the study area, though no differences in physical activity were found between groups by weather condition (Table 6). Because outdoor play, by design, is a component of a nature preschool model, there may be differences in overall physical activity based on weather and seasonal conditions compared to traditional indoor preschool models. It is possible that the mild weather led to more MVPA than would normally

occur in the control group, had there been more precipitation and the weather followed a more traditional trajectory.

A Canadian multidisciplinary expert panel conducted two systematic literature reviews and concluded in a position statement that for children aged 3-12 years, "Access to active play in nature and outdoors – with its risks – is essential for healthy childhood development." The group recommended increasing opportunities for active outdoor play in all settings, and made specific recommendations for educators, caregivers, and school and child care administrators (Tremblay et al., 2015b). For childcare and school administrators, the group suggested choosing "natural elements over pre-fabricated playgrounds and play areas." Furthermore, they proposed that children should be: 1) encouraged to play in these natural environments, and 2) given a voice in the design process to ensure that these play spaces facilitate interest in active outdoor play. They advocated for teachers and childcare providers to "regularly embrace the outdoors for learning, socialization and physical activity opportunities, in various weather conditions." These recommendations align with the fundamental philosophy of nature preschools and highlight the need to prioritize active outdoor play - emphasizing natural elements - in early childhood educational settings.

Conclusion

Physical activity is a critical component to health in early childhood; both children attending a nature preschool and children in traditional indoor settings had high levels of MVPA that exceeded the recommendation of 90 minutes per day. Parents of children attending the nature preschool reported more desire for, as well as, actual outdoor playtime at school, and a higher tolerance for their children being outside in inclement weather. This may indicate that having a child in a nature preschool increases the value and commitment to outdoor time and lowers perceived barriers to spending time outdoors. To the best of our knowledge, this is the first study to examine objectively measured physical activity and behavioral health in children attending an exclusively outdoor nature preschool. Future research is needed to examine the longitudinal impact of a nature preschool on objectively measured physical activity, in addition to other potential health benefits of nature preschools in early childhood.

Acknowledgements

The authors thank Avanthi Jayasuriya, Priya Patel, Amanda Marchese and Albert Hsu for their help with study coordination, data collection and management. We are grateful to our community partners and participants for their willingness to be part of this project.

Sources of Funding. Dr. Tandon's time was supported by a Career Development Award from the National Heart, Lung, and Blood Institute (K23: HL112950-0FA1). Dr. Fyfe-Johnson's time was supported by the Washington State University Elson S. Floyd College of Medicine. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

References

- Absoud, M., Cummins, C., Lim, M. J., Wassmer, E., & Shaw, N. (2011). Prevalence and predictors of vitamin D insufficiency in children: a Great Britain population based study. *PLoS One*, 6(7), e22179. <https://doi.org/10.1371/journal.pone.0022179>
- ActiGraph | GT3x+ Activity Monitor. <http://actigraphcorp.com/support/activity-monitors/gt3xplus/>. (n.d.).
- ActiGraph ActiLife: Actigraphy Data Analysis Software Platform. (n.d.). Retrieved from <http://actigraphcorp.com/products/actilife-6/>
- Addy, C. L., Trilk, J. L., Dowda, M., Byun, W., & Pate, R. R. (2014). Assessing Preschool Children's Physical Activity: How Many Days of Accelerometry Measurement. *Pediatric Exercise Science*, 26(1), 103–109. <https://doi.org/10.1123/pes.2013-0021>
- American Academy of Pediatrics, & American Public Health Association. (2011). *Preventing Childhood Obesity in Early Care and Education: Selected Standards from Caring for Our Children: National Health and Safety Performance Standards; Guidelines for Early Care and Education Programs, 3rd Edition*. Retrieved from <http://nrckids.org>

