Effectiveness of a Whole-of-School Approach in Promoting Physical Activity for Children: Evidence From Cohort Study in Primary Schools in Thailand

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Purpose: This study aims to examine the effectiveness of a whole-of-school approach by using the 4PC model (Active Policy, Active People, Active Program, Active Place, and Active Classroom) in improving physical activity and reducing sedentary behavior of school children in Thailand. Method: We employed a quasi-experimental cohort design in which the intervention group was exposed to the 4PC model and control schools performed their regular routine. We followed the same students from 10 participating schools over a 2-year academic period (2017–2019) from primary school Grades 4–6. A total of 119 of 184 students in the intervention group, and 173 of 254 students in the control group were present in all five rounds of data collection and are included in the analysis. Results: Compared to students in the control group without the 4PC exposure, students in the intervention group accumulated an additional 19–25 min of physical activity time and experienced a 31-min reduction in sedentary time. Conclusion: As a whole-of-school approach, the 4PC model was effective in increasing physical activity and reducing sedentary behavior of primary school children in Thailand.

Keywords: active children, sedentary behavior, health-promoting school

Adequate physical activity (PA) is important for children. Accumulating 60 min of daily moderate to vigorous PA (MVPA) is associated with improved physical fitness, fundamental motor skills, bone health, cognitive function, mental health, and socioemotional development (Bland et al., 2020; Bull et al., 2020; Donnelly et al., 2016; Zeng et al., 2020). Regular PA offers short- and medium-term benefits for children, and also reduces the risk of chronic diseases later in life (Heiskanen et al., 2021; Kallio et al., 2021). Nevertheless, amidst the global health promotion program (i.e., Global Action Plan on PA) to improve the health of children (World Health Organization, 2019), 80% of youth have insufficient levels of PA (Aubert et al., 2018; Guthold et al., 2020).

The ecological model of health suggests that behavior is influenced by multiple layers of factors, including intrapersonal, interpersonal, community, environment, and policy dimensions (Sallis et al., 2015). As a setting where children spend most of their daytime hours, school has been identified as a consistent environmental correlate of PA for youth (McMullen et al., 2021; Wilkie et al., 2018). School provides multiple opportunities for PA such as physical education (PE), organized sports, school recess, extracurricular intervention programs, and active transport to and from school (Hyde et al., 2020; Kelso et al., 2020; Larouche et al., 2018). School is also considered an ideal venue for PA promotion and intervention since there is a “captive” population of students, and the children are in the presence of role models such as peers and their teachers (Kelso et al., 2020; Sevil-Serrano et al., 2022).

The whole-of-school approach involves supportive policies by engaging multicomponents such as staff, students, families, and communities in providing PA opportunities across the school (Milton et al., 2021). This concept was introduced by the Committee on Physical Activity and Physical Education in the School Environment of Institute of Medicine in 2013 (Kohl & Cook, 2013) and has been widely used as a health promotion intervention program. Recently, the International Society of Physical Activity and Health also recommended the whole-of-school approach as one modality that works for PA (Milton et al., 2021).

A whole-of-school approach for PA includes providing regular, adequate, and high-quality PE classes, appropriate physical school environment for sport and PA, and access to resources and facilities to support structured and unstructured PA throughout the school day. It also aims to provide PA programs before and after school, including encouraging active travel to school (Milton et al., 2021). With the effectiveness ranging from low to moderate efficacy for short- to medium-term sustainability, whole-of-school approaches have been known to be effective in improving PA outcomes (Colabianchi et al., 2015; McMullen et al., 2021; Milton et al., 2021).

The whole-of-school approach for PA is an adaptation of a school health model, and it has been implemented in various settings for almost a decade. As well as other health programs in the school setting, sustainability of the approach is one of the challenges. Previous studies reported that school-based intervention programs are only sustained in the short to medium term, and only few could last long term (McMullen et al., 2021; Ní Chrónín & McMullen,
Barriers to sustainability of whole-of-school models include lack of commitment from the host institution (school), or individual teachers as the agents of change (Cassar et al., 2019; Herlitz et al., 2020), inadequate funding to support the PA program and intervention, and negative difference in the value positioning, as well as degrees of agency (Wilkinson et al., 2021). However, studies also reported that when the whole-of-school approach involved joint collaborative policies which considered organizational capacity, partnership, and strategic planning that were aligned with the school and government policies, and the designed PA program was also supported by a good communication mechanism between parties, there was a greater likelihood that the intervention could be sustained in the long run (Bodkin & Hakimi; 2020; Herlitz et al., 2020).

