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Original Article

Physical Activity, Sedentary Behaviour, and Sleep Habits in Kindergarten Children in Hong Kong

CCW ***Yu***, B ***Zhang***, CT ***Au***, FSF ***Lo***, F ***Sun***

Abstract ***Objectives:*** The purposes of the present study were to investigate the characteristics of physical activity, sedentary behaviour, and sleep habits in Hong Kong kindergarten children, as well as to explore the associations among these variables. ***Methods:*** Kindergarten children aged between 3 and 5 years in Hong Kong participated in the present study. Participants were instructed to wear an accelerometer to monitor their physical activity level for 7 days. The screen time and Children's Sleep Habit Questionnaires (CSHQ) were completed by their parents. ***Results:*** Totally 81 children provided valid accelerometer data, of whom only 32.1% of children met the World Health Organization (WHO) physical activity recommendation, i.e., 60 minutes of moderate-to-vigorous physical activity (MVPA) per day. Nearly 73% of children in our study did not match the WHO guideline of having less than 60 minutes screen time per day. For the CSHQ data, approximately 25.9% (18.5%) of children did not meet the WHO guideline of having 10-13 hours' sleep on weekdays (weekends). Screen time has positive associations with sleep-disordered breathing, whereas sedentary behaviour was positively associated with daytime sleepiness and total score of CSHQ. Low-intensity physical activity was positively associated with sleep onset delay and negatively associated with sleep duration. No significant association was found between MVPA and sleep characteristics. ***Conclusion:*** The majority of kindergarten children in Hong Kong in the present study did not meet the WHO guidelines on physical activity, screen time, and sleep duration. Both sedentary behaviour and low-intensity physical activity were associated with certain sleep problems.

Key words *Actigraphy; Kindergarten children; Physical activity; Sleep quality*

Department of Rehabilitation Sciences, The Hong Kong Polytechnic University, 11 Yuk Choi Road, Hung Hom, Kowloon, Hong Kong SAR, China
CCW **Yu** (余頌華) *PhD*
FSF **Lo** (盧笑歡) *BSc*

Department of Health and Physical Education, The Education University of Hong Kong, 10 Lo Ping Road, Tai Po, N.T., Hong Kong SAR, China
B **Zhang** (張博睿) *MSocSc*
F **Sun** (孫風華) *PhD*

Department of Paediatrics, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong SAR, China
CT **Au** (歐俊廷) *PhD*

Correspondence to: Dr F **Sun**
Email: fhsun@eduhk.hk

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Introduction

Sufficient physical activity, reduced sedentary behaviour, and adequate sleep are crucial for children's physical and mental health. Physical activity plays an important role in the physical development of children. Studies have shown that physically active children have higher bone mass, bone size, muscle strength, and motor development scores.[1] Adequate physical activity can also lower cardio-metabolic risk,[2] help to maintain healthy body weight,[3] improve cognitive control,[4] and may have a positive impact on the mental well-being levels in children.[5,6] On the other hand, excessive sedentary behaviour, such as screen time, negatively impacts health. Sedentary time or sedentary behaviour in children is closely related to obesity.[7] A study involving 12 countries indicated that sedentary time was positively correlated

with body fat percentage, and screen time was positively related to a larger waistline.[8]

Adequate and high quality of sleep benefit health, whereas insufficient and low quality sleep may cause adverse outcomes. Studies from various countries reported that short sleep duration is associated with a higher risk of being overweight and a higher body mass index (BMI) in young children.[9,10] Children with sleep deprivation have poorer cognitive performance and emotional control.[11,12] A longitudinal study conducted by Tso et al reported that children who sleep less than 8 hours per day in early childhood will have a higher risk of having attention deficit hyperactivity disorder compared to children who sleep 11-12 hours per day.[13] In contrast, children with 11-12 hours of sleep per day have a higher total score on school readiness assessment.[14] Besides the sleep duration, a growing number of researches have suggested that regular getup time and bedtime are thought to bring multiple positive outcomes in children.[15] In addition, the incidence of disordered breathing increases in children, which may cause many night-time problems such as mouth breathing, snoring, or even influence daytime behaviour.[16] Evidence also show that daytime sleepiness is now widespread in children, which may be associated with mood and behaviour problems.[17]