- Amoly, E., Dadvand, P., Fornes, J., López-Vicente, M., Basagaña, X., Julvez, J., ... Sunyer, J. (2014a). Green and blue spaces and behavioral development in Barcelona schoolchildren: the BREATHE project. *Environmental Health Perspectives*, 122(12), 1351–1358. <https://doi.org/10.1289/ehp.1408215>
- Amoly, E., Dadvand, P., Fornes, J., López-Vicente, M., Basagaña, X., Julvez, J., ... Sunyer, J. (2014b). Green and Blue Spaces and Behavioral Development in Barcelona Schoolchildren: The BREATHE Project. *Environmental Health Perspectives*, 122(12), 1351–1358. <https://doi.org/10.1289/ehp.1408215>
- Australia's Physical Activity and Sedentary Behaviour Guidelines. (2014). Retrieved October 22, 2018, from <http://www.health.gov.au/internet/main/publishing.nsf/Content/health-pubhlth-strateg-phys-act-guidelines#npa05>
- Balseviciene, B., Sinkariova, L., Grazuleviciene, R., Andrusaityte, S., Uzdanaviciute, I., Dedele, A., & Nieuwenhuijsen, M. (2014). Impact of Residential Greenness on Preschool Children's Emotional and Behavioral Problems. *International Journal of Environmental Research and Public Health*, 11(7), 6757–6770. <https://doi.org/10.3390/ijerph110706757>
- Bassett, D. R., John, D., Conger, S. A., Fitzhugh, E. C., & Coe, D. P. (2015). Trends in Physical Activity and Sedentary Behaviors of United States Youth. *Journal of Physical Activity and Health*, 12(8), 1102–1111. <https://doi.org/10.1123/jpah.2014-0050>
- Brussoni, M., Gibbons, R., Gray, C., Ishikawa, T., Sandseter, E., Bienenstock, A., ... Tremblay, M. (2015). What is the Relationship between Risky Outdoor Play and Health in Children? A Systematic Review. *International Journal of Environmental Research and Public Health*, 12(6), 6423–6454. <https://doi.org/10.3390/ijerph120606423>
- Burdette, H. L., & Whitaker, R. C. (2005). Resurrecting free play in young children: looking beyond fitness and fatness to attention, affiliation, and affect. *Archives of Pediatrics & Adolescent Medicine*, 159(1), 46–50. <https://doi.org/10.1001/archpedi.159.1.46>
- Burdette, H. L., Whitaker, R. C., & Daniels, S. R. (2004). Parental report of outdoor playtime as a measure of physical activity in preschool-aged children. *Archives of Pediatrics & Adolescent Medicine*, 158(4), 353–357. <https://doi.org/10.1001/archpedi.158.4.353>
- Cleland, V., Crawford, D., Baur, L. A., Hume, C., Timperio, A., & Salmon, J. (2008). A prospective examination of children's time spent outdoors, objectively measured physical activity and overweight. *International Journal of Obesity*, 32(11), 1685–1693. <https://doi.org/10.1038/ijo.2008.171>
- Coombes, E., van Sluijs, E., & Jones, A. (2013). Is environmental setting associated with the intensity and duration of children's physical activity? Findings from the SPEEDY GPS study. *Health & Place*, 20, 62–65. <https://doi.org/10.1016/j.healthplace.2012.11.008>
- Drown, K., & Christensen, K. (2014). Dramatic play affordances of natural and manufactured outdoor settings for preschool-aged children. *Children Youth and Environments*, 24, 53–77.
- Faber Taylor, A., & Kuo, F. (2011). Could exposure to everyday green spaces help treat ADHD? Evidence from children's play settings. *Appl Psychol Health Well Being*, 3(3), 281–303.
- Fjørtoft, I. (2001). The Natural Environment as a Playground for Children: The Impact of Outdoor Play Activities in Pre-Primary School Children. *Early Childhood Education Journal*, 29(2), 111–117.
- Fjørtoft, I. (2004). Landscape as playscape: The effects of natural environments on children's play and motor development. *Children Youth and Environments*, 14(2), 21–44.
- Frumkin, H., Bratman, G. N., Breslow, S. J., Cochran, B., Kahn Jr, P. H., Lawler, J. J., ... Wood, S. A. (2017). Nature Contact and Human Health: A Research Agenda. *Environmental Health Perspectives*, 125(7), 075001. <https://doi.org/10.1289/EHP1663>
- Goodman, R. (1997). The Strengths and Difficulties Questionnaire: a research note. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, 38(5), 581–586. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/9255702>
- Gray, C., Gibbons, R., Larouche, R., Sandseter, E., Bienenstock, A., Brussoni, M., ... Tremblay, M. (2015). What Is the Relationship between Outdoor Time and Physical Activity, Sedentary Behaviour, and Physical Fitness in Children? A Systematic Review. *International Journal of Environmental Research and Public Health*, 12(6), 6455–6474. <https://doi.org/10.3390/ijerph120606455>
- Healy, G. N., Dunstan, D. W., Salmon, J., Cerin, E., Shaw, J. E., Zimmet, P. Z., & Owen, N. (2008). Breaks in Sedentary Time: Beneficial associations with metabolic risk. *Diabetes Care*, 31(4), 661–666. <https://doi.org/10.2337/dc07-2046>
- Heerwagen, J., & Orians, G. (2002). The Ecological World of Children. In *Children and nature: Psychological,*

