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Understanding physical activity and sedentary behaviour among preschool-aged children in Singapore: a mixed-methods approach

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ABSTRACT

Objectives This study investigated physical activity (PA) and sedentary behaviour (SB) among preschool-aged children in Singapore and potential correlates at multiple levels of the socioecological model from in-school and out-of-school settings.

Design A cross-sectional study using a mixed-methods approach.

Participants Parent–child dyads from six preschools in Singapore.

Methods PA and SB of children (n=72) were quantified using wrist-worn accelerometers for seven consecutive days. Three focus group discussions (FGDs) among 12 teachers explored diverse influences on children's activities, and System for Observing Play and Leisure Activity in Youth (SOPLAY) assessed PA environment and children's activity levels at preschools. Seventy-three parents completed questionnaires on home and neighbourhood factors influencing children's PA and SB. Descriptive analyses of quantitative data and thematic analysis of FGDs were performed.

Results Based on accelerometry, children (4.4±1.1 years) spent a median of 7.8 (IQR 6.4–9.0) hours/day in SB, and 0.5 (0.3–0.8) hours/day in moderate-to-vigorous physical activity (MVPA). MVPA was similar throughout the week, and SB was slightly higher on non-school days. In preschools, SOPLAY showed more children engaging in MVPA outdoors (34.0%) than indoors (7.7%), and absence of portable active play equipment. FGDs revealed issues that could restrict active time at preschool, including academic requirements of the central curriculum and its local implementation. The teachers had varying knowledge about PA guidelines and perceived that the children were sufficiently active. In out-of-school settings, parents reported that their children rarely used outdoor facilities for active play and spent little time in active travel. Few children (23.5%) participated in extracurricular sports, but most (94.5%) reported watching screens for 1.5 (0.5–3.0) hours/day.

Conclusion MVPA was low and SB was high in preschool-aged children in an urban Asian setting. We identified diverse in-school and out-of-school correlates of PA and SB that should be taken into account in health promotion strategies.

Strengths and limitations of this study

- Multiple complementary approaches to measure physical activity (PA), sedentary behaviours (SB) and relevant correlates at multiple levels of the socioecological model, with particular consideration of in-school and out-of-school settings.
- Accelerometer data of PA and SB from preschool-aged children in a multiethnic Asian population living in Singapore.
- Limitations include small sample size and specific socioeconomic status.

INTRODUCTION

Globally, children are insufficiently active and becoming more sedentary. Little physical activity (PA) and excessive sedentary behaviours (SBs) in early childhood are associated with reduced motor skill development, poor psychosocial health outcomes and increased risk of chronic diseases (eg, diabetes and coronary heart disease).[1] One way to mitigate these risks is to encourage health behaviours through the socioecological model (SEM).

The SEM describes multilevel factors influencing PA and SB.[2] A child's behaviour is affected not only by the child's individual characteristics (eg, age and sex) but also by their inter-relationships with other individuals (eg, peers, family and educators), as well as by larger contextual factors related to the environment (eg, home, school, cultures and policies).[3–5] Health behaviours and individual behaviour changes are maximised and sustained when environments encourage them. Understanding the various factors influencing children's PA and SB is essential in facilitating the development and improvement of health promotion interventions.[6]

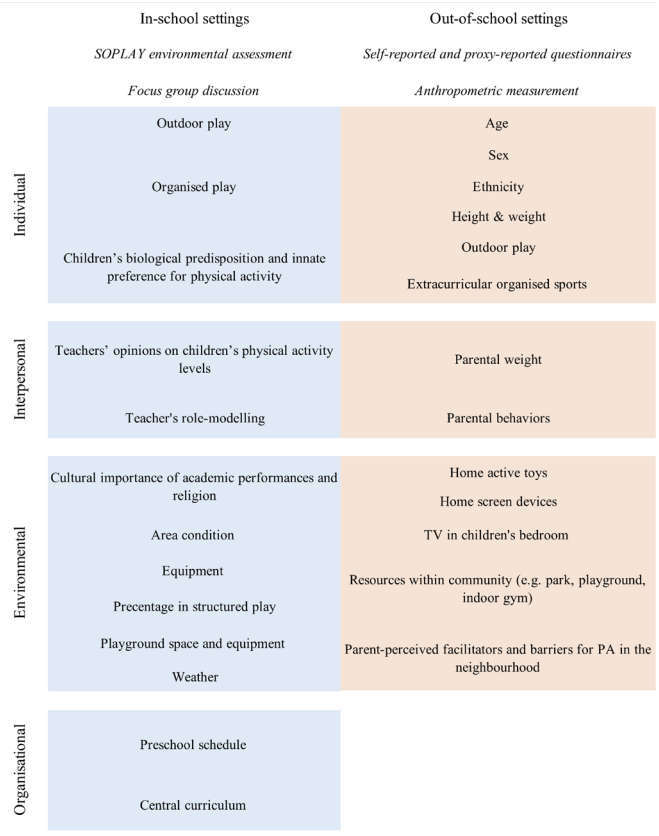

Figure 1 Overview of the correlates of physical activity and sedentary behaviour and their corresponding measurements based on the socioecological model.