In 2019, the World Health Organization (WHO) established the 24 hours movement guidelines for children under 5.[18] The recommendations suggested that 3-5 years old children should spend at least 180 minutes on different forms of physical activity of any intensity throughout the day, with at least 60 minutes of which being moderate-to-vigorous physical activity (MVPA). Sedentary time should not be longer than 60 minutes continuously. Time spent daily on a screen should be less than 60 minutes. Children should also have a good habit of regular sleep and wake-up times. Good quality sleep, including naps, for 10-13 hours is proposed for this age group. Research in different countries reported that the percentage of study children meeting all the above guidelines on physical activity and sleep duration[18] were only 12.7% in Canada,[19] 14.9% in Australia,[20] 21.5% in Japan[21] and 9.6% in Singapore.[22] For each individual item, more than 50% of children in these four countries can achieve the guidelines of physical activity, and over 70% of children can have enough sleep. However, for screen time, more than 70-90% of kindergarten children were in a state of overusing electronic devices.[19-22] Currently, physical activity patterns, sedentary behaviour, and the sleep status in kindergarten children in Hong Kong are still unclear.

Although physical activity, sedentary behaviour, and sleep may affect health outcomes separately, there may also be cumulative, synergistic, or interactive effects among these three behaviours.[18] Physical activity is considered an effective method to improve sleep quality in adolescents and adults. However, the evidence among children is unclear with inconsistent findings.[23] In a systematic review and meta-analysis including 47 studies, a weak association was observed between vigorous physical activity with sleep duration in children.[23] In a recent study, more physical activity led to shorter sleep duration but improved the sleep efficiency.[24] In addition, although some studies suggested that low level of physical activity may cause daytime sleepiness in children and adolescents,[25,26] there is a lack of data in kindergarten children.

Therefore, the objectives of the present study were to investigate the characteristics of physical activity, sedentary behaviour, and sleep habits, as well as explore the associations among these variables in kindergarten children in Hong Kong. The hypothesis was that a low level of physical activity or more time spent in sedentary behaviour may associated with more sleep problems in kindergarten children in Hong Kong.

Methods

Study Design and Participants

Kindergarten children (3-6 years old) were recruited using a convenient sampling method for this study. Invitation letters were sent to potential schools. With the principals' approval, enrolment forms were sent to parents to register their children for the study voluntarily. Children with chronic or acute diseases were excluded. Written informed consents were obtained from parents. Teachers and parents were invited to attend a briefing session before the study. In total, 136 children from three local kindergartens in Hong Kong agreed to join the study. The data collection period was from December 2018 to February 2019. This study was approved by the Human Research Ethics Committee of The Education University of Hong Kong.

Measurements of Anthropometry, Physical Activity and Sedentary Behaviour

Anthropometric Measurements

Body weight was measured to the nearest 0.1 kg with participants barefoot and dressed in light clothing with a

weighing scale. Standing height was measured to the nearest 0.1 cm with a Harpenden stadiometer (Holtain, Grymych, UK). The BMI was calculated by weight in kg divided by height in meters squared. BMI was then converted to z score based on age- and sex-adjusted local reference.[27]

Accelerometer

The accelerometer was used to monitor physical activity in this study. The participants were instructed to wear an accelerometer (Actigraph GT3X-BT, Pensacola, FL) on the non-dominant wrist for 7 consecutive days, except for taking a bath/shower, swimming, and sleeping. A sampling rate of 30 Hz was used and the accelerometer data was tallied at five-second epoch to capture the short bursts of activity that are commonly observed in preschool children.[28] Data were analysed using the ActiLife program (version 6.8, Actigraph, Pensacola, FL). Valid data was defined as having at least 8 hours of captured data in a single day, for at least three weekdays and one weekend day. The cut-off points for sedentary (<=221 vector magnitude counts per 5 seconds), low-intensity (>222 to <=729 vector magnitude counts per 5 seconds), and moderate-to-vigorous intensity activities (>=730 vector magnitude counts per 5 seconds) were defined according to a previous study in young preschoolers.[28]

Screen Time

Parents were instructed to complete one-item question to record their children's screen time. The question was extracted from the Netherland Physical Activity Questionnaire (NPAQ),.[29] i.e., "On average, how many hours and minutes per day does your child spend watching any type of electronical screens, including television, mobile phone, iPad, and video movies?" The screen time was then calculated to total minutes.