sociocultural, and evolutionary investigations (pp. 29–64).

- Herrington, S., & Brussoni, M. (2015). Beyond Physical Activity: The Importance of Play and Nature-Based Play Spaces for Children's Health and Development. *Current Obesity Reports*, 4(4), 477–483. <https://doi.org/10.1007/s13679-015-0179-2>
- Hinkley, T., Crawford, D., Salmon, J., Okely, A. D., & Hesketh, K. (2008). Preschool Children and Physical Activity. *American Journal of Preventive Medicine*, 34(5), 435–441.e7. <https://doi.org/10.1016/j.amepre.2008.02.001>
- JACKSON, R. J. J., TESTER, J., & Henderson, S. W. (2008). Environment Shapes Health, Including Children's Mental Health. *Journal of the American Academy of Child & Adolescent Psychiatry*, 47(2), 129–131. <https://doi.org/10.1097/chi.0b013e31815d6944>
- Jayasuriya, A., Williams, M., Edwards, T., & Tandon, P. (2016). Parents' perceptions of preschool activities: exploring outdoor play. *Early Education and Development*, 27(7), 1004–1017. <https://doi.org/10.1080/10409289.2016.1156989>
- Kellert, S. (2012). *Building for Life: Designing and understanding the human-nature connection*. Retrieved from <https://islandpress.org/book/building-for-life>
- Kenny, E. (2013). *Forest Kindergartens: The Cedar Song Way* (1st ed.). Vashon: Cedar Song Nature School.
- Kneeshaw-Price, S., Saelens, B. E., Sallis, J. F., Glanz, K., Frank, L. D., Kerr, J., ... Cain, K. L. (2013). Children's objective physical activity by location: why the neighborhood matters. *Pediatric Exercise Science*, 25(3), 468–486. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/23877357>
- Kuo, F. E., & Taylor, A. F. (2004). A potential natural treatment for attention-deficit/hyperactivity disorder: evidence from a national study. *American Journal of Public Health*, 94(9), 1580–1586. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/15333318>
- Lachowycz, K., & Jones, A. P. (2011). Greenspace and obesity: a systematic review of the evidence. *Obesity Reviews: An Official Journal of the International Association for the Study of Obesity*, 12(5), e183–9. <https://doi.org/10.1111/j.1467-789X.2010.00827.x>
- Lachowycz, Kate, Jones, A. P., Page, A. S., Wheeler, B. W., & Cooper, A. R. (2012). What can global positioning systems tell us about the contribution of different types of urban greenspace to children's physical activity? *Health & Place*, 18(3), 586–594. <https://doi.org/10.1016/j.healthplace.2012.01.006>
- Larimore, R. (2016). Defining Nature-Based Preschools. *The International Journal of Early Childhood Environmental Education*, 4(1), 32–36.
- Larouche, R., Garriguet, D., Gunnell, K. E., Goldfield, G. S., & Tremblay, M. S. (2016). Outdoor time, physical activity, sedentary time, and health indicators at ages 7 to 14: 2012/2013 Canadian Health Measures Survey. *Health Reports*, 27(9), 3–13. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/27655167>
- Lipnowski, S., Leblanc, C. M., & Canadian Paediatric Society, Healthy Active Living and Sports Medicine Committee. (2012). Healthy active living: Physical activity guidelines for children and adolescents. *Paediatrics & Child Health*, 17(4), 209–212. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/23543633>
- Little, H., & Wyver, S. (2008). Outdoor Play: Does Avoiding the Risks Reduce the Benefits. *Australian Journal of Early Childhood*, 33(2), 33–40.
- Louv, R. (2008). *The Genius of Childhood: How Nature Nurtures Creativity, in Last child in the woods: Saving our children from nature-deficit disorder*. Algonquin Books.
- Lubans, D. R., Morgan, P. J., Cliff, D. P., Barnett, L. M., & Okely, A. D. (2010). Fundamental Movement Skills in Children and Adolescents. *Sports Medicine*, 40(12), 1019–1035. <https://doi.org/10.2165/11536850-000000000-00000>
- Lubans, D., Richards, J., Hillman, C., Faulkner, G., Beauchamp, M., Nilsson, M., ... Biddle, S. (2016). Physical Activity for Cognitive and Mental Health in Youth: A Systematic Review of Mechanisms. *Pediatrics*, 138(3). <https://doi.org/10.1542/peds.2016-1642>
- Markevych, I., Tiesler, C. M. T., Fuertes, E., Romanos, M., Davvand, P., Nieuwenhuijsen, M. J., ... Heinrich, J. (2014). Access to urban green spaces and behavioural problems in children: Results from the GINIplus and LISAplus studies. *Environment International*, 71, 29–35. <https://doi.org/10.1016/j.envint.2014.06.002>
- McCurdy, L. E., Winterbottom, K. E., Mehta, S. S., & Roberts, J. R. (2010). Using Nature and Outdoor Activity to Improve Children's Health. *Current Problems in Pediatric and Adolescent Health Care*, 40(5), 102–117. <https://doi.org/10.1016/j.cppeds.2010.02.003>
- Mellor, D. (2004). Furthering the use of the strengths and difficulties questionnaire: reliability with younger child respondents. *Psychological Assessment*, 16(4), 396–401. <https://doi.org/10.1037/1040-3590.16.4.396>
- MeterPlus Software Support for Actigraph*. (n.d.). Retrieved from <http://www.meterplussoftware.com/>

