The Feasibility and Impact of a Painted Designs Intervention on School Children's Physical Activity

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Abstract

Interventions such as painted designs on school tarmacs may increase children's physical activity during school hours. This mixed-methods study examined the influence of a painted designs (e.g., traditional games, random circles) intervention on the physical activity experiences of elementary school children. Systematic observations and accelerometer data were collected to evaluate the type and quantity of student physical activity. Interviews were used to explore teacher and student experiences. Observed physical activity was not significantly different between intervention and control schools ($t(43) = 0.22$, $p = 0.83$), and children at the intervention schools undertook less physical activity (steps, moderate, vigorous, and combined moderate-to-vigorous activity) as compared with the control school ($t = 2.71$-4.35, $p < 0.05$). Teachers and students commented that the painted designs were confusing but held potential for inclusiveness, physical activity, and learning. Additional resources and instruction may assist in better use of painted designs for physical activity and academic learning.

Keywords: painted designs; physical activity; school children; mixed methods

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Many children fall short of the 150 minutes of moderate to vigorous physical activity (MVPA) recommended per week for optimal health (Ekelund et al., 2011). Furthermore, parents/ guardians and other adults responsible for supervising children, such as teachers, may structure the types and/or forms of physical activity that children are allowed to partake in, resulting in less unstructured physical activity, also known as play (Brussoni et al., 2015; Little, 2006). However, play has been linked to many developmental benefits, including fostering resiliency and creativity (Ginsburg, 2007; Milteer et al., 2012), confidence (Nelson et al., 2005), and decision-making and critical-thinking skills (Ginsburg, 2007). Giving children the freedom to self-select the forms of activity or play they engage in is associated with MVPA (e.g., Gray et al., 2015; Pate et al., 1996; Stratton & Mullan, 2005; Tremblay et al., 2015).

As children spend a significant portion of their day in schools, school-based physical activity interventions are a potential avenue for increasing children's physical activity (Taylor et al., 2011). Improved academic outcomes have also been found in youth who are more physically active during and after school (Bezold et al., 2014). According to the social ecological model, physical activity is influenced by a wide variety of determinants. These can be conceptualized as individual (e.g., physical skills), social (e.g., inclusion by peers), environmental (e.g., playground facilities), and policy (e.g., rules and regulations affecting play), and their interactions (Bronfrenbrenner & Morris, 1998; Sallis & Owen, 2015). Therefore, interventions that target the physical environment at schools have the potential to affect physical activity. Examining the interplay between such environmental interventions and the individual, social, and policy levels is important for understanding how interventions work as well as the potential avenues for

improvement.

The primary focus in this study was on interventions at the physical environment level, and how they occur in context with the social level. Playground environments at schools can be used in a variety of ways at recess, during physical education classes, and after school hours. Schools located within western countries mandate recess periods, which can allow children to reach up to 40% of the recommended daily physical activity (Ridgers et al., 2006). The quantity and variety of play equipment available (Verstraete et al., 2006) and the size of the playground in relation to the student population (Delidou et al., 2015) can affect children's physical activity levels. Linked or closely positioned play structures and areas allow for play to flow between areas and structures and can increase children's cooperative play and interactions (Barbour, 1999; Kuh, 2014; Yuill et al., 2007) while peers can influence the intensity of activity (Salvy et al., 2008). This suggests that there are multiple factors that can influence physical activity frequency and intensity within a school environment. Studies examining school playgrounds have shown moderate evidence for the contention that providing play equipment improves MVPA among primary and secondary school children, although the effect of playground markings (e.g., painted designs, including games such as hopscotch and four square or more abstract designs) has been mixed (Broekhuizen et al., 2014). Proximity of children's homes to parks and playgrounds, the availability of equipment and activity structures at their schools, and playground markings have also been found to be associated with greater physical activity in several studies (Davison & Lawson, 2006).

Painted designs have been positioned as a cost-effective way to increase children's physical activity levels (e.g., Ridgers et al. 2006; Stratton & Mullan, 2005). Research on this effect, however, has produced mixed results. Several physical activity interventions have found

that painted designs positively influence elementary school children's physical activity levels, especially in boys (Blaes et al., 2013; Loucaides et al., 2009; Stratton & Mullan, 2005). However, a physical activity intervention with pre-school children found that providing playground markings or play equipment was not sufficient for increasing activity levels (Cardon et al., 2009). Furthermore, one study suggested positive effects on physical activity may be limited to a novelty effect, wherein increases in activity levels may begin to taper off after six months and return to baseline levels after a year (Ridgers et al., 2010).

While the small body of research on painted designs, playgrounds, and children's physical activity levels provide important insights, most studies assess effects immediately after implementation of the painted designs. Qualitative methodologies may be useful for examining child and teacher perspectives on painted design interventions and their experiences with how they are used, which is important for understanding the effects of painted designs intervention within the context of the multiple levels of determinants of physical activity. Additionally, none have focused on the Canadian context, which can provide unique challenges such as inclement weather. The purpose of this quasi-experimental mixed methods pilot study was to assess the feasibility and impact of a school-based painted designs initiative on the physical activity of elementary school students in Calgary, Alberta, Canada approximately 16-months after implementation. We hypothesized that children in schools that received the painted designs would show higher levels of MVPA compared with children in schools that did not receive the painted designs. We expected that qualitative responses from children and teachers would provide useful insights for understanding how and why painted designs may affect physical activity behaviour, and ideas for improving future interventions.