Sleeping Habits

Children's Sleeping Habits Questionnaire (CSHQ)[30]

Parents completed a 45-item questionnaire to assess the sleeping behaviour of their children. Questions in the CSHQ were divided into 8 subscales including bedtime resistance, sleep onset delay, sleep duration, sleep anxiety, night waking, parasomnias, sleep-disordered breathing, and daytime sleepiness. Parents were asked to recall their child's sleeping behaviour in a "typical" recent week, and respond to each item in a 3-point Likert scale, where the 3 points refers to "usually" if the sleep behaviour was repeated five to seven times/week; 2 points refers to "sometimes" if the sleeping behaviour were repeated two to four times/week; and 1 point refers to "rarely" if the sleeping behaviour was only appeared from zero to one time/week.

Statistical Analyses

Student's t test, Mann-Whitney U test, and chi-square test were used for group comparisons for parametric, nonparametric, and categorical data, respectively. The associations between screen time, time spent in sedentary behaviour, low-intensity physical activity, MVPA, and sleep parameters (total sleep time, total score of CSHQ, and 8 subscales) were studied by multi-linear regression analyses adjusted for age, sex, BMI z scores. All variables were standardised to z scores to get regression coefficients (B) with 95% confidence intervals (CI). Multi-collinearity was also checked between all variables, and no collinearity was found. All statistical analysis was performed using SPSS for Windows (version 26, IBM Corp., Armonk, NY, USA).

Results

Questionnaires were sent to 200 parents from different kindergartens. A total of 136 parents showed interest and let their children participate in the study, resulting in a response rate of 68%. Table 1 shows the demographic data of the participated children. Out of the 136 children, 81 of them met the valid criteria of physical activity monitoring by accelerometer. There is no difference between boys and girls in age, height, weight, and BMI.

From the accelerometer results, children on average spent on sedentary, low-intensity physical activity, and MVPA per valid day are 354 minutes, 338 minutes, and 52 minutes respectively, correspondingly represent 47%, 46%, and 7% of valid daily monitoring time. Compared with the recommendation, all participated children in our study achieved 180 minutes of physical activity at any intensity on valid days. However, only 32.1% of them met the WHO guidelines of having 60 minutes of MVPA. Table 2 illustrates the children's time spent in sedentary activities and different levels of physical activities during weekdays and weekends. Children spent a longer time in sedentary and low-intensity physical activity during weekdays than in weekends ($p<0.05$). By contrast, children spent a longer time in MVPA during the weekends than in weekdays ($p<0.05$). Additionally, the estimated screen time per day was 96±70 minutes, and around 26.8% of children spent

less than 60 minutes of screen time. When considering the three guidelines, i.e., 180 minutes of physical activity at any intensity, 60 minutes of MVPA, and less than 60 minutes of screen time, only 6 children (7.3%) met with all the guidelines.

Table 3 compares the total activity counts and time spent in different levels of physical activity during weekdays and weekends measured by accelerometer between boys and girls. Boys had significantly higher total physical activity levels than girls in total counts per valid day of monitoring ($p<0.01$), including both weekdays ($p<0.05$) and weekends ($p<0.01$). Boys substantially spent more time in MVPA than girls each day.

The results of CSHQ were presented in Table 4. Only 3 children (3.7%) had a total CSHQ score of less than 41, which is the cut off value to differentiate between healthy and sleep-disordered children.[30] Total 60 out of 81 (74.1%) and 66 out of 81 children (81.5%) met the guideline of having 10-13 hours' sleep per weekdays and weekends. Approximately 10 hours of total sleeping time was reported for both boys and girls, and results are similar during weekdays or during weekends. Results showed that sleep-disordered breathing was more serious in boys than in girls ($p<0.005$). Scoring for daytime sleepiness was also found to be significantly higher for girls ($p=0.03$).