- Morrongiello, B. A., & Corbett, M. (2006). The Parent Supervision Attributes Profile Questionnaire: a measure of supervision relevant to children's risk of unintentional injury. *Injury Prevention, 12*(1), 19–23. <https://doi.org/10.1136/ip.2005.008862>
- National Oceanic and Atmospheric Administration. (n.d.). Retrieved August 11, 2018, from <http://www.nws.noaa.gov>
- North American Association for Environmental Education. (n.d.). Nature Start Alliance: Nature Preschools. Retrieved from <http://naturalstart.org/nature-preschool>
- Pate, R. R., Almeida, M. J., McIver, K. L., Pfeiffer, K. A., & Dowda, M. (2006). Validation and Calibration of an Accelerometer in Preschool Children*. *Obesity, 14*(11), 2000–2006. <https://doi.org/10.1038/oby.2006.234>
- PATE, R. R., O'NEILL, J. R., & MITCHELL, J. (2010). Measurement of Physical Activity in Preschool Children. *Medicine & Science in Sports & Exercise, 42*(3), 508–512. <https://doi.org/10.1249/MSS.0b013e3181cea116>
- Pellegrini, A. D., & Smith, P. K. (1998). Physical activity play: the nature and function of a neglected aspect of playing. *Child Development, 69*(3), 577–598. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/9680672>
- Puyau, M. R., Adolph, A. L., Vohra, F. A., & Butte, N. F. (2002). Validation and Calibration of Physical Activity Monitors in Children. *Obesity Research, 10*(3), 150–157. <https://doi.org/10.1038/oby.2002.24>
- R Core Team. (2017). R: A language and environment for statistical computing (version 3.4.0). *R Foundation for Statistical Computing, Austria, Vienna*.
- Saunders, T. J., Tremblay, M. S., Mathieu, M.-È., Henderson, M., O'Loughlin, J., Tremblay, A., ... QUALITY cohort research group. (2013). Associations of sedentary behavior, sedentary bouts and breaks in sedentary time with cardiometabolic risk in children with a family history of obesity. *PLoS One, 8*(11), e79143. <https://doi.org/10.1371/journal.pone.0079143>
- Schaefer, L., Plotnikoff, R. C., Majumdar, S. R., Mollard, R., Woo, M., Sadman, R., ... McGavock, J. (2014). Outdoor Time Is Associated with Physical Activity, Sedentary Time, and Cardiorespiratory Fitness in Youth. *The Journal of Pediatrics, 165*(3), 516–521. <https://doi.org/10.1016/j.jpeds.2014.05.029>
- Shen, B., Alexander, G., Milberger, S., & Jen, K.-L. C. (2013). An exploratory study of seasonality and preschoolers' physical activity engagement. *Journal of Physical Activity & Health, 10*(7), 993–999. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/23136385>
- Sobel, D. (2015). *Nature Preschools and Forest Kindergartens: The Handbook for Outdoor Learning*. Saint Paul, MN.
- Sobel, S. (2014). Learning to Walk Between the Raindrops: The Value of Nature Preschools and Forest Kindergartens. *Children, Youth and Environments, 24*(2), 228–238.
- Söderström, M., Boldemann, C., Sahlin, U., Mårtensson, F., Raustorp, A., & Blennow, M. (2013). The quality of the outdoor environment influences children's health - a cross-sectional study of preschools. *Acta Paediatrica, 102*(1), 83–91. <https://doi.org/10.1111/apa.12047>