Methods

Methodology

We adopted a parallel mixed methods approach with a pragmatic philosophy, which posits that experiences are embedded in social context, the links between actions and consequences can change over time and context, and action depends on socially shared beliefs (Morgan, 2014). Pragmatic research focuses on understanding the nature of experience, shared beliefs, and actions, and espouses selecting research methods based on their ability to address the research question, even if those methods come from varying philosophical perspectives (Morgan, 2014). Based on this philosophy, we selected methods that would provide insight into children's play behaviours. For the quantitative component we used a cohort study design, collecting data using systematic observation and physical activity monitoring devices. Qualitative data were gathered through photo-elicitation-based focus groups and semi-structured interviews. We used an additional coverage approach, whereby the qualitative and quantitative methods were used concurrently to address different facets of the overarching research question (Morgan, 2014).

Context

In September 2016, as part of a community initiative, volunteer teams used pre-made stencils to spray paint different designs on tarmac surfaces at local elementary schools. Forty-five schools participated in this initiative with the painted designs being self-selected by school administrators. The designs were meant to facilitate children's physical activity through traditional games/activities (e.g., hopscotch, left-right-out, bulls-eye toss, four square) as well as unstructured play (e.g., random circles of different colours and sizes). Once the painted designs were in place, workshops were provided by representatives of a government-funded health promotion organization to school staff on how to make use of the painted designs during recess,

lunch, and physical education classes. School staff were also provided with an instructional booklet suggesting activities/games that make use of the painted designs. This community initiative provided the impetus for this research project; the research began approximately 16-months after the painted designs were completed.

Procedure and Participants

Ethical approval was obtained from the university (REB16-2541) and two local school boards. Permission was sought from school administrators to recruit from schools that had received the painted designs and schools that had not, with a goal of obtaining four schools from each scenario, based on the timeframe of the study, availability of accelerometers, and what was determined as a viable number for data analysis purposes. A list of intervention and control schools that matched the inclusion criteria was compiled and applicable school administrators were contacted (by email and then by phone), one-by-one for each group. Many schools did not respond to the recruitment request; that, combined with timing of the research, resulted in the participation of three schools that had received the intervention and one school that had not. All four schools offered Grades 1 to 6. One intervention school was located in the central core of the city while the other two intervention schools and the control school were located outside the core, in what would typically be defined as the "suburbs". All had similar physical typologies in terms of the location of the school building, the tarmac play area, and the turf.

Once schools were confirmed, consent/assent packages were distributed at the beginning of the school year to grade 1-4 students in all schools that provided permission to recruit participants for the study. A total of 85 consent/assent packages were returned, with the following breakdown across intervention and control schools, and by grade: Intervention condition: n=69 students, Grade 1 n=13, Grade 2 n=17, Grade 3 n=18, Grade 4 n=21; Control

condition: *n*=16 students, Grade 1 *n*=6, Grade 2 *n*=2, Grade 3 *n*=3, Grade 4 *n*=5. Not all consented/assented students participated in all parts of the data collection, which is explained further in the following sections. Teacher participants included five teachers who taught at one of the three schools that had received the painted designs. At the time of interviews, teachers taught grades 2-6 and ranged in teaching experience from 1-24 years.

Quantitative data were collected at all four schools. Focus groups and interviews were conducted at the three intervention schools. The order and spacing of data collection were influenced by the needs of each school, as well as weather (for the observations); a timeline of all data collection at the four schools is in Table 1.

Insert Table 1 here

Systematic Observations

The System for Observing Play and Leisure Activities (SOPLAY) was used to systematically observe physical activity and determine the frequency and intensity of activity on the school playgrounds. SOPLAY is a valid, reliable, and objective method of coding physical activity behaviours (McKenzie et al., 2000; Saint-Maurice et al., 2011).

For the present study, aerial views of the playgrounds were obtained using Google Maps to define four target areas: (1) tarmac with painted designs, (2) tarmac with basketball hoops and open "free" space, (3) playground structure, and (4) field. SOPLAY observations were then performed at all four schools by eight trained observers blind to the study objectives. All eight observers participated in a 6-hour training session including instruction and practice coding. Observers obtained the standard 85% agreement with the trained instructor prior to conducting observations (McKenzie et al., 2000). Checks were also completed on randomly selected observation days to ensure at least 85% agreement was maintained throughout data collection.

All schools offered morning and lunch breaks (what is referred to as a "balanced" school day). For the present project, observations occurred during lunch recess on three days in the same week between May and June 2018. Pairs of observers completed 75-second scans from each of two viewpoints at opposing corners of a target area before rotating to the next target area. Counts of children who were sedentary, moderately active, or vigorously active based on momentary time-sampling were recorded. Observers also recorded the most common activity taking place in each target area and took field notes to contextualize activities. The observations of all four target areas took 20 minutes to complete. Two observations teams of two each completed two independent scans per target zone; observation pairs completed their scans, compared counts, and averaged counts if different.

There were some anomalies or challenges in collecting the systematic observation data, due to the realities of collecting this type of data *in situ*. In two instances (control school and intervention school 3), schools had split lunches (i.e., Grades 1, 2, and 3 had 25-minutes of recess, followed by 25-minutes for Grades 4, 5, and 6). Two full rotations of observations were completed at these schools to capture all children, and a sum of the two sets of scans was used in the analyses. Intervention schools 1 and 2 had shorter lunch recesses; therefore, two target areas were only observed once. Intervention school 1 also began lunch recess early one day, so only one round of observations occurred. One school (intervention school 2) was re-constructing their fixed playground structure and as such no observations were recorded for this target area. These data were treated as missing. As scans were independent of one another, data were not manipulated to account for missing data in target areas. Finally, students in higher grades (i.e., Grades 5 and 6) were also sometimes on the playground during these recess periods. Nevertheless, we believe the data collected provides an overall sense of physical activity at

recess in the four participating schools, as well as the types of activities students were doing, including the students who were participating in the accelerometer and/or focus groups parts of the study.