Table 5 showed the associations between screen time, sedentary behaviour, physical activity, and sleep habits. Screen time had a positive correlation with sleep-disordered breathing ($B=0.221$, $p<0.05$). A significant positive association between sedentary behaviour and daytime sleepiness was presented ($B=0.304$, $p<0.01$). Sedentary behaviour was also positively associated with the total score of CSHQ ($B=0.275$, $p<0.05$). Low-intensity physical activity was positively related to sleep onset delay ($B=0.306$, $p<0.05$). A negative association was found between low-intensity physical activity and sleeping duration ($B=-0.249$, $p<0.05$).

Discussion

The main findings of this study were that, according to the WHO's guidelines 2019 for children under 5 years old,[18] only 7.3% of children met all three guidelines, i.e., 180 minutes of physical activity at any intensity, 60 minutes of MVPA, and less than 60 minutes of screen time. Approximately 32.1% of children met the guidelines of at least 60 minutes of MVPA per day, and 26.8% of children

Table 1 The demographic data of the participants

	Boys [n=48]	Girls [n=33]	P value
Age (year)	5.0 ± 0.7	4.9 ± 0.5	0.358
Height (cm)	109 ± 7	107 ± 7	0.093
Weight (kg)	18.7 ± 4.1	17.7 ± 2.4	0.148
BMI ($kg \cdot m^{-2}$)	15.6 ± 2.2	15.5 ± 1.3	0.870
BMI (z score)	0.08 ± 1.25	0.37 ± 0.84	0.235

BMI: body mass index

Table 2 Sedentary activity, low-intensity physical activity, and MVPA measured by Actigraph Accelerometer during weekdays and weekends (time & percentage of daily time)

Patients	N=81 (minutes)	N=81 (percentage)
Sedentary activity per valid day	354 ± 113	47 ± 7%
Weekday	360 ± 109	48 ± 7%
Weekend	340 ± 145*	46 ± 12%
Low-intensity physical activity per valid day	338 ± 57	46 ± 6%
Weekday	339 ± 59	46 ± 6%
Weekend	328 ± 91*	45 ± 10%
MVPA per valid day	52 ± 24	7.0 ± 3.5%
Weekday	47 ± 22	6.3 ± 3.3%
Weekend	64 ± 40*	8.5 ± 5.4%

Values listed as mean ± SD. * P<0.05, Weekday vs. Weekend.

MVPA: moderate-to-vigorous physical activity

met the WHO guideline of less than 60 minutes' screen time. For sleeping, children reached the suggestion of 10-13 hours of sleep are 74.1% during weekday and 81.5% during weekend. Certain gender differences were observed in these characteristics. Another finding of the present study was that both physical activity and sedentary behaviour were associated with certain sleep problems. Increases in the time spent in sedentary behaviour were associated with total CSHQ Score and the daytime sleepiness sub-score, whereas the screen time was associated with the sleep-disordered breathing sub-score. Also, an increase in the time spent in low-intensity physical activity was associated with a higher disturbance score in the sleep onset delay subscale, but a lower disturbance score in the sleep duration subscale.

Few studies have reported physical activity level, sedentary behaviour, and sleep time in Hong Kong kindergarten children. According to the current study, only

Table 3 Activity counts and time spent in different physical activity levels measured by accelerometer during weekdays and at weekends between boys and girls

	Boys	Girls	P values
Total count per valid day	2719700 ± 539072	2404264 ± 411426	<0.01
Weekday (counts)	2621974 ± 545030	2394875 ± 406250	<0.05
Weekend (counts)	2909457 ± 764749	2428877 ± 662676	<0.01
Sedentary activity per valid day			
Per valid weekday (minutes)	357 ± 98	364 ± 126	0.797
Per valid weekend (minutes)	336 ± 136	344 ± 158	0.809
Per valid weekday (%)	47 ± 8	49 ± 7	0.417
Per valid weekend (%)	44 ± 12	48 ± 11	0.180
Low-intensity physical activity per valid day			
Per valid weekday (minutes)	344 ± 67	333 ± 45	0.383
Per valid weekend (minutes)	341 ± 93	310 ± 85	0.121
Per valid weekday (%)	46 ± 6	46 ± 6	0.961
Per valid weekend (%)	46 ± 10	44 ± 9	0.530
MVPA per valid day			
Per valid weekday (minutes)	52 ± 23	40 ± 19*	0.019
Per valid weekend (minutes)	73 ± 40	52 ± 39*	0.023
Per valid weekday (%)	6.5% (4.5 to 9.6)	5.1% (3.6 to 6.8)*	0.023
Per valid weekend (%)	8.7% (5.7 to 12.9)	6.0% (3.9 to 9.4)*	0.011