Understanding the importance of PA for youth, the Thai government has intensified its health promotion strategies by involving multisector leadership, partnership, and sustained commitment, as embodied in the Bangkok Declaration in 2016 (International Society of Physical Activity and Health, 2017). Various health promotion programs have been implemented, either in the school or community setting (e.g., Lankilaphat, or healthy school) in order to increase PA and reduce sedentary behavior of the younger generation. Nevertheless, in a survey conducted during 2017–2018, only 26% of Thai youth met the World Health Organization (WHO) recommended 60 min of daily MVPA (Katewongsa, Pongpradit, et al., 2021; Saonuam et al., 2018; Widyastari et al., 2021). Then, with the sudden advent of the COVID-19 pandemic in early 2020, the PA of Thai youth dropped to its lowest level (17.1%) in 9 years (Thailand Physical Activity Knowledge Development Centre, 2020).

The low level of PA among children despite the country’s various efforts in promoting healthy youth indicates that the existing programs/policies have inadequately addressed the root cause of the problem. Even though Thailand has instituted a policy to promote PA in schools by improving infrastructure and providing equipment/sport facilities, the opportunity for PA in school is still lacking. The Thai primary and secondary school curriculum calls for an average of only 40 min of PE per week, whereas daily classroom learning takes place over a long duration (usually from 8:00 a.m.–3:30 p.m.), and students are required to remain in a sitting position for most of the sessions. Moreover, a school recess policy is only implemented in about one-third of Thai schools (Amornsriwanatanakul et al., 2021). While organized PA is implemented in most schools, it lacks quality and guidelines to ensure uniformity. The structured PA in school also may not be of interest to the students, which further dampens motivation to take part in the organized activities.

The “Active School Thailand” project was designed as a pilot model to promote PA for children and youth in the school setting by adopting the whole-of-school approach and implementing the 4PC strategy (Active Policy, Active People, Active Place, Active Program, and Active Classroom). We refer to the whole-of-school approach in promotion as the implementation of “active” school policies where staff, students, parents, and the wider community were engaged in designing regular, high-quality PA programming, and providing a suitable physical environment, and resources to support structured and unstructured PA throughout the day (Milton et al., 2021).

Adopting the approach, the five components of the 4PC model (Figure 1) include the following: (1) policy to promote constructive PA at any/all opportunity (Active Policy), (2) personnel who are motivated and enthusiastic about implementing the program (Active People), (3) having a “Smart Play” activity plan (Active Program), (4) having designated areas for PA (Active Place), and (5) having a “Smart Classroom” (Active Classroom). This study aimed to examine the effectiveness of 4PC in improving PA and reducing SB of school children in Thailand. We expect an increase in PA and a reduction of SB among primary school students in the intervention schools, and the student outcomes should be positively, significantly different from their counterparts in control schools.

Methods

Design

We employed a quasi-experimental cohort design where the fourth graders from primary schools were followed until Grade 6, or for a 2-year academic period (2017–2019). Initially, a total of 14 schools were included in the baseline; seven schools were assigned as intervention and seven schools as control. Participating schools were matched by size and characteristics to ensure its comparability. After a year of implementation, several schools had withdrawn for one of two reasons: (a) inconvenience—the school was unable to perform the 4PC intervention fully or (b) significant change in the number of students due to high transfer-out rate. We included only surviving schools which completed 3 years of observation in the analysis: (a) four intervention schools adopting 4PC to promote PA and (b) six control schools performing their routine schedules without any special program for PA promotion. To ensure objective assessment of 4PC effects on the key outcome variables, data were collected at baseline, during the intervention, and after the completion of 4PC implementation, for a total of five rounds of data collection.