Sedentary (e.g., sitting down or standing still, individually or in groups), moderate activity (e.g., walking), and vigorous activity (e.g., playing soccer or basketball, using the painted designs or physical structures) scores were calculated as the sum of the counts of each scan for that type of activity in each target area for each observation day (e.g., number of children engaging in sedentary activity on all four scans). To calculate total activity in each target area for each observation day, walking and vigorous activity scores were summed (Saint-Maurice et al., 2011). Proportion of sedentary and active children was calculated as the ratio of sedentary (or total) activity per total number of children observed (i.e., sum of sedentary and total activity). Proportion of sedentary and active children in each area on each day were used in subsequent analyses.

Accelerometer-measured Physical Activity

Accelerometers (Actigraph® wGT3X-BT) captured daily bouts and time spent in physical activity as well as steps. Accelerometers are more accurate than self-report questionnaires in capturing the episodic and sporadic nature of children's physical activity, including play (Ott et al., 2000). Furthermore, accelerometers are not prone to reporting errors (Sallis & Saelens, 2000).

Accelerometers were initialized with a sampling rate of 100 Hz and 1-second epoch using ActiGraph® software (ActiLife®, Version 6.13.3). Non-wear time was defined using a zero-count threshold (90-minutes of consecutive zero counts with an allowance of two minutes on either side of the interval) and an upstream or downstream 30-minute consecutive zero-count

window to identify artifactual movement (Choi et al., 2011). Valid wear time was defined as a minimum of 360 minutes per day for a minimum of two days (Rich et al., 2013). Children-specific cut-points were used to classify moderate-intensity physical activity (MPA) and vigorous-intensity physical activity (VPA) (Freedson et al., 2005). All initialization and data processing were completed for the seven-day wear period as well as for school days only.

Twenty accelerometers were available for use for the present study. As such, a rolling schedule was developed whereby each participating school was designated one-week for accelerometer wear (see Table 1). Based on the number of available accelerometers and the rolling schedule, 80 of the 85 children who were consented/assented to participate in the study writ large could have participated in this mode of data collection. However, prior to distribution of the accelerometers at each of the schools a short presentation was given, which resulted in a total of 58 children (n=42 at the intervention schools, n=16 at the control school) agreeing at that time to take the accelerometer and wear it for seven days.

At two intervention schools and at the control school, there were fewer participants than accelerometers; thus, all children were included. At the one intervention school where there were more willing participants than accelerometers, participants were assigned a number and then a random number generator was used to select five students from each of Grades 1, 2, 3, and 4, for a total of 20 participants. A research team member demonstrated correct use of the accelerometers and provided participants with an information sheet. Participants were instructed to wear the accelerometer (fitted on an elastic belt) on the right hip for seven consecutive days, only removing it during water-based activities. Ultimately, of the 58 participants who wore an accelerometer, n = 45 participants had valid data for the 7-day wear period (week and weekend days), and n = 44 had valid school day data; valid data included at least 2-days and at least 6-

hours/day of accelerometer wear time.

Focus Groups

Photo-elicitation techniques were used at the three schools with painted designs. Using photo-elicitation-based techniques in focus groups may reduce intimidation for children (Leonard & McKnight, 2015), allowing them to collaborate and interact with each other.

For the present study, students were asked to document their experiences of play and use of the painted designs during a lunch or recess break. Cameras were distributed and students were instructed on how to use the cameras. Cameras were returned and a selection of each participant's pictures was printed and then used for discussion prompts in focus groups, to help children describe the meanings associated with their photos (Phoenix & Rich, 2019). Selection of pictures was determined by a few factors, including content and quality of images. With respect to the latter, blurry images were not chosen. With respect to the former, pictures that were felt by the researchers to best represent the various painted designs available at the school were chosen first. Images representing different experiences of play more generally in the school playground were also selected for discussion. Images that included a primary focus on play but bearing distinguishing features of children were blurred to maintain privacy. Photos that focused on other people primarily, were not chosen. Finally, photos were not used as data (i.e., were not analyzed, are not included in publications) for privacy reasons and in accordance with school policies.

Focus groups were held on a subsequent date at the schools, within one or two weeks of the pictures being taken. A total of five focus groups were conducted, with six children in each group, for a total of 30 child participants in this form of data collection. Based on consent/assent, in two of the schools all focus group participants also participated in the accelerometer portion of data collection; in the third school, the focus group participants were different from the

participants who wore accelerometers in attempt to include as many consented/assented children in the research as possible. During the focus groups, children were asked to indicate pictures that best captured their experiences with the painted designs and then to share their thoughts about those pictures. Specifically, children were asked what they liked and/or disliked about the painted designs as well as what improvements could be made. The focus groups also included questions about when and how children used the playground in general. One to two research team members conducted focus groups in private locations at the schools. Focus groups lasted 30-minutes in length and were audio-recorded; members of the research team transcribed the focus groups verbatim.

Interviews

Five teachers across the three intervention schools consented to be interviewed; they were approached based on the recommendation of school principals because they had knowledge of and experience with the painted designs. The teachers participated in one semi-structured interview, which took place at their school, during the same week that another aspect of data collection was taking place at the same school (See Table 1). The interviews lasted between 30 and 50 minutes and were audio recorded. The interview guide included questions about teachers' perceptions of the painted designs, student physical activity as it pertained to the painted designs, and the teachers' experiences using the painted designs resource booklet.

Data Analysis

Each set of data was analyzed independently, per the specific details in the following sections. Once all analyses were completed across the quantitative and qualitative data, the various results were mixed or put into discussion with one another to interpret our findings. The interpretation of findings was guided by our philosophical approach to the study as well as the

social ecological model and research on the playground built environment.