*P<0.05, boys vs. girls

MVPA: moderate-to-vigorous physical activity

Table 4 The results of Children's Sleep Habits Questionnaire (CSHQ) between boys and girls

	Boys	Girls	P values
Total sleep time in weekdays (minutes)	613 ± 63	617 ± 53	0.749
Total sleep time in weekends (minutes)	622 ± 83	622 ± 50	0.997
Bedtime resistance	11.0 ± 3.1	11.3 ± 2.4	0.720
Sleep onset delay	1.5 ± 0.7	1.5 ± 0.7	0.784
Sleep duration	4.8 ± 1.6	4.4 ± 1.4	0.349
Sleep anxiety	7.1 ± 2.0	7.4 ± 1.7	0.533
Night waking	3.3 ± 0.7	3.5 ± 1.0	0.329
Parasomnias	8.6 ± 1.4	8.5 ± 1.3	0.956
Sleep disordered breathing	3.5 ± 0.7	3.2 ± 0.4**	0.005
Daytime sleepiness	12.3 ± 2.7	13.6 ± 2.6*	0.030
Total CSHQ score	52.0 ± 7.6	53.4 ± 6.2	0.389

*p<0.05; **p<0.01, boys vs. girls

7.3% of kindergarten children met with all three WHO guidelines,[18] which is lower than that in Canada (12.7%), Australia (14.9%), Japan (21.5%), and Singapore (9.6%).[19-22] According to the Hong Kong's Physical Activity report card 2018, around 40-46% of 6-17 years old children met the requirements of over 60 minutes/day of MVPA, less than 2 hours of sedentary behaviour, and 9-13 hours/day of sleep.[31] However, in a territory-wide self-reported survey from primary and secondary school students, the proportion meeting the recommendation was less than 10%.[32] Therefore, it seems that the percentage of kindergarten children who met with all WHO guidelines were lower than that in primary and secondary school children. Tso et al used parent-reported questionnaires to study the screen time and sleep duration in preschool children. A total of 23.6% of the children spent over 3 hours per day on screens and 81.9% of the participants slept over 9 hours per day.[14] Similar findings were observed in the present study with over 74% of children could sleep 10-13 hours per day in weekday and the percentage was 81.5% in weekend. For screen time, around 73% of children could not met with WHO guideline and around 20% of children spent more than 3 hours in screen time per day. Although around 32% of kindergarten children in the present study had at least 60 minutes of MVPA per day, it should be noted that time spent in MVPA may decrease with increasing age in children. For example, Wong et al used accelerometer to investigate the MVPA and sedentary time for 6 to 8 years old children. After two years, they found that the MVPA had dropped from 61.5 to 45.6 minutes per day and that the sedentary time had increased from 402.1 to 439.8 minutes per day.[33] Insufficient physical activity among Hong Kong kindergarten children may be caused by parenting style of Hong Kong people.[34] Parents' TV time and support of regular physical activity are tightly related to children's sedentary behaviour, including screen time.[35] The fears or concerns of the parents or caregivers are transmitted to their children who in turn will generally adopt the same prejudices as their parents and create psychological barriers to a more physically active life. Therefore, according to the current study, the physical activity should be further improved and the sedentary behaviour, especially screen time should be further decreased for kindergarten children in Hong Kong.

Another purpose of the present study was to investigate the associations between screen time, sedentary behaviour, different levels of physical activity, and sleep. In the present study, the CSHQ was used to assess the sleep problems of children. The CSHQ is a useful sleep instrument to identify sleep problems in school-aged children.[30] Besides total CSHQ score, there are 8 subscales including bedtime resistance, sleep onset delay, sleep duration, sleep anxiety, night waking, parasomnias, sleep disordered breathing, and daytime sleepiness. A positive relationship was found between sedentary behaviour and total CSHQ score, as well as the daytime sleepiness sub-score. A positive relationship was also found between screen time and sleep-disordered breathing. The results are consistent with two recent systematic review and meta-