### Figure 1

Complete data collected from sample groups in R1–R5. R = round. (Ahead of Print)
Participants
The participants of the study were all students at the selected schools, which agreed to be involved in the project. All students in the intervention schools were exposed to the 4PC model, whereas those in the control schools performed their regular program. Participants for both the intervention and control schools were randomly selected based on their characteristics (i.e., school size, grade, and sex). A total of 119 of 184 students in the intervention group, and 173 of 254 students in the control group were present in all five rounds of data collection (66% follow-up rate for both groups) and are included in the analysis. Loss to follow-up was generally due to a student’s absence during the time of data collection (i.e., sick/personal leave). For any case that was absent for a given round of data collection, another student with matching characteristics (sex and age) from the same grade, classroom, and school was substituted in the sample (Figure 2).

Students who transferred out of participating schools were removed from the sample permanently, whereas those who were absent during a period of data collection and present in the classroom in the following rounds were returned as samples. The substituted students were then removed from the primary sample and considered as alternates. However, only students who were present in all five rounds of data collection were included in the analysis.

Instruments
The PA was measured objectively using the Feel-fit accelerometer, which recorded both duration and intensity of PA. The wearable tool itself has undergone a validity test by comparing objective and subjective measures with 30 individuals. The correlation of average daily MVPA measured by the Global Physical Activity Questionnaire (version 2) Thai version and Feel-fit showed a value of 0.809, suggesting an acceptable level of accuracy of the instrument as a tool to measure PA and SB of Thai population (Katewongs et al., 2020, 2021).

The Feel-fit device was attached to the students’ waist for a period of 7 hr (420 min, during 8:00 a.m.–3:00 p.m.) for five consecutive days (Monday–Friday). Any type of PA resulting in metabolic equivalent tasks ranged between 3.0 to <6.0, and >6.0 was defined as moderate and vigorous intensity, respectively (Holtermann & Stamatakis, 2019). SB was defined as “any waking behavior characterized by an energy expenditure ≤1.5 metabolic equivalents (METs), while in a sitting, reclining, or lying posture” (Tremblay et al., 2017).

Data recorded by Feel-fit were harvested on a daily basis and stored as daily and weekly minutes of MVPA. PA was assessed by two measures: (a) average daily MVPA, expressed in minutes, obtained from total weekly MVPA divided by the number of Feel-fit wearing days and (b) sufficient PA, whether or not the participants met the WHO recommendation of at least an average of 60 min of daily MVPA for youth (Bull et al., 2020). The assessment of whether the student engaged in sufficient MVPA during the day only refers to their time at school.

Procedures
The implementation of the 4PC model began with Active Policy to promote constructive PA at any/all opportunity, and was not only focused on PE, since most schools have implemented PE prior to the intervention. Capacity building training was conducted for teachers in order to (a) improve their awareness of the importance of PA for students, including the direct and co-benefits of PA for children in the short, medium, and long term; (b) enhance their self-efficacy in shifting their classrooms into a physically active learning mode; (c) develop their capacity in designing and integrating PA (movement) into lessons; and (d) build their capability in modifying available areas in schools to be a healthy space.

Four intervention schools implemented the 4PC model by integrating structured PA into the existing routine of the school day, while also promoting a reduction in SB by unstructured exercise at every/an opportunity. An undercurrent of this effort was to instill a Be active mind-set in the students so they would see constructive PA as a “positive,” and unproductive SB as a “negative.”

Since positive behavioral change is the main goal of the model, Active People serves as the heart of 4PC. Teachers, students, and families worked together to design the preferred elements of PA components to ensure student participation, and promote sustainable behavior change. Active Program tailored PA to the age, ability, and opportunity of the students, starting from home, until the end of the school day. For example, students who could, were encouraged to walk or bike to/from school. The morning assembly to sing the Thai national anthem and raise the flag was another opportunity to incorporate PA for all students. Aside from a 40-min weekly PE class guided by the Game Centred Approach (Harvey & Jarrett, 2014; Harvey et al., 2015), PA was also scheduled periodically in various classes throughout the day, and numerous organized and unstructured play/activity opportunities were offered after school.

Apart from the PA policy and program, intervention schools rearranged the environment to be an Active Place by the following: (a) modifying the existing area into a friendly and safe healthy space, (b) providing more spaces for health-promoting PA (i.e., running and working out), and (c) modifying the classroom space. The Active Classroom component shifted the emphasis from passive learning (i.e., sitting at a desk) to...
physically active learning using participatory education methods. Every 1-hr class was divided into three sections: 10 min playing, 30 min active learning, and 20 min “insight” to allow the students to provide feedback and exercise their soft skills.