Systematic Observations

Due to the small sample size, the primary focus for the observational data collected was on reporting descriptive statistics regarding the proportion of children engaged in physical activity in each target area, in both the intervention and control schools. We also explored whether there were statistically significant differences in observed levels of physical activity using a 2 (condition) X 4 (number of target areas) analysis of variance (ANOVA). Tukey post-hoc analyses was employed to discern where any significant differences in activity level between the intervention and control schools, and between the four target areas. All analyses were run using IBM SPSS Statistics (Version 25). Significance was set at $\alpha = 0.05$. To assess for normality, we examined the skew and kurtosis of the histograms. Examination of the histograms and skewness values indicated that the data displayed some kurtosis. A significant Shapiro-Wilk Test of Normality ($p < 0.001$) further confirmed that the data set was not normally distributed. Levene's Test of Equality of Error Variance also demonstrated that the data were heteroskedastic ($p = 0.01$). These findings were likely due to two specific observations yielding a 0% score, wherein no children were engaging in one of the target zones during two observations. Upon the removal of the two outliers, both the Test of Normality and Levene's Test of Equality of Variance were no longer significant ($p = 0.41$ and $p = 0.08$, respectively). Given that the 0% observations were plausible and meaningful values, they were retained in the main analyses, but the results should be interpreted with caution given the deviation from normality.

Accelerometer-Measured Physical Activity

Independent t-tests were used to identify significant differences ($p<.05$) in accelerometer outcomes captured for 7-days and for school days only between the control and intervention

schools (combined). Primary accelerometer outcomes included: days worn, wear time, MPA, VPA, and MVPA minutes/day, and steps/day. One case from Intervention School 3 was excluded from the analysis involving school days, as they provided accelerometer data for Saturday and Sunday only. All variables derived from the accelerometer data were considered to be normally distributed (except for "days worn"). Levene's Test of Equality of Variances was only significant for "Vigorous physical activity (minutes/day)" in the 7-day sample, in which case we reported findings from the independent t-test for this variable based on the corrected p-value (p=0.004). We also verified to see whether the hypothesis testing was sensitive to the distribution of the accelerometer variables by repeating all analysis using independent samples Mann-Whitney U tests. We found the same results in terms of statistically significant differences between the intervention and control groups. We therefore reached the same conclusions regardless of whether we used the parametric or non-parametric tests.

Focus Groups and Interviews

Thematic analysis (Braun & Clarke, 2006; Braun et al., 2019) was used to identify themes from participant responses by (1) familiarization through successive readings and making notes, (2) generating initial codes based on similar ideas and patterns, (3) combining similar or relevant codes to reflect potential themes, (4) reviewing the themes in relation to their codes and the data, (5) defining and naming themes, and then (6) producing a report. The first author completed the analysis of the focus groups, and the fourth author completed the analysis of the interviews prior to combining the results in a collaborative consensus process. Feedback was sought from the rest of the research team throughout analysis.

Results

Systematic Observations

Proportions of children engaged in physical activity can be found in Table 2. Descriptive analyses of the observational data demonstrated that over 50% of children were participating in active forms of physical activity in all four areas in both intervention and control schools (range = 52.16-70.00%). For the intervention schools, the highest proportion of engagement in physical activity was found in the playground structure (70.00%) while the lowest rates were found for the designs (52.16%). The control school tarmac area had slightly higher rates of physical activity than most of the other areas (69.94%) and the playground structure had the lowest rates at 56.96%. The overall 2 (condition) x 4 (target area) ANOVA was not significant ($F(3, 37) = 0.75$, $p = 0.53$, $\eta_p^2 = 0.06$). An independent Student's t-test found no significant difference between the control and intervention schools in the amount of physical activity being engaged in by students ($t(43) = 0.22$, $p = 0.83$). Pairwise comparisons of the target areas found no significant difference in the activity levels being produced across all four zones ($F(3, 37) = 0.55$, $p = 0.65$, $\eta_p^2 = 0.04$) (Figure 1).

Insert Table 2 here

Insert Figure 1 here

Accelerometer-estimated Physical Activity

There were no significant differences between the intervention and control schools in accelerometer wear time or days worn for the 7-day wear period (Wear time: Intervention $M = 93.44$, $SD = 53.66$ minutes; Control $M = 112.83$, $SD = 45.30$ minutes, $t(43) = 1.15$, $p = 0.26$; Days worn: Intervention $M = 5.16$, $SD = 1.85$ days; Control $M = 5.92$, $SD = 1.66$ days, $t(43) = 1.30$, $p = 0.20$) or for school days only (Wear time: Intervention $M = 73.98$, $SD = 32.90$ minutes; Control $M = 81.49$, $SD = 31.21$ minutes, $t(42) = 0.70$, $p = 0.49$; Days worn: Intervention $M = 4.19$, $SD = 0.98$ days; Control $M = 4.23$, $SD = 1.17$ days, $t(42) = 0.11$, $p = 0.9$) (Table 3).

Compared with the control school, participants in the three schools that had painted lines undertook fewer minutes of MPA and VPA for the 7-day period (MPA: Intervention $M = 108.63$, $SD = 27.24$; Control $M = 133.09$, $SD = 28.09$, $t(43) = 2.71$, $p = 0.01$; VPA: Intervention $M = 28.34$, $SD = 8.25$; Control $M = 39.27$, $SD = 12.02$, $t(43) = 3.51$, $p < 0.01$) and on school days (MPA: Intervention $M = 109.45$, $SD = 27.84$; Control $M = 142.06$, $SD = 30.57$, $t(42) = 3.44$, $p < 0.01$; VPA: Intervention $M =28.28$, $SD = 8.41$; Control $M = 42.10$, $SD = 12.97$, $t(42) = 4,2$, $p < 0.01$).