Table 5 The association between screen time, time spent in sedentary behaviour, low-intensity and moderate-to-vigorous intensity physical activity, and sleep habits

	Screen time	Time spent in sedentary behaviour	Time spent in low-intensity physical activity	Time spent in MVPA
			B (95% CI)	
Bedtime resistance	0.047 (-0.211, 0.305)	0.193 (-0.056, 0.443)	0.086 (-0.167, 0.339)	0.039 (-0.231, 0.310)
Sleep onset delay	-0.229(-0.473, 0.015)	-0.195 (-0.431, 0.041)	**0.306 (0.067, 0.546)***	-0.145 (-0.401, 0.111)
Sleeping duration	-0.091 (-0.345, 0.162)	0.217 (-0.028, 0.462)	**-0.249 (-0.497, 0.000)***	0.083 (-0.183, 0.348)
Sleeping anxiety	-0.101 (-0.357, 0.154)	0.223 (-0.024, 0.470)	-0.090 (-0.341, 0.160)	0.022 (-0.246, 0.290)
Night waking	-0.002 (-0.258, 0.255)	-0.087 (-0.335, 0.161)	0.093 (-0.159, 0.344)	0.200 (-0.068, 0.469)
Parasomnias	0.028 (-0.235, 0.292)	-0.037 (-0.292, 0.218)	0.079 (-0.180, 0.338)	0.020 (-0.256, 0.297)
Sleep disordered breathing	**0.221 (0.003, 0.439)***	0.133 (-0.077, 0.344)	0.040 (-0.174, 0.254)	0.087 (-0.141, 0.316)
Daytime sleepiness	-0.070 (-0.298, 0.158)	**0.304 (0.084, 0.524)****	-0.041 (-0.265, 0.182)	0.030 (-0.208, 0.269)
Total score of CSHQ	-0.056 (-0.309, 0.197)	**0.275 (0.030, 0.519)***	0.001 (-0.247, 0.249)	0. 071 (-0.194, 0.335)

*p<0.05; **p<0.01; Values are standardised regression coefficients (B) with 95% confidence intervals (CI) adjusted for age, sex and BMI z scores.

MVPA=moderate-to-vigorous physical activity; CSHQ=Children's Sleep Habits Questionnaire

analysis papers including 31 and 16 studies which concluded that screen time and sedentary behaviour were associated with a higher risk of insomnia and sleep disturbance.[36,37] Sedentary activities have been suggested to relate to the hypothalamic pituitary axis and stress hormones, influencing circadian rhythm and sleep.[38] Additionally, as daytime sleepiness is a multifactorial problem, another possible explanation behind this observation is that sedentary behaviour leads to a variety of sleep disorders, which in turn affect daytime sleepiness. The increased screen time is a serious social problem for all children nowadays. One recent research observed similar results that screen time and BMI were positively associated with risk of sleep-disordered breathing in children.[39] It is still unclear regarding the mechanism behind this association as the sleep-disordered breathing is a multi-factorial problem, not only caused by clinical reasons, but also may be influenced by adiposity, physical activity, behaviour, hormone, and metabolic or genetic factors. Therefore, more research is still needed to clarify this association in kindergarten children. It should be noted that, although previous studies have suggested the negative association between screen time, sedentary time, and total sleep duration, one recent meta-analytic study suggested that the association was non-significant in preschoolers.[37] The result is consistent with the present study. Despite this result, strategies to decrease the sedentary behaviour especially screen time is important to improve the health of kindergarten children in Hong Kong.