Schools in the control group were not exposed to any special PA promotion programs and were presumed to have conducted only their routine schedule during the 3 years of data collection. To control for extraneous factors that might influence the level of PA of students independent of the 4PC intervention, the following steps were undertaken: (a) the participating schools comprise both medium and large classroom sizes (i.e., with at least 30 students in each primary Grade 4 class at the baseline), to enable a more robust statistical analysis and reduce the effects of stray variance of the sample; (b) the schools in the intervention and control groups were matched so that they differed the least, except for the fact that one group had the 4PC and the other did not; and (c) to minimize contamination, participating schools agreed to opt out of other intervention programs—except for those related to national policy—during the 3 years of the study.

Fidelity of Intervention

To ensure the planned strategies were implemented, a series of workshop were conducted: (a) at the end of the first year, to allow schools modifying and improving their strategies; (b) in the beginning of new academic year, to orient teachers in the new grades (i.e., primary Grades 5 and 6), or new homeroom teachers; and (c) at postintervention, to provide feedback and distill lessons learned from implementing 4PC and to encourage schools to continue implementing 4PC.

As a measure of fidelity, in each round of data collection, teachers were asked whether they implemented the 4PC strategies according to plan. We asked the teachers, how many times in a day they provided PA programs for their students in a given period (i.e., morning, afternoon). We cross-checked the information with the school schedule, students’ responses, and also with the activity log recorded by teachers which was sent to the research team every semester. Field observation was also undertaken by the research team during the data collection period.

Data Analysis

The independent t test was employed to compare PA and SB between intervention and control groups for all five rounds of data, whereas the paired t test was used to compare the mean difference of the two behavioral outcomes (PA and SB) between Round 1 (R1, baseline) and Round 5 (R5) for students who participated in all five rounds of data collection. Any differences that favored the students in the intervention group should be attributable to the 4PC intervention (IBM SPSS Statistics, version 25, IBM Corp).

Ethical Approval

The protocol for the Active School Project was approved by the ethical review committee of the Institute for Population and Social Research, Mahidol University: COA. No. 2017/10-219, COA. No. 2018/01-003, and COA. No. 2019/01-024. By Thai law, only persons age 17 years or older have the legal right to sign the consent form to participate in a research project. As this study comprised persons age 9–12 years, parental/guardian consent was obtained prior to a participant’s inclusion.

Results

Effectiveness of the 4PC Model in Increasing PA Level

Prior to the intervention (R1), there was no significant difference in the PA level (average daily MVPA) between intervention and control groups (t = .544, p = .587; Table 1). Fourth graders in both intervention and control schools accumulated less than 60 min of MVPA daily, with less than 5% of students meeting the recommended level. After the implementation of the 4PC model, the PA of students in the intervention school improved, as shown by an increase in the average daily MVPA in Round 2 and the subsequent rounds (73.6, 71.1, 71.7, and 73.1 min, respectively), whereas their

| Table 1 | Independent t Test Comparing PA Level Between Intervention and Control Groups |
|---------|----------------------------------|-----------------|---------|-----------------|---------|
| Mean difference | t test (df) | p value | Lower CI | Upper CI |
| Average MVPA (min) | | | | |
| R1-Grade 4 | 0.726 | .544 (304) | .587 | −1.903 | 3.355 |
| R2-Grade 4 | 21.648 | 13.818 (313) | .000 | 18.565 | 24.731 |
| R3-Grade 5 | 21.290 | 12.731 (270) | .000 | 17.998 | 24.583 |
| R4-Grade 5 | 19.694 | 12.735 (303) | .000 | 16.651 | 22.737 |
| R5-Grade 6 | 25.428 | 15.815 (270) | .000 | 22.262 | 28.593 |
| Sufficient MVPA (%) | | | | |
| R1-Grade 4 | 0.013 | .638 (386) | .524 | −0.027 | 0.053 |
| R2-Grade 4 | 0.314 | 7.689 (244) | .000 | 0.234 | 0.395 |
| R3-Grade 5 | 0.273 | 7.256 (207) | .000 | 0.199 | 0.347 |
| R4-Grade 5 | 0.237 | 6.964 (178) | .000 | 0.170 | 0.304 |
| R5-Grade 6 | 0.210 | 6.289 (171) | .000 | 0.144 | 0.276 |

Note. PA = physical activity; MVPA = moderate to vigorous physical activity; R = round; CI = confidence interval.