Studies assessing PA and SB correlates among children have increased over the recent years; however, some reviews[7 8] suggest that there is a lack of heterogeneity in findings regarding the correlates at different levels of the SEM, and there is limited evidence on environmental correlates. In addition, most of these studies were conducted in Europe or the USA,[9] and the findings may not be culturally appropriate to Asian populations.[10] Previous evidence from a large-scale birth cohort study in Singapore suggests that preschool-aged children in Singapore are less active and more sedentary when compared with Western countries.[11] Longer school hours and more emphasis on children's academic performance may partly explain these differences.[12] Given the economic and cultural differences between Singapore and Western regions, relevant research assessing correlates comprehensively in a Singaporean population could facilitate the development of interventions that are applicable, effective and efficient in the local context. Because Singapore is a multiethnic country mainly made up of Chinese, Malays and Indians, findings from Singapore may be able to provide information that applies to other Asian countries.

We conducted this study to implement a comprehensive assessment approach that would allow us to generate hypotheses about the diverse correlates of PA and SB of preschool-aged children in an urban Asian population. Specifically, we aimed (1) to measure and describe patterns of PA and SB in preschool-aged children, with particular consideration for in-school and out-of-school settings; and (2) to explore the potential correlates at multiple levels of the SEM that affect PA and SB in these settings.

METHODS

Study design

This cross-sectional study used a mixed-methods approach to assess different levels of influences on children's PA and SB for in-school and out-of-school settings. The mixed-methods approach integrates quantitative with qualitative data to more comprehensively understand complex public health issues.[13] Figure 1 shows a multilevel model of PA and SB influences, which guided the classification of variables measured in this study. Both qualitative and quantitative data were collected in parallel and were analysed independently after data collection was completed. Findings presented in this paper synthesise the qualitative and quantitative data together.

Recruitment and enrolment

With the support of the People's Action Party Community Foundation (PCF) Headquarters, PCF preschools, which include childcare centres and kindergartens, were invited to participate in this study. In Singapore, childcare centres provide full day care with education programmes to children from 2 months to 6 years old, while kindergarten programmes are half-day programmes for children aged 4–6 years. Both of them followed the curriculum framework proposed by the Ministry of Education, Singapore.[14] Preschool principals who declared interest were contacted by researchers and were provided with more information on the study. Active recruitment started after the school principal agreed to participate. Researchers recruited parent–child dyads from six interested preschools (ie, five child care centres and one kindergarten) between July 2015 and July 2016, when parents picked up or dropped off their children from the preschool.

Before recruitment, materials (eg, letters, participant information sheet and consent forms) were sent to the parents of eligible children. Parents and children were eligible if (1) the child was between 3 and 6 years of age and registered in a participating preschool, (2) the registered child and at least one parent were Singapore citizens or permanent residents, and (3) parents were able to read/write in English and/or Chinese (Mandarin). In addition, researchers were on-site at the preschools during specified mornings and afternoons to provide more information and invite children and their parents to join the study. All parents provided written informed consent at enrolment, and children provided their verbal assent prior to any measurements. Parents who completed the questionnaires received S$25 vouchers. Participating children received small gifts worth less than S$5 in appreciation of their effort.

Patient and public involvement

No parent or preschool staff (ie, teacher and principal) were involved in the design of the study and interpretation of the results.

Measures

Figure 1 provides an overview of variables captured using various methodologies. In general, children's PA and SB were proxy reported in questionnaires by parents and collected using accelerometers. Children focus group discussions (FGDs) and direct observations during various periods of the preschool day provided the in-school correlates of children's PA and SB. Parents proxy-reported child-level out-of-school correlates to PA and SB and self-reported their own PA and SB. A researcher collected children's anthropometrics, while parents self-reported on questionnaires. Details on these measures are described in the next sections.

Parent self-reported and proxy-reported questionnaires

These two questionnaires assessed multidimensional influences on young children's PA and SB from out-of-school settings, reflecting the SEM (figure 1). Participating parents were asked to report their child's behaviours using adapted and validated questionnaires designed to measure habitual PA and SB among preschool-aged children outside of school.[15] Assessment of child PA and SB (one school day and two non-school days) included a list of behaviours typical in preschool-aged children, with time spent in each activity type. One school day but both non-school days were included in the questionnaire since previous research reported that activity patterns varied less at home on a school day than non-school days.[15] These activities were then classified into five progressive levels according to the Child Activity Rating Scale, reflecting SB and activities at different intensities.[16] For each child, the average time for each behaviour was calculated as (school day×5+non-school days)/7. It was then aggregated to generate average time spent in SB, light physical activity (LPA), and moderate-to-vigorous physical activity (MVPA). In addition, the questionnaire also captured information concerning potential correlates on PA and SB, including (1) children's demographics, including age, sex, ethnicity (Chinese, Malay and Indian), parental highest level of education (primary/secondary, postsecondary certificate/diploma, university degree and above), marital status (married/living with partner or single/never married), housing (public housing with ≤3 or 4–5 bedrooms, condominium or landed property); (2) other individual activities (eg, transport-related activities, outdoor activities and extracurricular organised sports); (3) home and neighbourhood environment (eg, presence of active toys at home and resources within the community).[15] In addition to proxy-reporting for their child, parents reported their own (1) sociodemographics, (2) height and weight, and (3) daily leisure-time MVPA and SB. Items assessing MVPA and SB were derived from a questionnaire which has been validated for use with adults.[17]

Anthropometrics

Two trained researchers went to each preschool to measure children's height and weight. Weight (to the nearest of 0.1 kg) was measured using a weighing scale (SECA model 803, Hamburg, Germany), with no objects in the pockets. Height (to 0.1 cm) was measured using a stadiometer (SECA model 213), without shoes, looking straightforward. To ensure accuracy, both height and weight were measured twice. We calculated the child's weight status using age-specific and sex-specific body mass index (BMI)-for-age percentiles recommended by the Centers for Disease Control and Prevention[18] (overweight=85th–95th percentile, obese≥95th percentile). As mentioned previously, information on parents' height and weight was obtained from the self-reported survey. Parental weight status was classified using WHO Asian BMI cut-points[19] (overweight=23–27.5 kg/m^2, obese ≥27.5 kg/m^2) .