In addition, compared with the control school, participants in the three schools that had the painted designs undertook significantly fewer MVPA minutes/day and steps/day during the 7-day wear period (MVPA: Intervention $M = 136.98$, $SD = 33.62$ minutes/day; Control $M = 172.36$, $SD = 36.83$ minutes/day, $t(43) = 3.12$, $p < 0.01$; Steps/day: Intervention $M = 7961.66$, $SD = 2025.68$ steps/day; Control $M = 10427.81$, $SD = 1973.39$ steps/day, $t(43) = 3.73$, $p < 0.01$) and when examining school days only (MVPA: Intervention $M = 137.73$, $SD = 34.50$ minutes/day; Control $M = 184.16$, $SD = 39.82$ minutes/day, $t(42) = 3.89$, $p < 0.01$; Steps/day: Intervention $M = 8021.03$, $SD = 2096.90$ steps/day; Control $M = 11067.38$, $SD = 2179.82$ steps/day, $t(42) = 4.35$, $p <0.01$) (Table 3).

Insert Table 3 here

Focus Groups and Interviews

As might have been expected given the differences in populations and perspectives, thematic analysis revealed some differences between the student focus groups and the teacher interviews; however, there were also many similar perspectives that emerged. Given their predominance across conversations with children and teachers, our analysis identified themes addressing the influence of school policies and practices on design usage, confusion, and

inclusiveness.

School Policies and Practices and Design Use

School policies and existing equipment and infrastructure influenced how and where children played. Several schools designated specific days for certain grades to use the playground to reduce the risk of accidents and injuries. When it was not their scheduled playground day, children expressed having to find other places to play that were not often their preferred choice. The painted designs were more attractive at these times, as were field games.

> *Interviewer: So, when you can't use the playground, what else or where else do you guys play? Child 15: Uh soccer field. Child (unidentifiable): Mmhmm [agrees] Child 4: We play all around. Child 17: We play hopscotch. Interviewer: So, you play hopscotch? Do you use the lines on the tarmac? Child 17: Yes.*

Some schools utilized different sets of doors for children to enter and exit the school to alleviate congestion. Teachers noted that the location of the painted designs in relation to the school doors that children used during recess/lunch blocks might have influenced children's use of the painted designs, as the school doors were not always near the designs themselves.

> *I think also, because they're [the designs] located in like the Grade 3, 4, 5, 6 section versus where the Grade 1s and 2s come out their doors. So, it's just less obvious for them. And because we tell them to sort of stick together and play with kids your own age and not play with the Grade 6s then they kind of just learn to stick over there, "This is my zone, that's their zone" (Teacher 2)*

Furthermore, some teachers mentioned that some of the painted designs were close to basketball courts and nets, leading to busy areas and rogue balls. Younger children tended to stay away due to fear of being hit by flying equipment, especially those who were timid and who then

may gravitate towards the painted designs due to the lower competitiveness or risk.

> *Some of the others [painted designs] because of their placement with the basketball hoops, and we have some really strong basketball players right now, and so those basketball hoops are always being used so they can't really play with the games that are in or around that space. (Teacher 3)*

Availability of equipment was another factor in children's use of the painted designs. Some games required equipment that was not provided by the teachers or supervisors during the recess/lunch blocks unless asked for by the children. When equipment was provided at the beginning of the recess/lunch blocks, teachers noted greater engagement in some of the painted designs, such as four-square or hopscotch: *"Now they're using far more equipment out there, which is good! And hence, possibly using the lines more! As I've seen a lot more four-square since now everybody has access to balls. And that's a factor"*.

Confusion

The painted designs were perceived by some children as unappealing and confusing for play. Children conveyed boredom and dislike as they talked about the painted designs, particularly designs they perceived to be more suited for individual play.

> *Child 4: Um, I use it when I'm really, really bored. Interviewer: You use it when you're really, really bored? Child 4: Uh huh. [in agreement] Interviewer: Ok is that like everybody else here? Do you guys only use the black top when you're really, really bored? Child 17: No. Child 15: And there's nothing to play with yeah. Interviewer: Oh okay. You said no, why did you say no? Child 17: 'Cause I don't know what it is … so you don't play with it.*

Another child stated their disinterest in the painted designs quite succinctly: *"Yeah. Even I don't*

like them [painted designs]. Cause there [painted designs]… hardly no one plays. They only play sports, uh [on the] playground, or [are] talking" (Child, unidentifiable). In general, painted designs were seen as a last resort by the students and were infrequently or no longer used by many of the children due to confusion with how to use them. Instead, children expressed a desire to see painted designs incorporating more bright colours and different shapes or themes that hold more excitement for students, such as outer space or Pokémon.

Teachers expressed that the children's and their own unfamiliarity with how to play on the more abstract designs, confusion, and a lack of awareness of the designs, may contribute to low use:

> *Some of them, I don't know what to do with them. And so, I don't know that the kids know what to do with them. Sometimes they say, "How do you play this game?" and I just make something up, which not all the kids are able to do. They actually need like specific instructions on what to do, whereas, like an adult, could just be like "Okay, we'll just make something up that works with these parameters". (Teacher 2)*

Most of the teachers attributed their lack of knowledge to a perceived lack of available resources, commenting that they weren't aware that a resource had been provided:

> *We teachers are looking for something that we can do tomorrow and that we can do it fast and efficiently and it's engaging and creative and good to do and good for students' wellness. If it comes in a manual like this? And I'm not sure, I can't even visualize what the manual looked like… I don't know if it was a big thick book, or…? (Teacher 4)*

When teachers were directed to the resource booklet that was provided to all painted designs schools, they often commented on a lack of time to read the booklet, with one teacher commenting that, *"I probably would've… [taken it] out and taken the kids out and maybe shown*

them a bit more. I usually mostly just rely on the stuff I used to do when I was a kid" (Teacher 5).