(Ahead of Print)
counterparts in the control group showed no improvement (Figure 3a). There was also no difference in the proportion of students who met the recommended level for MVPA at baseline ($t = .638$, $p = .524$; Table 1). The proportion of students with sufficient MVPA in the intervention schools increased significantly from 3.2% at baseline to 36.6%, 31.2%, 23.0%, and 23.7% in R2–R5, respectively (Figure 3b).

The effectiveness of the 4PC model in improving PA was confirmed by the independent $t$ test, which found a significant difference in the average daily MVPA between students in the intervention and control groups. Students who were exposed to the 4PC model accumulated an average of 21, 21, 19, and 25 min additional PA in R2–R5, respectively. The proportion of students in intervention schools who met the recommended PA was also 21%–31% higher than their control counterparts after the 4PC model was implemented (Table 1).

The effectiveness of the 4PC model in increasing the PA level of Thai children could also be seen from the results of the paired $t$ test comparing PA level between the baseline (R1) with the last round (R5) of data collection. Overall, by R5, students in the intervention group showed a significant improvement by adding 22 min of MVPA from the baseline ($t = 15.539$, $p = .000$), whereas students in the control group experienced a decrease of about 2 min ($t = −2.744$, $p = .007$) (Table 2).

**Effectiveness of the 4PC Model in Reducing Sedentary Behavior**

This study showed that Thai students experienced a high level of sedentary time during the typical primary school day. Of 7 hr (420 min) at school (8 a.m.–3 p.m.), students spent an average of 337 min (80%) in SB (Figure 4).

The results of the independent $t$ test show that there was a statistically significant difference in the level of SB of students in intervention and control groups at baseline (R1; $t = −4.402$, $p = .000$). However, the difference was only about 10 min throughout the course of a 7-hr school day (Table 3). What is noteworthy though is that, by R2, students in intervention schools had reduced their SB by 30 min, whereas their control school counterparts showed no significant change ($t = −13.999$, $p = .000$).

The effectiveness of the 4PC model in reducing SB can also be seen from the results of the paired $t$ test comparing SB level at

![Figure 3](image.png)

**Figure 3** — (a) Comparison of average daily MVPA (minutes) between intervention and control groups. (b) Percentage of students with sufficient MVPA, comparison between intervention and control groups. MVPA = moderate to vigorous physical activity; R = round.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Paired t Test Comparing PA Level Between Round 1 and Round 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group comparison</td>
<td>Mean difference</td>
</tr>
<tr>
<td>Average MVPA (min)</td>
<td></td>
</tr>
<tr>
<td>Intervention group</td>
<td>22.401</td>
</tr>
<tr>
<td>Control group</td>
<td>−1.844</td>
</tr>
<tr>
<td>Sufficient MVPA (%)</td>
<td></td>
</tr>
<tr>
<td>Intervention group</td>
<td>0.169</td>
</tr>
<tr>
<td>Control group</td>
<td>−0.025</td>
</tr>
</tbody>
</table>

*Note. PA = physical activity; MVPA = moderate to vigorous physical activity; CI = confidence interval.*
baseline (R1) and last round (R5) of data collection. Students in the intervention schools experienced a statistically significant 25 min decrease in SB ($t = -12.817$, $p = .000$) as of the final round. As hypothesized, students in the control group who were not exposed to the 4PC model did not show any improvement and, in fact, showed a slight increase in SB (by 1.9 min; $t = 1.904$, $p = .000$; Table 4).

**Discussion**

The 2020 WHO guidelines recommend 60 min of MVPA daily for children and youth, and limiting the amount of time in SB, particularly recreational screen time (World Health Organization, 2020). Previous research on the dose–response relationship between PA and health suggested that an increase in PA will result in better cardiorespiratory and muscular fitness, cardiometabolic, bone, and mental health, and cognitive outcomes (Nevill et al., 2020; Sriram et al., 2021; World Health Organization, 2019). Studies have also documented school as an ideal setting for implementing PA interventions for children. The effectiveness of school-based interventions in increasing the PA level of students has been reported as positive and consistent (Cheung et al., 2019; Hyde et al., 2020; Schmidt et al., 2020; Sevil-Serrano et al., 2022).