Accelerometer

To assess detailed PA and SB patterns, researchers attached a triaxial accelerometer (Actigrah wGT3X-BT) on each child's non-dominant wrist with a non-removable strap. Each accelerometer was set to record raw acceleration data of PA, SB and sleep for the entire spectrum throughout the 24-hour day.[20] Children were asked to wear the accelerometer for seven consecutive days and nights, allowing recording of 24-hour activities throughout a week. Raw acceleration was subsequently collapsed into 60 s epoch data. To process accelerometer data, we conducted the following steps. First, sleep and wake epochs were scored using Sadeh algorithm,[21] together with the built-in ActiGraph sleep period detection. Two trained researchers further manually corrected in-bed and out-of-bed time to determine sleep period (including night-time sleep and nap) using the same scoring rule (15 min rule).[22] Second, non-wear time was defined time windows of consecutive zero counts that lasted ≥90 min; tolerance to activity spikes was set to default (2 min).[23] Valid accelerometer data were defined as ≥3 days (including ≥1 weekend day) valid wear time with ≥480 min waking time/day, which was considered acceptable for providing a reliable estimate of usual activity behaviour.[24] Third, to derive the time spent being sedentary and in a range of PA intensities, age-specific cut-points according to Chandler *et al* were used.[25] The cut-offs (sedentary: <305, light: 306–817, moderate: 818–1968 and vigorous: >1969 counts) were originally developed using the ActiGraph accelerometer (Manufacturing Technologies) with 5 s epochs. To accommodate our data, we first reintegrated the thresholds to 60 s (×12). Valid accelerometer data was then used calculate to (1) daily average time spent in sleep, SB, LPA and MVPA; and (2) hourly average time spent in SB, LPA and MVPA across the hours between 07:00 and 22:00. This time window was based on sleep and wakeup

time reported by parents, and at least 80% of participants recorded data during hours within this period.

Preschool System for Observing Play and Leisure Activity in Youth (SOPLAY)

An objective, observational audit was performed in the preschool environment using an adapted version of SOPLAY. SOPLAY was developed to directly observe children's activities in the preschool setting and validated among preschool-aged children.[26] All observers completed training workshops, video analysis and field practice prior to data collection. Consistent with previous studies, inter-rater agreement criteria were set at >80% for each assessed variable.[27 28] To capture the diverse places where children can be active, the school site was divided into different areas. Targeted areas were those areas that were likely to provide opportunities for children to be physically active, such as playgrounds. On an observation day, observers completed scans in predetermined areas across four different periods (morning recess, morning instruction, afternoon recess and after school), coding the percentage of children who engaged in the three distinct activity categories (sedentary, walking and vigorous) in a separate record for boys and girls. The corresponding codes of 'sedentary', 'walking' and 'vigorous' were used to reflect participation in SB, LPA and MVPA, respectively.[26] The average percentage of children engaging in different activities in each area were estimated across observational periods in five schools and further aggregated by location of the areas (ie, indoor vs outdoor). In addition, researchers recorded environmental contexts of each area, including its usability, accessibility and organised activities, if it was supervised by school personnel and if the preschool provided portable active play equipment.[29]

Teacher FGDs

In addition to quantitative measures, three FGDs in topic areas (see Topic guide, online supplementary appendix 1) reflecting the SEM were conducted among 12 teachers in three participating preschools to further explore the socioecological influences on children's PA levels in school from the teachers' perspectives.

A purposive sample of teachers who were responsible for the care of participating children from the PCF preschools were invited to participate. Based on the agreement of preschools, nominated teachers were involved in FGDs. Teachers who participated in the FGD received S$20 vouchers. Three FGDs were conducted at three preschools from February to April 2016 during after-lunch breaks. Each FGD consisting of four teachers was facilitated by an experienced moderator and conducted in a semistructured approach which enabled participants to focus on topics of the most significance to them. Three main topics were covered in FGDs, including (1) teacher's knowledge and beliefs of PA, (2) teacher's role-modelling and (3) school environment for PA. All discussion questions (online supplementary appendix 1) were adapted from Pate *et al*,[30] pretested and modified according to feedback. Care was taken to ensure that the questions were not leading and/or judgemental. Each FGD lasted on average 60 min and was conducted in English. Verbal consent was obtained from all teachers before the discussion. All FGDs were audio-recorded and subsequently transcribed verbatim, with discussion labelled using a deidentified code for each participant.

Data analysis

For quantitative data (ie, from questionnaires, accelerometer, measured anthropometrics and SOPLAY), descriptive analyses were conducted, including medians (IQR) and means (±SD). Because proxy-reported and accelerometer-measured data were not normally distributed, mixed linear regression was performed to test whether school clustering has an effect on daily activity levels during school days and non-school days. However, no significant difference between schools was observed. As such, Mann-Whitney U tests were then used to assess the difference of daily activity minutes between school days and non-school days, as well as in-school and out-of-school hours. Student t-test was used to compare proportions of children at different activity intensities between indoors and outdoors from SOPLAY. All statistical tests conducted were two-sided. A p value of <0.05 was considered statistically significant. All statistical analyses were performed using STATA V.14.0.