- Stata Corp. (2015). *Stata/SE 14. StataCorp, College Station, TX*.
- Stephenson, A. (2003). Physical Risk-taking: Dangerous or Endangered? *Early Years, 23*(1), 35–43.
- Strengths and Difficulties Questionnaire: Scoring Website*. (n.d.). Retrieved from www.sdqscore.org
- Tandon, P. S., Saelens, B. E., & Christakis, D. A. (2015). Active play opportunities at child care. *Pediatrics, 135*(6), e1425–31. <https://doi.org/10.1542/peds.2014-2750>
- Tandon, P. S., Zhou, C., & Christakis, D. A. (2012). Frequency of parent-supervised outdoor play of US preschool-aged children. *Archives of Pediatrics & Adolescent Medicine, 166*(8), 707–712. <https://doi.org/10.1001/archpediatrics.2011.1835>
- Taylor, A., Kuo, F., & Sullivan, W. (2002). Views of Nature and Self-Discipline: Evidence From Inner City Children. *Journal of Environmental Psychology, 22*, 49–63.
- Taylor, A., Wiley, A., Kuo, F., & Sullivan, W. (1998). Growing up in the inner city: Green spaces as places to grow. *Environment and Behavior, 30*(1), 3–27.
- Tremblay, M., Gray, C., Babcock, S., Barnes, J., Bradstreet, C., Carr, D., ... Brussoni, M. (2015a). Position Statement on Active Outdoor Play. *International Journal of Environmental Research and Public Health, 12*(6), 6475–6505. <https://doi.org/10.3390/ijerph120606475>
- Tremblay, M., Gray, C., Babcock, S., Barnes, J., Bradstreet, C., Carr, D., ... Brussoni, M. (2015b). Position Statement on Active Outdoor Play. *International Journal of Environmental Research and Public Health, 12*(6), 6475–6505. <https://doi.org/10.3390/ijerph120606475>
- Tucker, P., & Gilliland, J. (2007). The effect of season and weather on physical activity: A systematic review. *Public Health, 121*(12), 909–922. <https://doi.org/10.1016/j.puhe.2007.04.009>

- United Kingdom Physical Activity Guidelines. (n.d.). Retrieved October 22, 2018, from <https://www.gov.uk/government/publications/uk-physical-activity-guidelines>
- van den Berg, A. E., & van den Berg, C. G. (2011). A comparison of children with ADHD in a natural and built setting. *Child: Care, Health and Development*, 37(3), 430–439. <https://doi.org/10.1111/j.1365-2214.2010.01172.x>
- Warden, C. (2015). *Learning With Nature: Embedding Outdoor Practice* (1st ed.). London: Sage.
- Washington State Legislature. (2017). *Outdoor, nature-based early learning and child care programs—Pilot project*. Retrieved from <http://app.leg.wa.gov/RCW/default.aspx?cite=43.215.566>
- Wells, N., & Evans, G. (2003). Nearby Nature: A buffer of life stress among rural children. *Environment and Behavior*, 35(3), 311–330.
- Xiong, S., Sankaridurg, P., Naduvilath, T., Zang, J., Zou, H., Zhu, J., ... Xu, X. (2017). Time spent in outdoor activities in relation to myopia prevention and control: a meta-analysis and systematic review. *Acta Ophthalmologica*, 95(6), 551–566. <https://doi.org/10.1111/aos.13403>

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