Consistent with studies of the effectiveness of the whole-of-school approach in improving PA of children and youth worldwide (Colabianchi et al., 2015; McMullen et al., 2015), the results of this study indicate that the whole-of-school approach with 4PC strategies are appropriate for the Thailand context. By incorporating a supportive policy/program/environment for PA, the model was able to increase the average daily MVPA and the proportion of students who met the WHO-recommended level of MVPA. Students in the intervention schools accumulated 19–25 min additional PA compared to their control school counterparts without 4PC exposure. The effectiveness of 4PC in improving the PA level of students can also be seen by the consistent increase throughout the four rounds of data collection during the intervention (R2–R5).

Compared to baseline (R1), students who were exposed to the 4PC model accumulated 22 min of additional PA as of the last round of observation (R5), whereas students without 4PC exposure experienced a decrease of PA by about 2 min.

This study also found that Thai students experience a high level of sedentary time during school days. Of the 7 hr of a typical school day (420 min), an average of 337 min (80%) was spent being sedentary. The 4PC model was effective in reducing SB by nearly 30 min/day among students in the intervention group, compared to no change in their control counterparts. By the end of observation (R5), the difference in daily SB between intervention and control groups was 37 min.

Throughout 2017–2019, the 4PC model consistently demonstrated its effectiveness in improving PA and reducing SB when sex, residential area (urban/rural), and school size were being controlled. This implies that the PA and SB outcomes in the study were not caused by differences in the physical or socioeconomic characteristics of the students, or schools, but was due to the intervention effect. The strength of 4PC in driving a successful

**Figure 4** — Sedentary behavior of Thai children in R1–R5 (2017–2019). R = round.

**Table 3** Independent $t$ Test Comparing Sedentary Behavior Between Intervention and Control Groups by Round of Data Collection

<table>
<thead>
<tr>
<th>Sedentary behavior (min)</th>
<th>Mean difference</th>
<th>$t$ test (df)</th>
<th>$p$ value</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1-Grade 4</td>
<td>−9.022</td>
<td>−4.402 (286)</td>
<td>.000</td>
<td>−13.056</td>
</tr>
<tr>
<td>R2-Grade 4</td>
<td>−31.244</td>
<td>−13.999 (318)</td>
<td>.000</td>
<td>−35.635</td>
</tr>
<tr>
<td>R3-Grade 5</td>
<td>−29.805</td>
<td>−13.237 (282)</td>
<td>.000</td>
<td>−34.238</td>
</tr>
<tr>
<td>R4-Grade 5</td>
<td>−28.512</td>
<td>−14.014 (391)</td>
<td>.000</td>
<td>−32.512</td>
</tr>
<tr>
<td>R5-Grade 6</td>
<td>−37.500</td>
<td>−17.115 (285)</td>
<td>.000</td>
<td>−41.813</td>
</tr>
</tbody>
</table>

*Note.* R = round; CI = confidence interval.

**Table 4** Paired $t$ Test Comparing SB at Baseline (R1) and at End of Observation (R5)

<table>
<thead>
<tr>
<th>SB (min)</th>
<th>Mean difference</th>
<th>$t$ test (df)</th>
<th>$p$ value</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention group</td>
<td>−25.680</td>
<td>−12.817 (141)</td>
<td>.000</td>
<td>−29.641</td>
</tr>
<tr>
<td>Control group</td>
<td>1.995</td>
<td>1.904 (203)</td>
<td>.058</td>
<td>−0.071</td>
</tr>
</tbody>
</table>

*Note.* SB = sedentary behavior; R = round; CI = confidence interval.
intervention lies, firstly, in the sequence and components of the model. *Active Policy* was established in the beginning of the program to ensure the whole-of-school components (*Active People*) understood the concept of the model, the strategies to deliver the intervention, and the expected outcomes arising from implementing the model.

Second, to increase the sense of ownership of the school toward success of the intervention, the *Active Program* component of 4PC encouraged communication between teachers, families, and students in designing preferred PA. Involving pupils to design their own PA is considered crucial to maintaining long-term behavioral change given the age-related fluctuation in PA that usually occurs during the transition from childhood to adolescence (Lai et al., 2014; Marchant et al., 2020). This strategy was similar to the whole-of-school intervention in Finland, Ireland, Poland, and the United States, where the schools were given freedom to design their own PA initiatives (Colabianchi et al., 2015). Likewise, in the 4PC model, monitoring and evaluation of progress in the intervention schools was only conducted to encourage the school administrators and teachers to adjust PA implementation when some activities did not work as well as intended.