Thematic analysis was conducted to analyse the FGD data.[31] After familiarising themselves with the data, two independent analysers (BC and NAP) coded the data before meeting to discuss the codebook. Where the two analysers did not agree, a third person (NXW) facilitated discussion until an agreement was reached on a complete list of codes which were grouped under six topic areas. The codes were sorted into potential themes, and the relevant coded data extracts were collated within the identified themes. After a set of candidate themes was generated, analysers reviewed the coded data extracts under each theme, to ensure a meaningful coherence of data within the themes and a clear distinction between themes. The analysis was conducted in NVivo V.11. A table presenting themes and subthemes with relevant descriptions and quotes was created (online supplementary appendix 2).

Integration of quantitative and qualitative data

This study used a concurrent triangulation design[32] where qualitative and quantitative data were collected concurrently in one phase. Qualitative data were collected to support quantitative data on children's PA and SB, as well as to illustrate the factors contributing to children's PA and SB from teachers' perspectives. Quantitative and qualitative data were integrated by comparing and combining the separate results from each component, illustrating factors influencing PA and SB among preschool-aged children in different settings, and synthesising the results.

RESULTS

Study participants

Eighty-five parent–child dyads from six preschools were enrolled in this study, but eight parents withdrew before data collection and four parents did not return any questionnaires. Of the remaining 73 dyads, 72 (93.5%) parents agreed to have their children wear an accelerometer and 49 (67.1%) children provided valid accelerometer data (online supplementary appendix 3). In addition, 12 teachers were enrolled in the FGDs.

Children's characteristics are presented in table 1. Based on parent-reported data, children had an average age of 4.4 (±1.1) years. The majority of children were female (61.6%) and were of Chinese ethnicity (63.0%), and parents were their most common main caregivers (72.2%). Around 17.0% of children were overweight

Table 1 Sociodemographic characteristics of participating children according to success of providing valid accelerometer data

	All (N=73)		Children with accelerometer (n=49)		Children without accelerometer (n=24)	
	n	%	n	%	n	%
Age (years), mean±SD	73	4.4±1.1	49	4.5±1.0	24	4.3±1.2
Sex	73		49		24	
Boy	28	38.4	9	37.5	19	38.4
Girl	45	61.6	15	62.5	30	61.6
Ethnicity	73		49		24	
Chinese	46	63	27	55.1	19	79.2
Malay	24	32.9	19	38.8	5	20.8
Others	3	4.1	3	6.1	0	0
Body status*	65		49		16	
Underweight	4	6.2	4	8.2	0	0
Normal	50	76.9	37	75.5	13	81.3
Overweight	7	10.8	6	12.2	1	6.3
Obese	4	6.2	2	4.1	2	12.5
Main caregiver	72		48		24	
Parent(s)	52	72.2	36	75	16	66.7
Grandparents, domestic helpers and others†	20	27.8	12	25	8	33.3
Parental education level						
Primary/secondary school	8	11	6	12.2	2	8.3
Postsecondary certificates/diploma	44	60.3	29	59.2	15	62.5
University degree and above	21	28.8	14	28.6	7	29.2
Marital status	73		49		24	
Married/living with partner	66	90.4	43	87.8	23	95.8
Single/never married	7	9.6	6	12.2	1	4.2
Housing	72		48		24	
HDB≤3 bedroom(s)‡	24	33.3	16	33.3	8	33.3
HDB 4–5 bedrooms	42	58.3	29	60.4	14	58.3
Condominium or landed property	5	6.9	3	6.3	2	8.3

*Children's body status was classified according to Centers for Disease Control and Prevention cut-offs (overweight=85th–95th percentile, obese≥95th percentile).
†Included grandparents, domestic helpers or together with others.
‡HDB refers to public housing managed by the HDB.
HDB, Housing and Development Board.

Table 2 Activities measured by proxy-reported questionnaire and accelerometers

	Proxy-reported questionnaire (N=73)			
	Median (IQR)			
	Overall	School days*	Non-school days*	P value†
Time spent (hours/day)				
Sleep	11.3 (10.0–12.0)	11.0 (10.0–12.0)	11.5 (10.3–12.5)	0.003
Sedentary	3.3 (1.8–4.6)	2.8 (1.8–4.5)	4.0 (2.1–6.0)	<0.001
Light intensity	0.6 (0.3–1.5)	0.5 (0.3–1.4)	1.0 (0.4–2.0)	0.088
Moderate-to-vigorous intensity	1.0 (0.3–2.6)	1.0 (0.2–2.0)	1.0 (0.2–2.5)	0.246
	Accelerometer (n=49)			
Time spent (hours/day)				
Sleep	9.6 (9.1–10.3)	9.7 (8.0–10.9)	9.4 (8.0–9.7)	0.009
Sedentary	7.7 (6.9–8.6)	7.7 (6.6–8.4)	8.2 (6.8–9.4)	0.011
Light intensity	5.5 (4.8–6.2)	5.5 (4.8–6.3)	5.6 (4.8–6.3)	0.873
Moderate-to-vigorous intensity	0.5 (0.3–0.8)	0.5 (0.3–0.7)	0.6 (0.4–0.8)	0.169
	Overall	**In-school hours‡**	**Out-of-school hours‡**	
Wear time spent per waking hour on school days (min/hour)				
Sedentary	30.5 (25.7–34.3)	29.3 (25.6–34.2)	30.8 (25.8–34.2)	0.492
Light intensity	22.1 (19.6–21.9)	22.9 (20.6–26.6)	20.7 (17.4–23.1)	0.011
Moderate-to-vigorous intensity	1.0 (0.0–3.0)	1.0 (0.0–3.0)	1.0 (0.0–3.0)	0.496