Sleep outcomes may be influenced by different intensities of physical activity. However, less studies reported relationships between light- or low-intensity physical activity and sleep. The results of the present study revealed that more time the children spent in low-intensity physical activity, they may be more difficult to fall asleep in 20 minutes. One previous study also suggested that low-intensity physical activity was associated with later bedtime in preschoolers.[40] One possible reason is that kindergarten children may have more free time to play close to sleep, whereas low-intensity physical activity before bedtime may affect the level of neural excitation that make it hard to fall asleep. However, because of very limited study in this topic, it is difficult to make any concise conclusion at this moment. Another finding was that low-intensity physical activity was positively associated with the "sleep duration" sub-score of the CSHQ. One systematic review suggested that exercise decreased non-rapid eye movement sleep stage 1 and increased rapid eye movement sleep, sleep continuity, sleep efficiency, and indirectly increase sleep duration.[41] Furthermore, an increase in low-intensity physical activity may be accompanied by an increase in outdoor activities and in turn sunlight exposure, which may have a beneficial effect on sleep duration as well.[42] It should be noted that several studies reported opposite results[24] or no associations[43] between these variables, possibly because time for physical activity may interfere time for sleep, and sedentary behaviour may offset the positive relationship between time in light-intensity physical activity and sleep duration. Therefore, it seems that more studies are still needed to clarify the potential beneficial effect of low-intensity physical activity on sleep in kindergarten children, especially considering that previous study has suggested that time spent asleep was related more to sedentary or low-intensity physical activity, rather than MVPA.[40]

According to one recent systematic review,[37] MVPA seems to be related to sleep quality and sleep stability in preschoolers. However, in the present study, no significant association was found between MVPA and sleep. One possible reason is that kindergarten children in the present study spent much more time on low-intensity physical activity and sedentary behaviour, instead of MVPA. The relatively less time in MVPA may make it difficult to detect the potential influence of MVPA on sleep parameters in the current study. It is hard to examine sleep efficiency using CSHQ, while many researchers suggested that MVPA may lead to better sleep efficiency.[37] Future research should carefully consider all these factors to investigate the associations between different intensities of physical activity and sleep parameters in kindergarten children.

The study's findings also revealed that kindergarten children were usually more active and accumulated more MVPA time during the weekend than during weekdays. Accordingly, the low-intensity physical activity or sedentary time during the weekend were less than those during weekdays (Table 2). This may be explained by the long academic study time in weekdays. According to the Legislative Council Secretariat, students in primary and secondary school in Hong Kong spend on average 10 hours per day studying, whether at school or after school.[44] Therefore, parents may encourage their children to spend more time on their academic studies or get sufficient rest to go through the next day at school. Additionally, boys attended more physical activity than girls on weekdays and weekends, which may be caused by more MVPA in boys (Table 3). In the current study, gender differences were also observed in daytime sleepiness and sleep-disordered

breathing (Table 4), which is consistent with several previous studies indicating high prevalence of daytime sleepiness in girls.[17,45,46] In contrast, our study is contrary to one recent study suggesting worse sleeping-disordered breathing in girls.[47] The underlying reason may be the presence of respiratory conditions, orofacial symptoms[48] or behaviour, or dental problems.[46]

Strength and Limitations

This study successfully used both objective and subjective measurements to assess physical activity level and sedentary behaviour in the daily lives of kindergarten children in Hong Kong. The accelerometer is user-friendly, convenient to wear, and sensitive enough to measure young children's daily activities. The limitations of the accelerometer are compensated by the questionnaires completed by the parents. One limitation of the present study is the assessment of sleep duration, for which only a subjective report is used. It would be preferable to use biometric tools in addition to self-reporting by the parents, so as to verify or question such reporting. Another limitation is that the habitual snorers were not excluded from the present study although it may affect the sleep behaviour. It should also be noted that the sample size was small in the present study, and it may not be able to represent the Hong Kong kindergarten children. Therefore, the study should be carried out on a larger scale to reveal the actual trends and minimise the bias that may be associated with location and living environment. The results of the present study should be interpreted with caution because of the above-mentioned limitations.

Conclusion

In conclusion, the majority of kindergarten children in the present study did not meet the WHO guidelines on physical activity, screen time, and sleep duration. Both sedentary behaviour and low-intensity physical activity were associated with certain sleep characteristics. In the future research, specifically designed intervention programmes should be applied to improve physical activity and sleep, as well as decrease sedentary behaviour of kindergarten children in Hong Kong, to set up appropriate health strategies, policies and give support to kindergartens, nursery schools and caregivers for them to promote healthy growth and establish a healthy living environment for early childhood.

Ethics Approval

The present study was supported by Dean's Research Fund - Individual Research Scheme (Ref. FLASS/DRF/IRS-4), The Education University of Hong Kong, and the General Research Fund (grant numbers 18608018 and 18603120). No conflict of interest should be disclosed.

Declaration of Interest

The authors declare that there is no conflict of interest.

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