Third, the *Active Program* was also designed to provide joyful and fun PA opportunities throughout the day. Although limited to 40 min weekly, the PE class adopted the Game Centred Approach to enhance motivation for PA, and facilitate effective decision-making skills for students (Harvey & Jarrett, 2014; Harvey et al., 2015). In addition, the *Active Classroom* incorporated 10 min playing, 30 min active learning, and 20 min feedback in every hour, to encourage students to be physically active while learning. Modification of the classroom and playground also allowed the students to learn (i.e., math) through play. Studies have documented effectiveness of learning through play methods in improving academic performance and reducing anxiety (Cavanagh, 2008; Ramani & Eason, 2015; Vogt et al., 2018).

Fourth, the 4PC health promotion model uses the whole-of-school approach, and that can be sustainable in the presence of the following facilitating factors (Cassar et al., 2019; Hertlit et al., 2020): (a) supportive policy environment, (b) compatibility and adaptability of the intervention, (c) characteristics of the providers (e.g., perceived need and benefit of the intervention), and (d) organizational capacity (e.g., positive work climate, shared vision, shared decision making, communication, and leadership). Upon the completion of the field component of the study in 2019, a series of workshops were convened as part of postintervention follow-up. We collected qualitative information to assess whether the schools in the intervention group were continuing to implement the 4PC program, and to distill the lessons learnt from participating in the program. We also discussed the possibility and strategy of scaling up the 4PC model to achieve wider coverage. The representatives from the schools in the intervention group said they were continuing to implement the 4PC approach, and they believe that the model can be adapted, applied, and seamlessly integrated into other policy and learning activities of the typical Thai school.

One of the greatest challenges in 4PC implementation was during the initial phase of implementation, particularly in convincing policy makers at the central level of the potential effectiveness of the model to improve health outcomes of students. Multiple advocacies were conducted before the Ministry of Education finally approved implementation of the 4PC model in pilot schools. This reluctance to try a new approach, even on a pilot scale, can be seen as an aversion to change that could disrupt the policy process and create repercussions for stakeholder priorities and sociopolitical considerations (Chhetri & Zacarias, 2021). However, the successful advocacy by the research team during the initial phase facilitated approval to pilot test and the 4PC’s scale up. Based on the positive experience of the participating schools, and the statistical evidence of the effectiveness of 4PC in improving student PA, and reducing SB in the pilot phase, the Ministry of Education subsequently supported the replication of the model in 800 public primary schools across the country.

Despite the promising results of the effectiveness of 4PC in increasing average daily MVPA of the students, it cannot be denied that some of the improvements were less than hoped for, particularly related to the proportion of students who met the WHO-recommended threshold for daily MVPA. This study found that only about one in three students in the intervention schools attained an average of at least 60-min MVPA throughout the five rounds of observation. In addition, the proportion of students in the intervention group who accumulated sufficient MVPA was only 20–30 percentage points higher than the control group. However, it should be noted that this study only collected PA data during the school day, and there were some opportunities for PA outside of the school that could not be recorded. These findings imply that, in order to achieve the ambitious goal of all students having adequate MVPA every day, a successful model requires more than just a school-based intervention. The family and home community also need to be encouraged to create more opportunities for PA, and motivate youth to be more physically active. In addition, there has to be a two-way linkage between the school and the home so that there is mutual reinforcement of the *healthy active norm*.