All teachers expressed openness to learning how to use the painted designs if the resources were available online or as posters, that were quick and easy to read. The one teacher who was aware of the booklet expressed that the booklet was unclear, and that not everyone had an opportunity to learn how to properly use the painted designs and booklet:

> *I think there needed to be a little bit more time for the direct teaching of those playground games to the kids. There was a little bit of time for that, but not a lot. And then certainly there were some resources provided for the teachers, but I don't know how clear they were. So, then we didn't have the opportunity to really teach the games to them, because we didn't really understand the rules as well. They could have been probably worded a little bit more clearly. Or the opportunity for everybody to be out there at different times and learn them. (Teacher 1)*

Children also found it difficult to use the painted designs due to fading paint as well as cracks in the tarmac that made the designs hard to see, as noted in the following exchange:

> *Child 8: And they could really try to like fix the cracks in here. Interviewer: Okay. Child 8: I always trip in those cracks. It makes no sense. I don't even know how. Interviewer: Okay. Child 7: And the cracks, actually… Child 8: Like they're so tiny and I'm just like ahhh [falling sound effect]*.

Teachers similarly commented that the lines had faded, suggesting a lack of durability in the paint used for the designs: *"To be honest, I was shocked that they just used spray paint to put them on because they certainly didn't last very long. Because they really wore off very quickly" (Teacher 1)*.

Inclusiveness

Both children and teachers constructed the painted designs as creating opportunities for inclusiveness, which they discussed in terms of allowing multiple children to take part in the game or play with others. But children and teachers identified different ways in which the painted designs encouraged inclusiveness. Children used the painted designs for games, with many preferring to play on designs that they perceived to be for group-based games. For example, when asked if the children played by themselves on the painted designs or with others, the children responded: *Child (unidentifiable): Nope. With other people. Interviewer: With other people? Children [together]: Mmhmm. Interviewer: Do you play anything by yourself? Child 1: No. Child 2: Not that much. Child 3: Sometimes. Child 12: We don't know any solo stuff.*

Children preferred the designs that they perceived as allowing them to play with friends. However, most children expressed that they seldom saw other children using the painted designs, and they saw no one to play on the painted designs with. One child (Child 13) voiced: "*We don't really see anyone playing with them anymore so, so if I want, if I try to play four-square, no, no one*". Some children expressed that they only used the painted designs to play with their peers, and that they played wherever their friends were.

Although the painted designs were intended to encourage diverse forms of creative play, children perceived many of them as having a singular use. Some children specifically chose to play individual activities on the painted designs, such as hopscotch, jumping, or throwing activities. The view that the designs were meant for individual play rather than group play limited some children's use of the designs, as they expressed preference for playing with others or alluded to not knowing how to play by themselves. Painted designs perceived to be for individual activities were used less often, and when children were playing alone.

Some teachers commented how the painted designs provided opportunities for diverse activities, allowing children of various backgrounds to play with their peers. Teachers noted that sometimes the lack of knowledge about how to use some of the painted designs sparked creativity and imaginative play. In these cases, children were seen blending multiple games, or teaching games from previous experience or various countries to other children in an inclusive manner. As one teacher noted, *"I think they definitely just make up their own rules and make up their different, like own games with the different lines cause they're so versatile too"* (Teacher 1). It is interesting to note the contrast in this teacher's perspective to the earlier assertion by another teacher that children needed specific directions in order to make use of the painted designs, which speaks to the non-monolithic ways that these designs were experienced and discussed. That said, in general, teachers noted the potential of the painted designs as educational tools and for encouraging further group play across diverse school populations.

Discussion

This study explored how painted designs impacted the physical activity, including play, of elementary school students in Calgary, Alberta, Canada. The quantitative and qualitative data demonstrated that the painted designs did not have the intended impact on children's overall physical activity levels. Although some studies on the efficacy of painted designs/playground markings have reported increased MVPA (Blaes et al., 2013; Escalante et al., 2014; Parrish et al., 2013; Ridgers et al., 2010) other studies, like ours, have found no impact on children's physical activity (Cardon et al., 2009; Mayfield et al., 2017). While the reason for these findings remains unclear, it is possible that other unmeasured or unstudied determinants of physical activity were more influential over that period. Indeed, social ecological models posit that determinants at multiple levels influence physical activity, and that influences of an intervention at the more

distal levels in the model (e.g., environment) may not have as strong an influence if they are not supported by also intervening at more proximal levels (e.g., individual or social) as well in a multi-component intervention (Sallis & Owen, 2015). That possibility, combined with the small sample size, single control school, lack of baseline data, potential self-selection bias of children and their parents who assented/provided consent for their child to participate in this research, the differences in the timing of data collection across schools, and that in one school children had to be randomly assigned to determine who would wear the accelerometers raise the chances that there were unknown unique school level factors that may have influenced children's physical activity. Furthermore, the painted designs may have been subject to a novelty effect. Students may have utilized them more when they were first painted, 16-months prior to data collection, and then recalling them with boredom in the months following (Escalante et al., 2014; Ridgers et al., 2010).

Similar to previous research, the painted designs on their own were not a sufficient intervention: additional leadership, instruction, and resources are needed to facilitate use (Ickes et al., 2016; Mayfield et al., 2017). Several participants voiced confusion and frustration with not knowing how to use the painted designs, with some children choosing not to use them for this reason. The intended purposes of some designs were also not clear to some teachers. Although a resource booklet was provided to schools, difficulties in accessing it and limited time to learn the activities inhibited the potential effectiveness of the painted designs. Teachers also noted that a different format (e.g., posters) would potentially be helpful and more usable moving forward. These observations are consistent with the idea from the social ecological model that physical activity is influenced simultaneously by factors at multiple levels, and that physical environment interventions will be more effective if they are accompanied by efforts at other levels such as the

social and policy levels that also support their effective use.