*Typical week comprised five school days (weekdays) and two non-school days (weekend days).
†Mann-Whitney U test was conducted to compare between school days and non-school days, as well as in-school and out-of-school hours.
‡In-school time refers to the period between 08:00 and 18:00, excluding napping time at 14:00–15:00; out-of-school time refers to periods from 07:00 to 08:00 and from 18:00 to 22:00.

(10.8%) or living with obesity (6.2%). Most children's parents had postsecondary education or above (89.0%) and were living with a partner (90.4%). Public housing with 4/5 bedrooms was the most commonly reported housing type (58.3%). There were no statistically significant demographic differences between children who provided valid accelerometer data and those who did not (table 1). On average, children reported to start school at 08:00 and finish school at 18:00.

PA and SB

Based on parent proxy-reported data, children spent a median of 3.3 (IQR 1.8–4.6) hours being sedentary, with less sedentary time on school days than non-school days. Children engaged in a median of 0.6 (IQR 0.3–1.5) hour in LPA and 1.0 (IQR 0.3–2.6) hour in MVPA each day, and no significant differences were observed between school days and non-school days (table 2 and online supplementary appendix 4).

According to the accelerometer assessments, children had a median wear-time of 6.7 (IQR 6.1–7.0) days and 24.0 (IQR 24.0–24.0) hours/day). Overall, the majority of waking time was spent in SB (7.7 (IQR 6.9–8.6) hours/day), which was generally high throughout the week. Compared with school days, children's engagement in SB was higher on non-school days (7.7 vs 8.2 hours/day). The median time spent in LPA was 5.5 (IQR 4.8–6.2) hours/day and that in MVPA was 0.5 (IQR 0.3–0.8) hours/day. No significant differences were observed between school and non-school days. On school days, higher LPA (22.9 vs 20.7 min/hour) but similar SB and MVPA levels were observed when comparing in-school with out-of-school hours (table 2).

Correlates of PA in school

FGDs provided additional information on factors influencing PA and SB in schools. The focus groups revealed teachers' perceptions of children's activity levels at school and in-school factors determined the amount of time children spent being active.

Factors at different levels were identified, and some deductive interpretation of these factors was generated as follows. Detailed results are presented in online supplementary appendix 2.

Children's biological predisposition and innate preference for PA

At the individual level, teachers spoke about the importance of activity for children because the children enjoy it and that activity improves learning and behaviour. Teachers also related this to important aspects of their day, like managing behaviour and the routines around sleep. The influence of sex and age also impacted activity, since the teachers believed that boys may be more likely

to be active and that younger children may need some initial encouragement and guidance with play.

Teachers' opinions on children's PA levels

At the interpersonal level, the influence of teachers' own knowledge around PA and their perceptions of appropriate amounts were evident. When asked about their awareness of PA guidelines and the amount of PA children should be engaged in at this age, it appeared from the statements such as the quotes presented in online supplementary appendix 2 in domain 2 that the teachers did not understand the guidelines and that they perceived the amount of PA children were engaged in at preschool was adequate.

Cultural importance of academic performance and religion

For the sociocultural environment at the environmental level, there was a large volume of discussion about the influence of the cultural importance of academic performance impeding children's participation in PA. Teachers demonstrated the need to fulfil academic requirements of the central curriculum, which could lead to less PA at school. As some of these discussions on academic performance were more related to the organisational level, they were presented there too. Although religion was discussed only in one group, the discussion emphasised this as an important factor influencing PA since they felt it was a barrier to participation in some forms of PA (eg, yoga).

Equipment, space and weather

For the physical environment at the environmental level, when participants were prompted to discuss the equipment and space at the school for children to play, they mostly responded that the equipment was adequate, but two groups who responded felt the playground spaces could be improved and that this may result in more active play. Suggestions included that the size of the playground was an issue and that providing interesting play areas with more equipment could be beneficial for children's activity levels. The weather was mentioned in all three groups, where teachers talked about strategies for playing indoors if it rains and that the tropical heat can impact on playtime in the playground.

Preschool schedule and central curriculum

The largest volume of discussion was focused on organisational level issues, and these were often intertwined with discussion about policy-level issues related to the central curriculum. Although teachers described the need to achieve all elements of the curriculum under a theme of scheduling of activities, depending on the principal's approach, local school level interpretation meant teachers at some schools had the flexibility to provide opportunities for active play in daily routines. Two subthemes were the use of cross-curricular learning opportunities that took children outside moving about while learning and being active at the same time, and being aware of the balance between indoor and outdoor times. However, this local interpretation of the central curriculum did not always result in routines that were supportive of active play, nor did it consistently result in a balance of indoor and outdoor time since teachers relayed experiences of principals who interpreted the curriculum in ways that could be more or less supportive of children's PA and outdoor time. The low teacher to child ratio was also mentioned in two groups, where teachers stated that children may need to play indoor when there were not enough teachers to bring them outdoors.