Second, although there was a noticeable reduction of SB associated with 4PC implementation, the total sedentary time of students remained high over the period of the study. This finding is possibly due to the initially high level of SB, both in school and at the home, prior to the intervention. Critics point to the fact that the standard Thai school curriculum calls for only 40 min of PE class per week, while the rest of the classroom time for students is primarily conducted while sitting at a desk (Amornsriwatanakul et al., 2016; Saonuam et al., 2018). The findings from this study also imply that PA is independent from SB, and that additional PA gained from the 4PC intervention did not necessarily lead to reduction in SB. In a related study, Thai researchers also conclude that the factors affecting PA were somewhat independent of SB, shown by a health promotion intervention aimed at increasing PA during the COVID-19 pandemic was not significant in reducing SB (Katewongsa et al., 2021). The *Active Program* component of the 4PC model mostly focuses on increasing PA through such mechanisms as active transport to/from school and structured/unstructured play. However, the program (e.g., modifying the classroom environment by providing sit-to-stand or height-adjusting desks) does not have interventions which specifically target SB reduction, (Aminian et al., 2015; Clemes et al., 2016; Erwin et al., 2018; Guirado et al., 2021; Hegarty et al., 2016; Hinckson et al., 2016) and providing breaks to interrupt prolonged periods of sitting (Aho et al., 2021; Hargreaves et al., 2020; Owen et al., 2020). Therefore, further action research should include interventions to reduce SB, apart from those to increase PA.

**Strengths and Limitations**

In terms of the design, the strength of this study is the time-series data collection with a panel of students (primary Grades 4–6). By following the same individuals over time, the effectiveness of the intervention could be more accurately assessed, while the pattern of
the outcomes could also be observed at different points of time. The study also has a clear focus and validity, with specific behavioral outcomes being observed (PA and SB). The use of objective measures (e.g., the wearing of the Feel-fit accelerometer by the participating students) also ensures the accuracy of estimates of PA and SB levels. With age, type of residence, and school size being controlled, some potential confounders have also been accounted for. However, there are two limitations of this study related to the data collection. First, the PA and SB indicators were measured only during the school day and, thus, do not necessarily reflect the whole-day PA or SB. The decision to only take measurements of the students at school was made in order to reduce the burden on parents/guardians in monitoring and reporting, as well as in maintaining the Feel-fit device. While it is true that the researchers were unable to document PA after school (e.g., free play in the early evening), the convenience of the parents/guardians’ was considered important to sustain their child’s behavior changes. Second, as this study only focused on school-based observations, data on family and community in relation to youth PA and SB were not collected.

**Conclusions**

The overall findings of this study suggest that the 4PC strategy, as a comprehensive whole-of-school model incorporating a supportive policy/program/environment for PA, was effective in increasing PA and reducing SB among a sample of Thai primary school students. The 4PC program is an important intervention which can be applied to most primary schools around Thailand, with confidence that there will be positive outcomes, at least in the near term. This study found less sustained impact on PA after the first year of implementation. Thus, there needs to be more in-depth study of this plateauing effect since sporadic increases in MVPA are unlikely to have the sustained health impacts as envisioned by health authorities.

To have impact at the population level, the 4PC program as a whole-of-school approach must be widespread and sustained until daily MVPA becomes an ingrained habit of the students and, hopefully, a social norm. Structured and unstructured PA should be available at the school and the home community, since that will send a consistent message to children that MVPA is imperative and expected. In the school setting, the teachers who sit on the project task force are the critical factor in determining whether the 4PC program is successful. That means that those teachers need to have a complete and correct understanding of the 4PC concept and interventions, and have the determination to sustain the program from year to year until MVPA becomes a part of the routine lifestyle of primary school youth in Thailand.

The findings of the study also suggest that the 4PC intervention had less impact on PA after the first year of implementation. This phenomenon is not unusual in long-term studies and is mostly attributable to several barriers to sustainability. Although schools have shown their commitment to implementing 4PC over the long term, there could be challenges in keeping the initiative interesting and fresh, particularly when the teachers lack the authority and resources to make changes in the daily curriculum. The Thai school regimen, as a PA promotion system, may have institutional barriers to innovation, particularly when there is a competing pressure for funding, teacher self-efficacy, curriculum demands, and centralized control of formal education. Therefore, sustainability of a PA program in Thailand also depends upon supportive national policy, and a school’s ability to maintain staff knowledge, skill, and motivation to continue implementing a new intervention in the context of ever-changing circumstances.

**Acknowledgments**

The authors gratefully acknowledge the funding support from Mahidol University with grant number 10101002, and Thai Health Promotion Foundation with grant number 59-00769, 60-02303, and 61-02130. P. Katewongsa conceived and designed the study; P. Choolers conceived the study, performed the data compilation, and data analysis; D.A. Widyardastri conceptualized and drafted the manuscript, interpreting the findings, and wrote the manuscript; P. Katewongsa and P. Saouam provided the final approval of the version. All authors reviewed and contributed to the final manuscript. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

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