In the present study, although teachers and students expressed some interested in using the new painted designs, students mostly played games they knew previously, such as hopscotch and four-square. It is possible that less rigid or static forms of playground interventions may be more impactful. For example, researchers have found an increase in cooperative play and peer interactions among children on playgrounds when offered "loose parts" (Barbour, 1999; Bundy et al., 2009; Dowling, 2010; Kuh, 2014), which are easily transportable items with wide-ranging uses (Barbour, 1999). These features appear to be favoured for their simple design and flexible use, giving children the freedom to exercise their creativity and imaginations in play in contrast to fixed, static designs, such as those investigated in this project. Similar to what was observed in this study with painted designs, the durability and sustainability of loose parts has been identified as a challenge for schools implementing these interventions (Spencer et al., 2019), and incorporating more sustainable materials may be an important consideration when using painted designs in school playgrounds, something both children and teachers recommended either implicitly or explicitly.

Beyond physical activity, students and teachers commented on the potential of the painted designs to increase inclusiveness, or opportunities for multiple children to play together, but also noted that painted designs were not enough on their own to increase inclusiveness. Features of playground-built environments along with the proximity of play structures and play areas can help to influence the play and social interactions of children (Barbour, 1999; Brussoni et al., 2017; Kuh, 2014; Yuill et al., 2007). This can work to encourage inclusion or division based on competence or age, and influence or be influenced by popularity. Therefore, considering the interaction of the built environment (at the physical environment level of the

social ecological model) as well as children's peer relationships (at the social level) on physical activity has the potential to help strengthen school-based physical activity interventions, although that was not necessarily realized in the present study. To help foster greater use of the painted designs to address both physical activity and inclusion, ambassadors—students and/or teachers—may also be an option. It would be necessary, however, to consider the students' social dynamics in the selection of student ambassadors, as children in the present study expressed a desire to play where their peers played.

School policies and practices impacted children's play and use of the painted designs. While policies are instrumental in ensuring children's safety, they also produced unintended barriers. Students talked about school rules and scheduled playground days that impacted where they played, and at times prevented them from playing where they desired. Moreover, some research suggests that there is incongruence between adults' and children's perspectives of what is fun and what is safe (Little, 2015; Ward & Bayley, 2007), with adults often approaching risk particularly from an aversion or mitigation standpoint (Brussoni et al., 2012; Bundy et al., 2009). Considering existing research alongside the barriers discussed by our participants—while not losing sight of schools' need to address child safety—there does nevertheless seem some need to determine how children's, teachers', and administrators' perspectives can be effectively combined to implement rules and policies that could facilitate play in general as well as play and activity using tools such as painted designs. One policy option to consider would be to designate specific days/times where teachers had explicit use of the painted designs for educational and activity purposes, which might then also increase the use of the painted designs during recesses and before or after school. In the present study, some teachers commented on the potential to use painted designs in physical education and math classes, and for developing problem-solving

skills. However, they also mentioned the need for teacher resources to help facilitate the use of painted designs in teaching and learning activities.

Limitations

Limitations of this study include having only one control school, as many school-level factors could impact physical activity (e.g., school facilities, programs, and initiatives; neighbourhood environment features; socio-demographic characteristics). The small sample sizes also may have contributed to Type II error. We also did not control for the multiple comparisons made with the accelerometer data. The small sample size, combined with the lack of available data on individual children's socioeconomic status, also limited the ability to consider confounders in the statistical models. The lack of baseline measures made it impossible to examine whether the schools in the two conditions had similar levels of physical activity prior to the intervention. This design also limits the internal validity of the study but does take advantage of an opportunity to examine an intervention that was already taking place and so the timing of the school interventions were outside of the research team's control and precluded taking baseline measurements. Compared with daily minutes of accelerometer-based MVPA found previously in Canadian children (Colley et al., 2017; Comte et al., 2013), our sample appeared more physically active than the general population. However, methodological differences (i.e., wearable devices, criteria for valid wear time and data, and intensity thresholds) and the fact our measures were taken post-intervention with a small number of children from 4 schools might explain why we observed higher MVPA (Borghese et al., 2016; Colley et al., 2017). Moreover, we cannot rule-out that the systematic observation might have influenced children's physical activity behaviour (i.e., Hawthorne Effect).

The SOPLAY tool relies on the creation of subjective boundaries for observational scans. The areas for the current study were created to maximize observations of common school yard features (e.g., playground structure, field, tarmac/basketball hoops, tarmac with painted designs); however, shifts in these boundaries could have resulted in differing aggregated data (Anthamatten et al., 2014). The tool also relies upon direct observations and is therefore subject to potential misclassification bias, although that likelihood was mitigated through intensive training, and requiring observers to attain and maintain acceptable inter-rater agreement of 85% in training and periodically throughout data collection. The convenience sampling may have resulted in selection bias, and the small, non-representative sample limits the generalizability of the results. There are also limitations to the data not meeting the assumptions of an analysis of variance.

With respect to the qualitative materials, the young age of children in the focus groups also limits the level of discussion, and older versus younger children may have been able to provide more detailed information through this method. While the teachers provided keen insights from their perspectives, each had different levels of involvement with the painted designs, and they were interviewed many months after the initiative had been completed. In future research, teachers or other personnel involved with the implementation of similar interventions could be interviewed multiple times following implementation to provide a better sense of use and impact over time both in relation to recess and teaching and learning activities.

Despite these limitations, the findings do provide a contribution to practical knowledge about the use of painted designs in school playgrounds. Our pragmatic approach was focused on examining this question in the context of the real-world circumstances of schools where researchers do not necessarily have the ability to control aspects of the sample, the intervention,

or some elements of the design of the study due to policies and practices affecting the schools and organizations providing intervention resources, in addition to practical limitations related to weather and willingness to participate in studies (Harrington & O'Reilly, 2020). This type of pragmatic study, and the use of a mixed methods design that addressed student and teacher perspectives, provides value in illuminating some of these real-world challenges early in the development of a program of research, prior to investing the level of resources necessary for conducting tightly controlled designs, and provides direction for future research and practice.