Table 3 Activity levels of children assessed by System for Observing Play and Leisure Activity in Youth

	Indoor†	Outdoor‡
Number of scans	112	26
Number of unique children scanned	555	143
Activity level (% of children engaging in activities of different intensities)		
Sedentary	81.8	53.3*
Light intensity	10.5	12.7
Moderate-to-vigorous intensity	7.7	34.0*

*P<0.001.
†Indoor refers to indoor areas at preschool such as classrooms.
‡Outdoor refers to outdoor areas at preschool such as playgrounds.

Preschool SOPLAY

SOPLAY was conducted to provide additional information related to the individual and the environmental level determinants of PA. In total, 138 scans over five preschools were conducted. Targeted areas within schools ranged from 2 to 4 (mean: 2.8, total: 14). More children were observed indoors than outdoors during our assessments (555 vs 143).

More children engaged in MVPA outdoors than indoors (34.0% vs 7.7%), and less of them engaged in SB outdoors than indoors. Observed SOPLAY target areas were always usable and accessible to children, and they were supervised by school personnel. On average, organised activities occurred during 40.6% of the observations with slightly more in indoor areas (41.1% vs 38.5%). We did not observe any portable equipment for active play (eg, balls and jump ropes) in any of the five preschools (table 3).

Correlates of PA outside school

Table 4 summarises correlates at different levels of the SEM for out-of-school settings.

At the individual level, parent reports found that most children (79.1%) walked between home and school; 43.3% took a car or public transport; and 1.5% cycled. On average, children spent a median of 38.6 (IQR 17.1–98.6) min/day in outdoor play and 90.0 (50.0–180.0) min/day screen viewing (SV). In addition, 23.5% of children had extracurricular organised physical activities per week.

At the interpersonal level, the majority of children lived with both parents (90.4%). More than half of the

Table 4 Parent-reported determinants of physical activity and sedentary behaviour

	N	n (%)*	Median (IQR)†
Individual			
Transport-related activities‡	67		
Walking		53 (79.1)	20.0 (15.0–30.0)
Cycling		1 (1.5)	30.0 (30.0–30.0)
Sitting on a bike/ bus/mass rapid transit (MRT)/car		29 (43.3)	25.0 (20.0–30.0)
Outdoor playtime (min/ day)	73	61 (83.6)	38.6 (17.1–98.6)
SV (min/day)	73	69 (94.5)	90.0 (50.0–180.0)
Extracurricular organised sports weekly	68	16 (23.5)	
Interpersonal			
Parental weight classification (%)§	72		
Underweight/normal		32 (45.0)	
Overweight		15 (21.1)	
Obese		25 (33.8)	
Parental behaviours (min/day)			
Leisure time MVPA	60	44 (73.3)	2.9 (0.0–17.1)
Leisure time SV	73	61 (83.6)	192.9 (90.0–360.0)
Environmental			
Active equipment (%)	71		
Presence of active toys at home¶		65 (91.5)	
Balls at any kind at home		56 (78.9)	
Bicycle/tricycle		46 (64.8)	
Scooter or skateboard/ waveboard		37 (52.1)	
Screen devices			
Number of home screen devices	69	69 (100.0)	7.0 (6.0–9.0)
Presence of TV in children's bedroom (%)	72	9 (12.5)	
Children's usage of resources within the community			
Once or more per month (%)	73		
Park		20 (27.4)	
Playground		8 (11.0)	
Indoor gym**		51 (69.9)	
Parents' perceptions of neighbourhood safety for PA			
Strongly agree, agree (%)	67		
Safe to play outdoors		63 (94.0)	
Usable footpaths on most streets for walking with child		52 (77.6)	
Sufficient traffic lights/pedestrian crossings to make it safe to walk with child		60 (89.6)	

*Number of participants with any reported activity time.
†Median (IQR) among all participants with valid data.
‡Multiple responses possible; the corresponding median (IQR) accounted only for children engaged in each transport-related activity.
§Parent's body status classified using WHO Asian body mass index cut-points (overweight=23–27.5 kg/m^2; obese≥27.5 kg/m^2).
¶'Active toys' refers to any type of exercise equipment or toys that are typically used in an active way, such as bicycles, jump ropes and balls.
**Indoor gym refers to those offering programmes for young children, such as play gym.
MVPA, moderate-to-vigorous physical activity; PA, physical activity; SV, screen viewing.

parents were overweight (21.1%) or obese (33.8%). About three-quarters of the parents engaged in leisure-time PA, but the average amount was only 2.9 (0.0–17.1) min/day. Meanwhile, parents spent a median of 192.9 (IQR 90.0–360.0) min/day watching screen devices during leisure time. At the environmental level (home and neighbourhood), most families (95.6%) had at least one active toy. On average, parents reported a median of 7.0 (IQR 6.0–9.0) screen devices at home and 12.5% of families had a TV in their child's bedroom. Indoor play gyms, which offer programmes for young children, were the most frequently used resource by children within the community, followed by the park and playground (frequencies of using facilities at least once per month: 69.9%, 27.4% and 11.0%, respectively). The vast majority of parents (94.0%) reported that within the neighbourhood, it was safe to play outdoors; there were accessible footpaths on most streets (77.6%) and sufficient traffic lights or pedestrian crossings (89.6%) to make it safe to walk with children in the neighbourhood.