Conclusion

Our findings demonstrate different needs that should be considered when manipulating the built playground environment in elementary schools to effectively encourage use. Although quantitative data revealed that the painted designs had no significant impact on children's physical activity levels at the time of study, the focus group and interview data provided insights on the potential of these painted designs. Given that this was a community-based initiative, we believe a key message back to community groups and schools is that painted designs can be a relatively low-cost intervention with minimal required resources, but that school champions are needed who promote the use of the painted designs both during recess and as educational aids; this could be a teacher, an older student, or a collaboration of teachers and students. The qualitative findings of this research suggest that children need to know how to use the designs and/or be encouraged to explore their own creativity for the designs to be impactful. Given the conflicting findings of studies on painted designs and physical activity levels in the current literature as discussed earlier in this paper, more research is required.

In general, we would encourage researchers interested in such investigations to also consider using mixed methods approaches to provide insights from objective and subjective

measures. More specifically, researchers should consider rigorous, experimental/quasi-experimental study designs that include pre- and post-testing, multiple post-tests (to assess adherence/use over time), and equivalent groups. Such inquiries could address the influence of other students and/or teachers on frequency of use and intensity of activity in relation to painted designs, influence of other features of the built environment on the use of painted designs, or assessment of the cost effectiveness of painted designs in relation to activity levels. When pre-testing is not possible (i.e., when research is conducted post-intervention as was the case in the present study), collecting physical activity data might still be useful if a secondary intervention is offered such as the refurbishing of existing painted designs, provision of a workshop, or making suggested games and applicable rules more accessible to children (e.g., large posters in the vicinity of the painted designs). Post-intervention research might also draw exclusively on qualitative research methods such as observation, interviews and/or focus groups, drawing, or photovoice to further investigate efficacy of painted designs in terms of physical activity and educational use in the context of schools, or to explore questions related to social support, emotional safety, or even aspects of social justice. Another area for further inquiry would be to compare painted designs of different quality and size. Such investigations would allow for richer and deeper conversations about children's physical activity experiences and what may or may not influence activity levels in playground scenarios.

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1

Table 1. Timeline of Data Collection

School	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Intervention School 1			S1, S2, S3	CFG, TI	A	
Intervention School 2	S1, S2	S3	A, CFG, TI			
Intervention School 3	S1, S2, CFG, TI	S3, A				
Control School	S1	S2, S3				A

S=SOPLAY; A=Accelerometer; CFG=Child Focus Groups; TI=Teacher Interviews

Table 2. Proportion of Children Engaging in Active Forms of Physical Activity

School Type	Area	*M*	*SD*
Control School	Designs	64.73%	8.38%
	Tarmac	69.94%	6.46%
	Playground Structure	56.96%	4.70%
	Field	66.41%	9.25%
	Total	64.51%	8.03%
Intervention Schools	Designs	52.16%	30.83%
	Tarmac	67.55%	15.61%
	Playground Structure	70.00%	9.59%
	Field	65.40%	11.82%
	Total	63.21%	19.94%
Total	Designs	55.30%	27.14%
	Tarmac	68.15%	13.64%
	Playground Structure	65.66%	10.27%
	Field	65.65%	10.83%
	Total	63.56%	17.48%

Table 3. Comparisons of accelerometer-measured physical activity between the control and intervention schools

	7-day (Week and Weekend Day) Physical Activity				**5-day (Weekday) Physical Activity**			
	Control School (*n* = 13)	**Intervention Schools Combined (*n* = 32)**			**Control School (*n* = 13)**	**Intervention Schools Combined (*n* = 31)**		
	M (SD) [95% CI]	***M (SD) [95% CI]***	***t(43)***	***p***	***M (SD) [95% CI]***	***M (SD) [95% CI]***	***t(42)***	***p***
Days worn	5.92 (1.66) [4.92, 6.92]	5.16 (1.85) [4.49, 5.82]	1.30	0.20	4.23 (1.17) [3.53, 4.94]	4.19 (0.98) [3.83, 4.55]	0.11	0.91
Monitor wear time (hours)	112.83 (45.30) [85.45, 140.21]	93.44 (53.66) [74.09, 112.78]	1.15	0.26	81.49 (31.21) [62.63, 100.35]	73.98 (32.90) [61.91, 86.05]	0.70	0.49
Moderate physical activity (minutes/day)	133.09 (28.09) [116.12, 150.07]	108.63 (27.24) [98.81, 118.46]	2.71	0.01	142.06 (30.57) [123.58, 160.53]	109.45 (27.84) [99.23, 119.66]	3.44	<0.01
Vigorous physical activity (minutes/day)	39.27 (12.02) [32.00, 46.53]	28.34 (8.25) [25.37, 31.32]	3.51	<0.01	42.10 (12.97) [34.27, 49.94]	28.28 (8.41) [25.20, 31.36]	4.22	<0.01
Moderate-to-vigorous physical activity (minutes/day)	172.36 (36.83) [150.10, 194.62]	136.98 (33.62) [124.86, 149.10]	3.12	<0.01	184.16 (39.82) [160.09, 208.23]	137.73 (34.50) [125.07, 150.38]	3.89	<0.01
Step count (steps/day)	10427.81 (1973.39) [9235.30, 11620.32]	7961.66 (2025.68) [7231.32, 8691.99]	3.73	<0.01	11067.38 (2179.82) [9750.12, 12384.63]	8021.03 (2096.90) [7251.88, 8790.18]	4.35	<0.01

p value is two-tailed for independent t-tests. Includes participants with at least 2 days and at least 6 hours/day of accelerometer data across all days (7-day) or weekdays (5-day). N=1 missing from the 5-day (weekday) analysis because this participant provided accelerometer data for Saturday and Sunday only.

Figure 1. Proportions of Physical Activity Engagement Between Activity Target Areas