DISCUSSION

This study was conducted in a multiethnic Asian population and used a comprehensive set of methodologies to investigate PA and SB of Singaporean children within and outside the preschool setting, as well as their diverse influencing factors. To the best of our knowledge, this is the first study of its kind in Asia. We found that on school days, children spend an average of 10 hours in preschool, which clearly illustrates the importance of preschools in promoting PA and health behaviours. The median of accelerometer-measured MVPA time of 29.0 min/day in our study falls short of guidelines for PA in this age group by around half an hour,[33] and children spent the largest

amount of their time in SB. These findings were consistent on school versus non-school days and during school versus non-school hours.

Potential correlates of PA and SB among this age group have been identified in the literature. We explored these correlates in depth by integrating information from different measures and summarised them on the basis of the socioecological framework (figure 1). At the individual level, SOPLAY revealed a limited amount of organised PA in preschools, as well as low levels of PA and high levels of SB particularly during indoor classroom time, which represented the largest part of school days with rain and the tropical heat being correlates reported to inhibit outdoor playtime. Meanwhile, parents reported that children had very limited outdoor playtime during non-school hours, and only a small proportion of them had extracurricular organised sports. In addition to outdoor play and organised play, most parents reported that children walked to school rather than using public or private motorised transport or cycling. High levels of SB after school and on non-school days may also be explained by the fact that children spend a considerable amount of time on screen devices. Despite low activity levels from quantitative results, FGDs found that teachers believed that children were sufficiently active at preschool and that teachers were not familiar with PA recommendations for children. When combining and comparing correlates at interpersonal, environmental and organisational levels, the teachers recognised that focus was on academic achievements. Teachers explained that the need to fulfil the academic requirements of the central curriculum was a barrier to opportunities for PA at school. Teachers viewed the central curriculum and the principals (who can adjust this curriculum to the local setting) as key factors in determining the amount of activity time, as well as indoor and outdoor times in preschools. These opinions from teachers were partly consistent with SOPLAY data because direct observations confirmed the potential relevance of sufficient outdoor time also in increasing PA and reducing SB. In addition to curricular aspects, SOPLAY data also indicated that schools may not have (or not use) sufficient amount and variety of portable active play equipment to promote active play within and outside the classroom. During non-school hours, from the information provided by parents, it appeared that PA-promoting opportunities may be generally underused. For instance, unstructured activities, such as visits to playgrounds and parks in the neighbourhood appeared to be rare among most children despite the perception that these are generally safe and accessible. Similar to the school setting, there also seemed to be a preference for indoor activities outside of the school setting, as illustrated by the use of indoor gyms most frequently for leisure-time PA. This underuse of opportunities for activity may be related to parents' own preferences and influences, because parents reported minimal engagement in leisure-time PA as compared with large amounts of leisure-time SV.

Accelerometer data revealed that children engaged in less than half an hour of MVPA and almost 8 hours of SB per day in our sample, indicating a sedentary lifestyle at a young age in Singapore. Compared with our findings, studies in the USA,[34] Canada[35] and Australia[36] showed that preschool-aged children spent much more time in MVPA and less in SB. Although research among early childhood is limited in Asia, similarly low levels of PA and high levels of SB were objectively measured and reported in Japanese preschoolers.[37] Unlike findings from accelerometer data, proxy reports suggest that parents estimate their children's time spent in PA to be high and their children's SB time to be considerably lower. This may be due to parents' misconceptions about the activity level of children. Similar to our observations, previous research has also highlighted that parents demonstrated little awareness about the amount of SV time their children should engage in.[38] In addition to the overall low MVPA and high SB, accelerometer data reported even higher SB on non-school days than school days. However, lower SB on school days may be a result of more regular naps and night-time sleep on school days rather than greater levels of PA. Similar findings of SB[39 40] and PA[41–43] by day of the week were reported by previous studies in preschool-aged children. In contrast to the low levels of MVPA during out-of-school hours in our study sample, young children in Australia were more active during non-school time.[44] This may be a result of higher engagement in organised sports and lower SV. Interestingly, parents in our study reported longer sleep time during weekend compared with weekdays, in contrast with findings from objectively measured sleep. This suggests that parents' perception of how early children went to bed on weekend days was less accurate than on weekdays.[45]

FGDs and SOPLAY clearly showed that different levels of the SEM can independently and simultaneously influence children's engagement in PA and SB during school time. Similar to other studies,[46 47] differences in activity levels between boys and girls were reported by teachers during FGDs. Interestingly, teachers across all focus groups consistently expressed the belief that children were doing enough PA at school. Teachers also believed they were informed about PA guidelines for children; however, they underestimated the recommended PA levels. This may be an important misconception for health promotion efforts in the Singapore preschool setting to address, since teachers with this misconception are less likely to promote any additional activity in preschool time if they believe it is already sufficient. In addition, sociocultural values regarding the emphasis on academic performance seem to influence how decisions about curricular time allocation are made in schools.[48] This importance of academic performance as a barrier for promoting PA in Asia has previously also been reported in university students[49]; however, it has not been investigated in the context of preschool-aged children. A possible explanation may be that most of the existing studies are from Western countries. Compared with these

countries, (South) East Asian nations, for example, Singapore, China, South Korea and Japan, tend to emphasise academic achievement more strongly, even during preschool years.[50 51] During FGDs, teachers indicated that children enjoyed the cross-curricular learning opportunities when they were learning and being active at the same time. Similarly, existing evidence suggests that PA, especially physically active learning, could improve children's cognitive development[1] and academic performance.[52] Therefore, it may not be ideal to improve children's academic performance by the sacrifice of their engagement in PA. Contrary to teachers' perception that children were involved in more organised play rather than free play during school hours, little organised PA actually happened during school hours. Given that organised PA has been associated with greater PA and lower SB among children than free play,[53] delivery of more organised PA during school hours may be able to increase PA levels in our study population. This study also assessed the use of active play equipment at preschool. Teachers reported that schools need more play equipment for PA in the form of fixed play equipment such as slides or tunnels on playground. They appeared not to be aware of the need for portable active play equipment, such as jumping ropes and balls. SOPLAY observation did not notice any portable active play equipment presented indoors or outdoors at participating preschools. In contrast to our findings, preschools and schools in the USA appear to have portable play equipment.[27 54 55] These observations are important because portable active play equipment has been identified as a significant predictor of PA and motor skill development.[56]

Out-of-school time (before or after school, non-school day) is considered a discretionary period because parents and children should be able to make some choices about their participation in activities.[57] During out-of-school time, children have three distinct opportunities to be active: transport-related activities, outdoor play and extracurricular organised sports.[58] Compared with previous studies in young children in Canada and the UK,[59 60] a higher proportion in our sample chose active transport but spent a shorter duration during daily commute to school. Transport-related PA does not seem to be making a significant contribution to out-of-school accelerometer-measured MVPA in our study population, which may be due to this activity being light and of short duration. Since most preschools in Singapore were located in residential areas (ie, the Housing and Development Board estates),[48] the short distance to school may not be able to provide adequate opportunities for active travel to accumulate high levels of PA. In addition to daily transport, outdoor play and weekly extracurricular organised sports provide opportunities to accumulate PA. However, little organised sports happened outside of school in our study sample, which does not seem to be consistent with studies from other countries.[44 53] Our study revealed that children were generally more active during outdoor play, but outdoor playtime among children was limited not only in school but also outside school. As opposed to findings from other studies,[61 62] parents in our study considered their neighbourhood safe enough for children. However, few children visited parks and playgrounds regularly and parents tended to bring their children to indoor play gyms more often. Therefore, other factors rather than safety might discourage parents from taking their children outdoors. For example, hot weather was suggested by teachers as a factor leading to less outdoor play at school, and it could also be parents' concern. Meanwhile, children appeared to engage in as much as 1.5 hours of SV at home per day, exceeding American Academy of Pediatrics recommendations.[63] Children's low engagement in organised and outdoor PA outside of school and high levels of SV may indicate that parents cannot or do not support or encourage children's PA adequately. This may also be explained by parental preferences and behaviours.[64] In that context, our study found multiple screen devices at home and even TVs in children's bedrooms paired with unsupportive engagement in PA and SV among the parents.

Strengths and limitations

The major strength of this study is the use of multiple complementary approaches to measure behaviours and relevant correlates at multiple levels of the SEM. Nevertheless, we also have to acknowledge some limitations. First, selection bias and reduced generalisability could be introduced by excluded participants and a relatively small sample size. Besides, children attending PCF preschools are more likely to come from families with lower income.[65] Therefore, this cohort may not represent the general Singaporean population. However, the purpose of this study was not to enrol a representative sample[66] but to implement a comprehensive assessment approach that will allow us to generate hypotheses about the diverse correlates of PA and SB among preschool-aged children. Second, children were from one kindergarten and five child care centres so that between-school differences may exist. However, we conducted sensitivity analysis and did not observe any significant differences between these groups. Third, the Chandler *et al* cut-offs to define activity levels from wrist-worn accelerometers were developed and validated among children aged 8–12 years, which may have resulted in bias in the younger children. However, compared with other existing cut-offs for children,[67 68] the application of Chandler *et al* cut-offs can more accurately reflect the true activity levels since it was validated against objective measures, that is, oxygen consumption based on indirect calorimetry and per cent of heart rate reserve, respectively.[25]

CONCLUSION

The findings of our study indicate low levels of PA and high levels of SB among preschool-aged children in Singapore, and this applies to both time spent within and outside of preschool. Emphasis on academic performance

materialised as a key underlying factor that was verbalised by teachers. Thus, to promote PA, discourage SB, as well as health and well-being of children, strategies have to address the diverse factors within the preschool setting. In particular, school curricula and its local implementation, including the lack of organised PA in preschools, may warrant evaluation to increase the amount of PA and outdoor playtime and to lower the levels of SB. In addition, activities to improve teacher's PA knowledge and to evaluate children's current activity levels may be useful. Consideration of structural aspects by policymakers, such as the availability of active play equipment in schools, may further help to support higher activity levels. Outside school, there appears to be potential to better use opportunities for active outdoor play and/or organised sport. Reducing the large amounts of time spent watching screen devices may be important in that context. To achieve these goals, enhancing parents' awareness of the importance of PA and reducing SV, as well as their children's PA levels, is likely essential. This may also require strategies to address parents' lack of engagement in PA and excessive SV at home. Similar studies in other Asian countries are warranted to confirm our findings. Meanwhile, further research is also needed to understand the underlying parental motivations and reasoning for children's PA and SB in the local context.

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